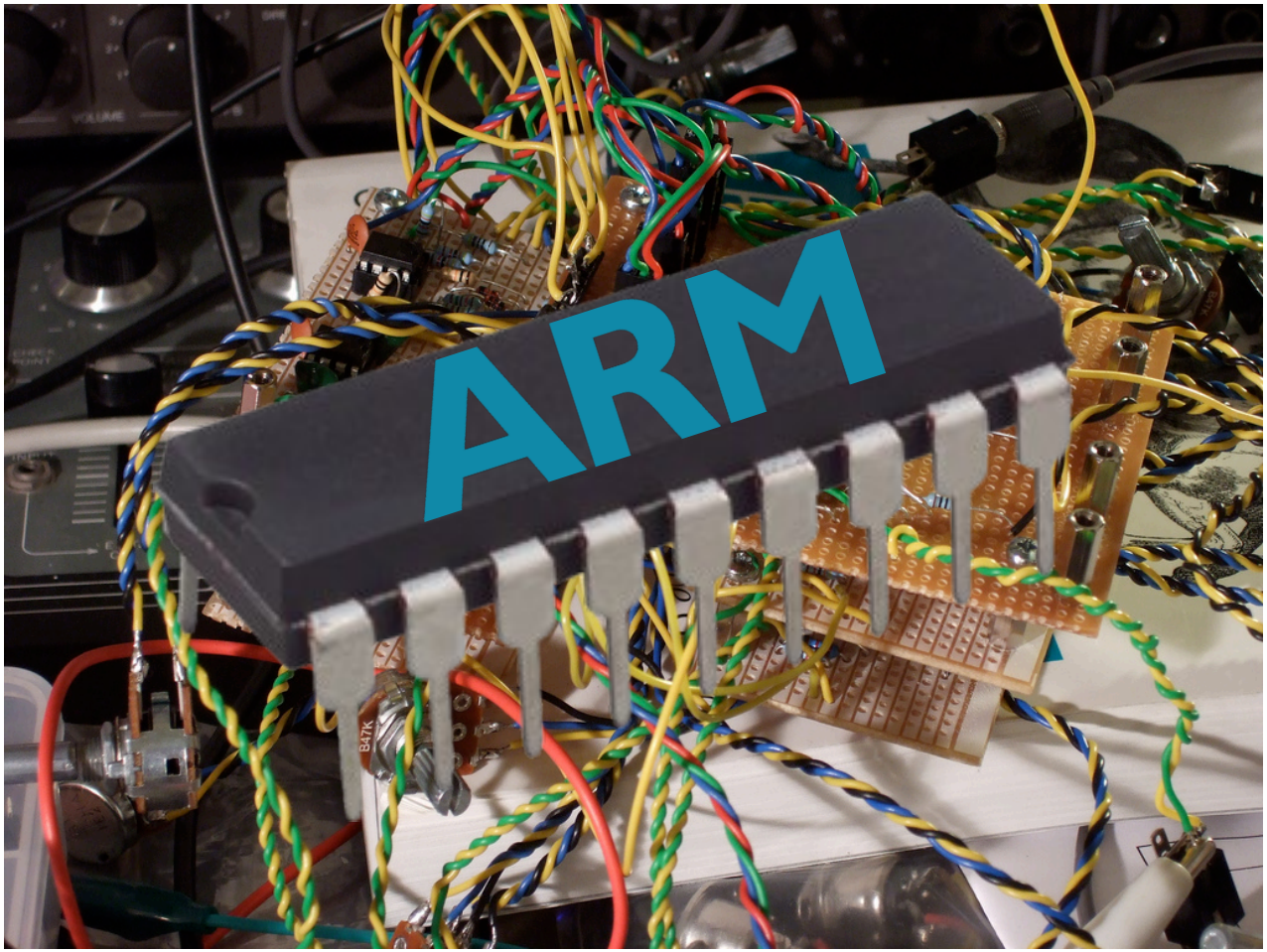
The UK - a natural home for global engineering and technology champions?

Warren East

January 2019

Certain material courtesy of ARM and Rolls-Royce

Making an Engineer



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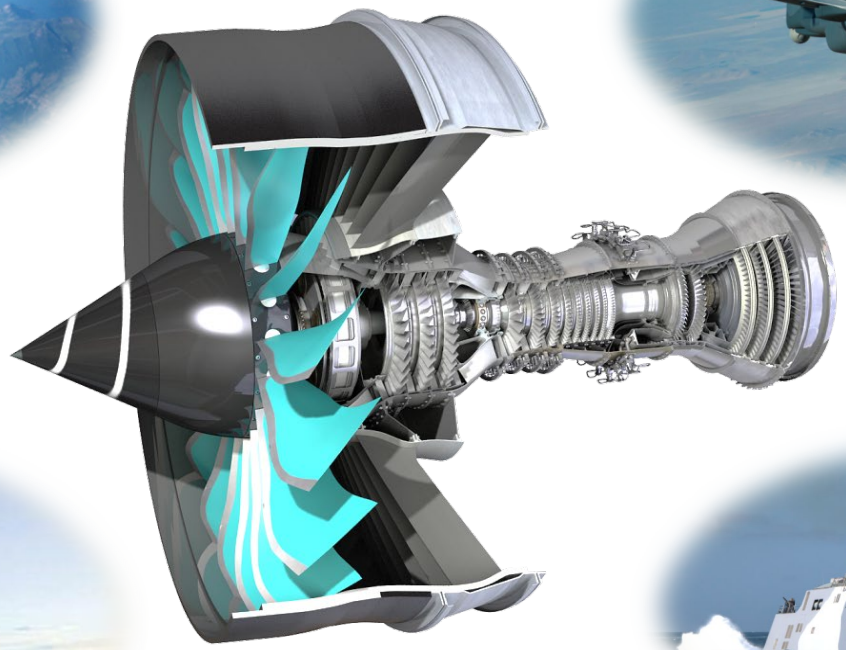
Rolls-Royce: A Leading Industrial Technology Company





Manufacturing and Service, ~2% of UK exports

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Nature…..

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Context

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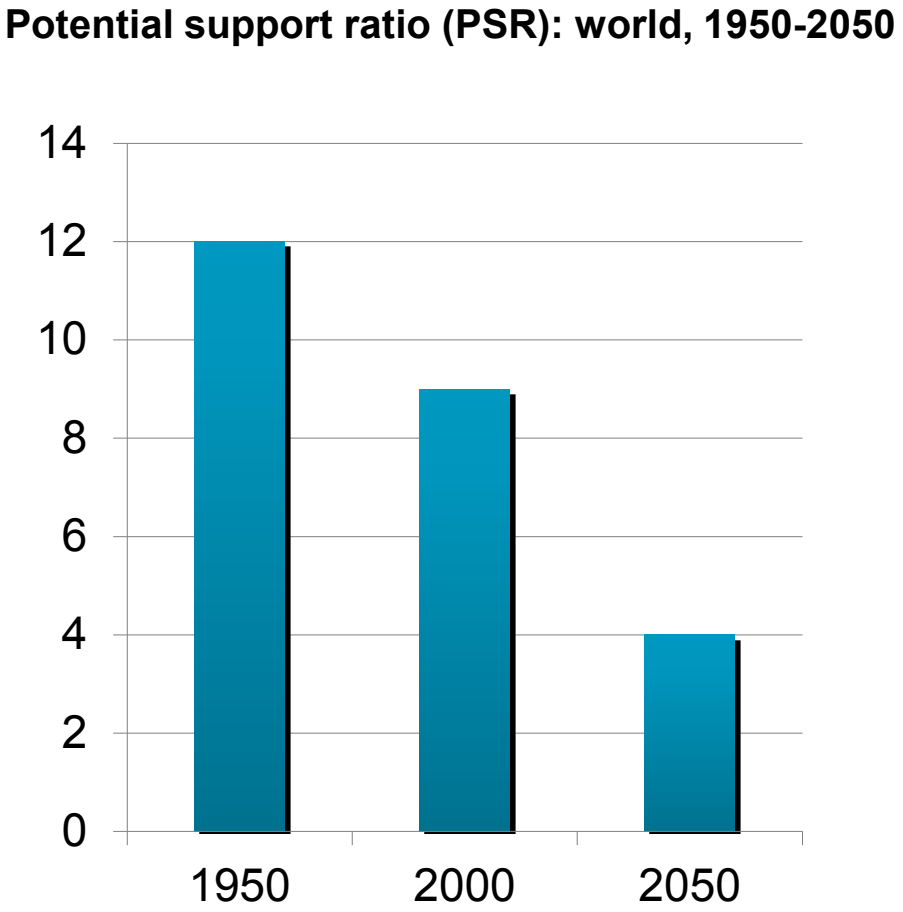
Ageing population – growing problem



Source: World Population Ageing 1950-2050, United Nations

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Food is running out of room

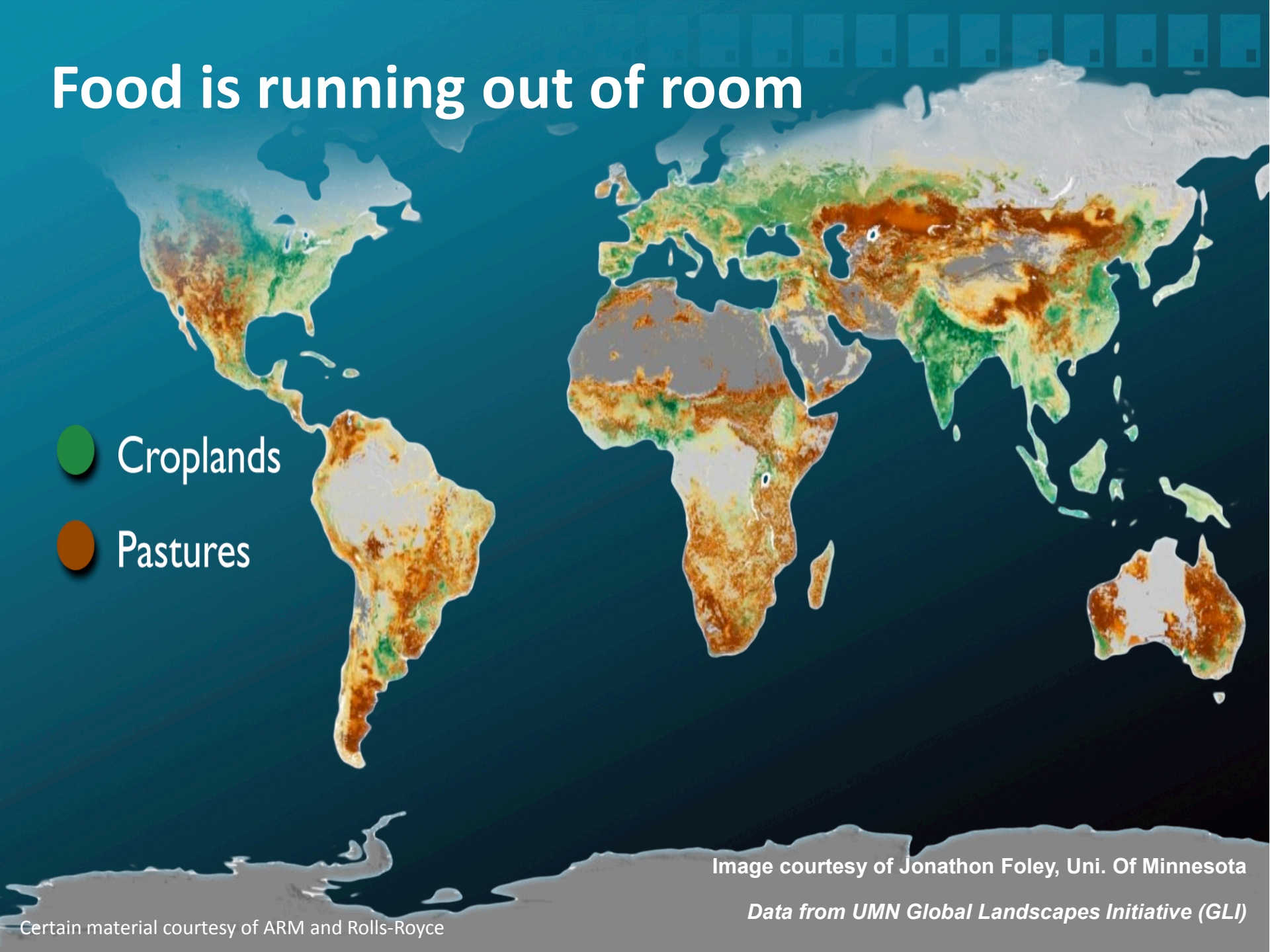

Image courtesy of Jonathon Foley, Uni. Of Minnesota

Data from UMN Global Landscapes Initiative (GLI)

Certain material courtesy of ARM and Rolls-Royce

Water is our rarest commodity

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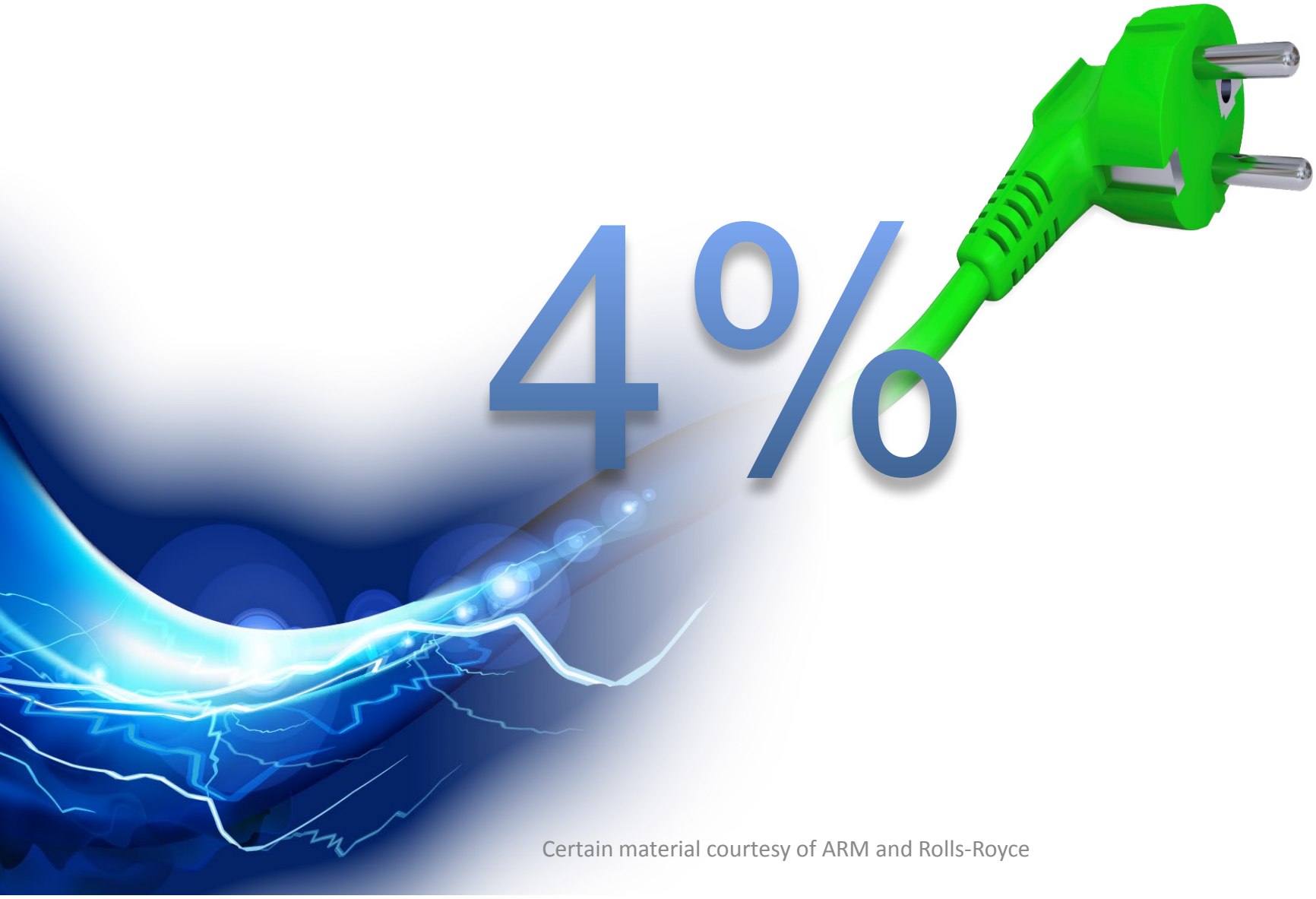
Energy – Cheaper to be efficient



Context

Health, Food, Water, Energy, Inequality

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Now is an exciting time for Engineering and Technology as we grapple with the big challenges flowing from global population growth.

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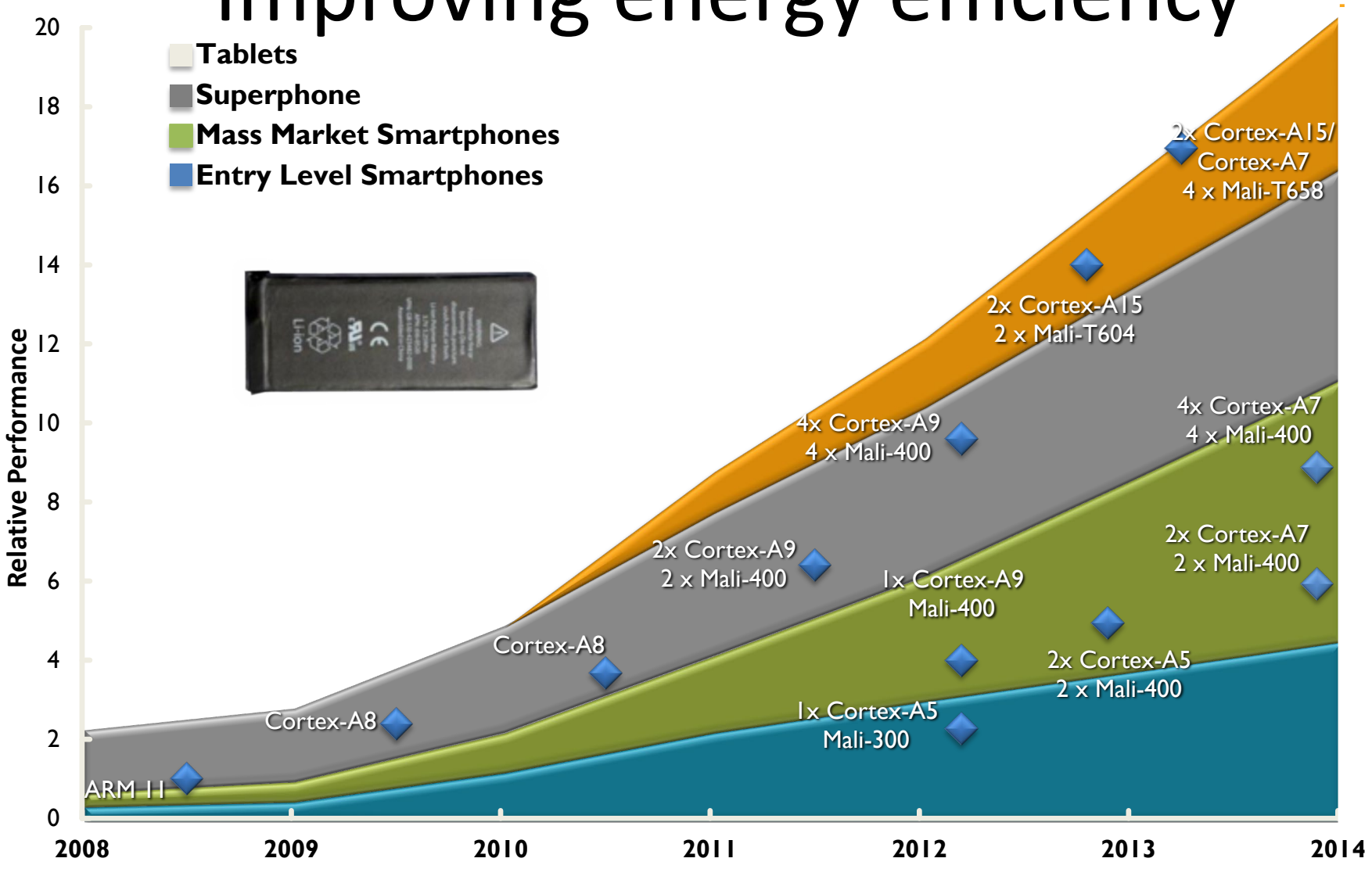
Improving energy efficiency



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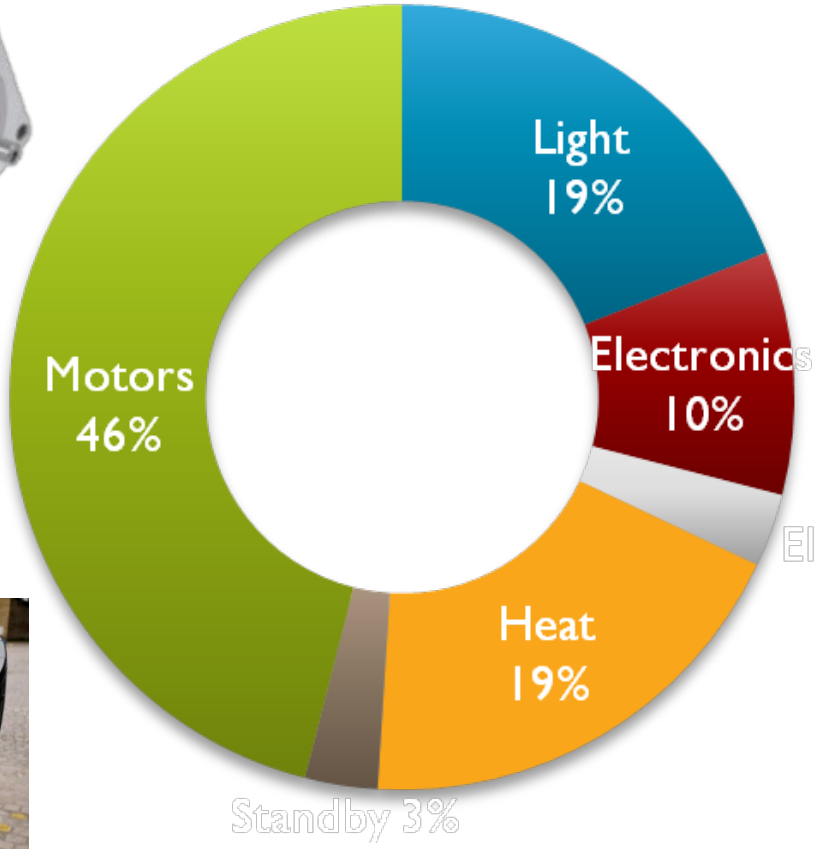
Smart Energy



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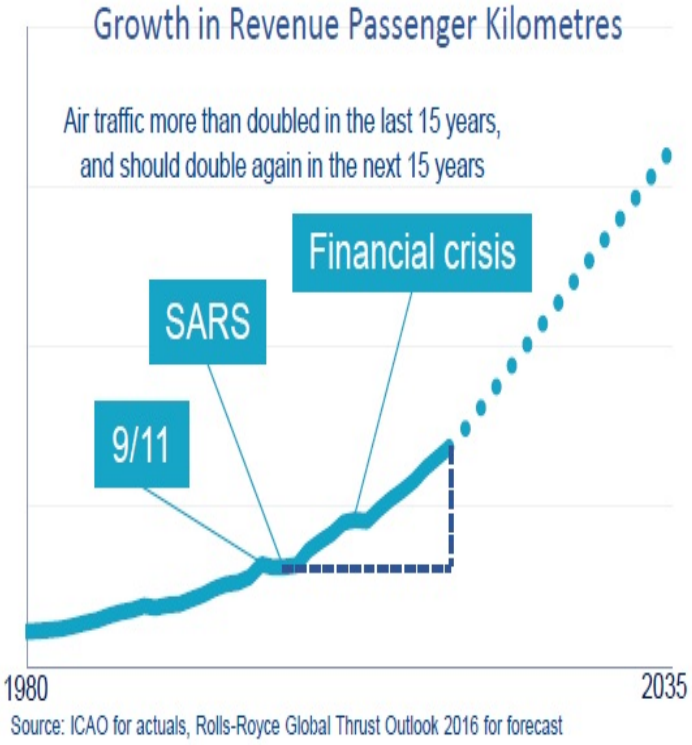
Energy again



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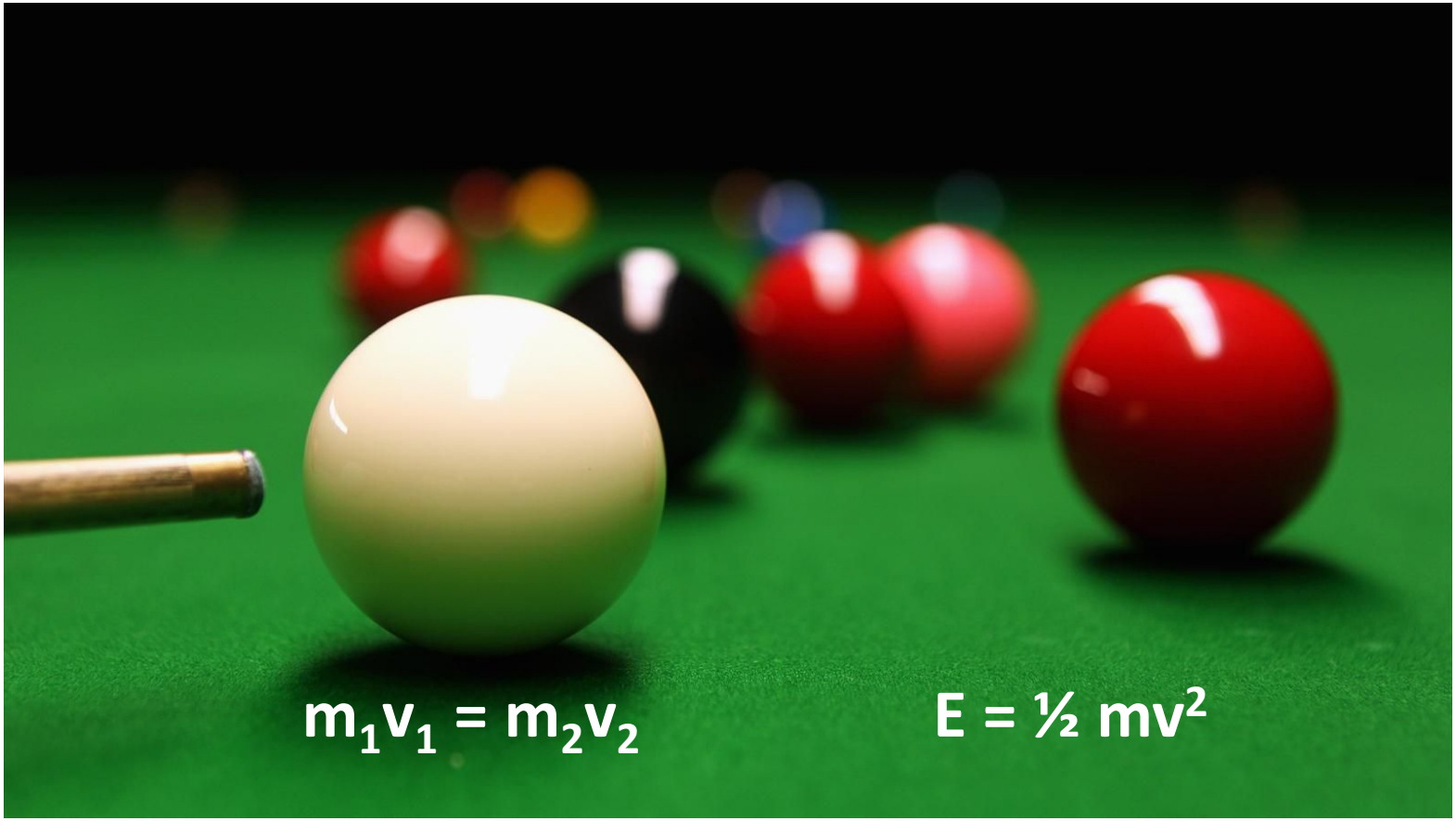
Efficient flying machines



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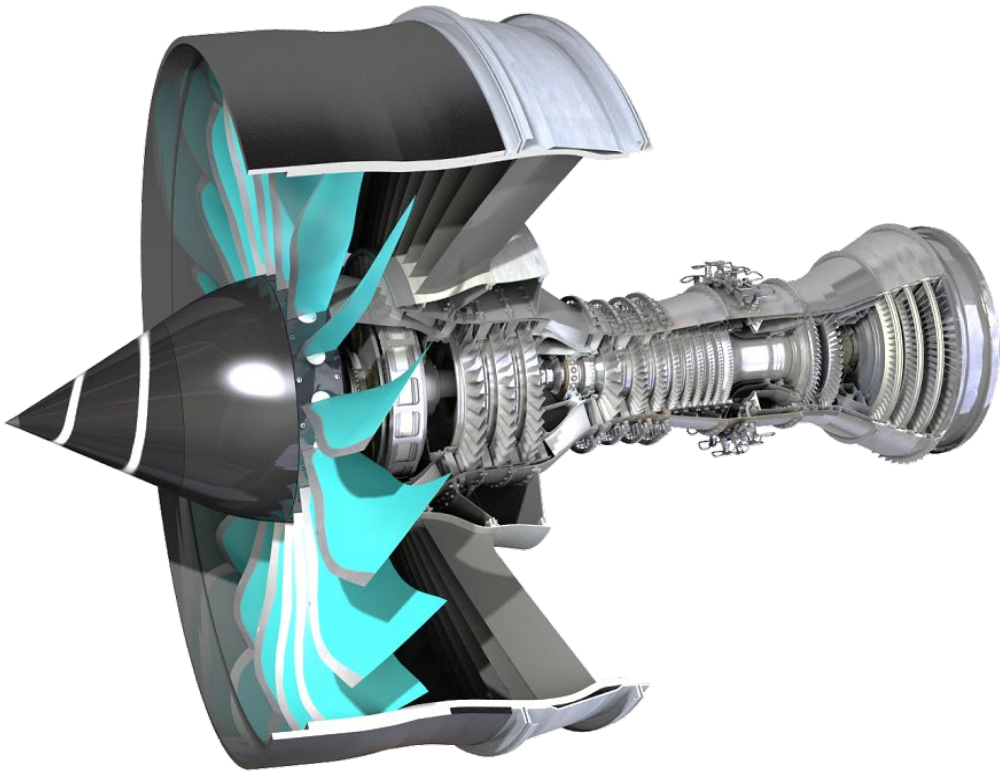
Efficient flying machines



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Regional Hybrid Electric Flight

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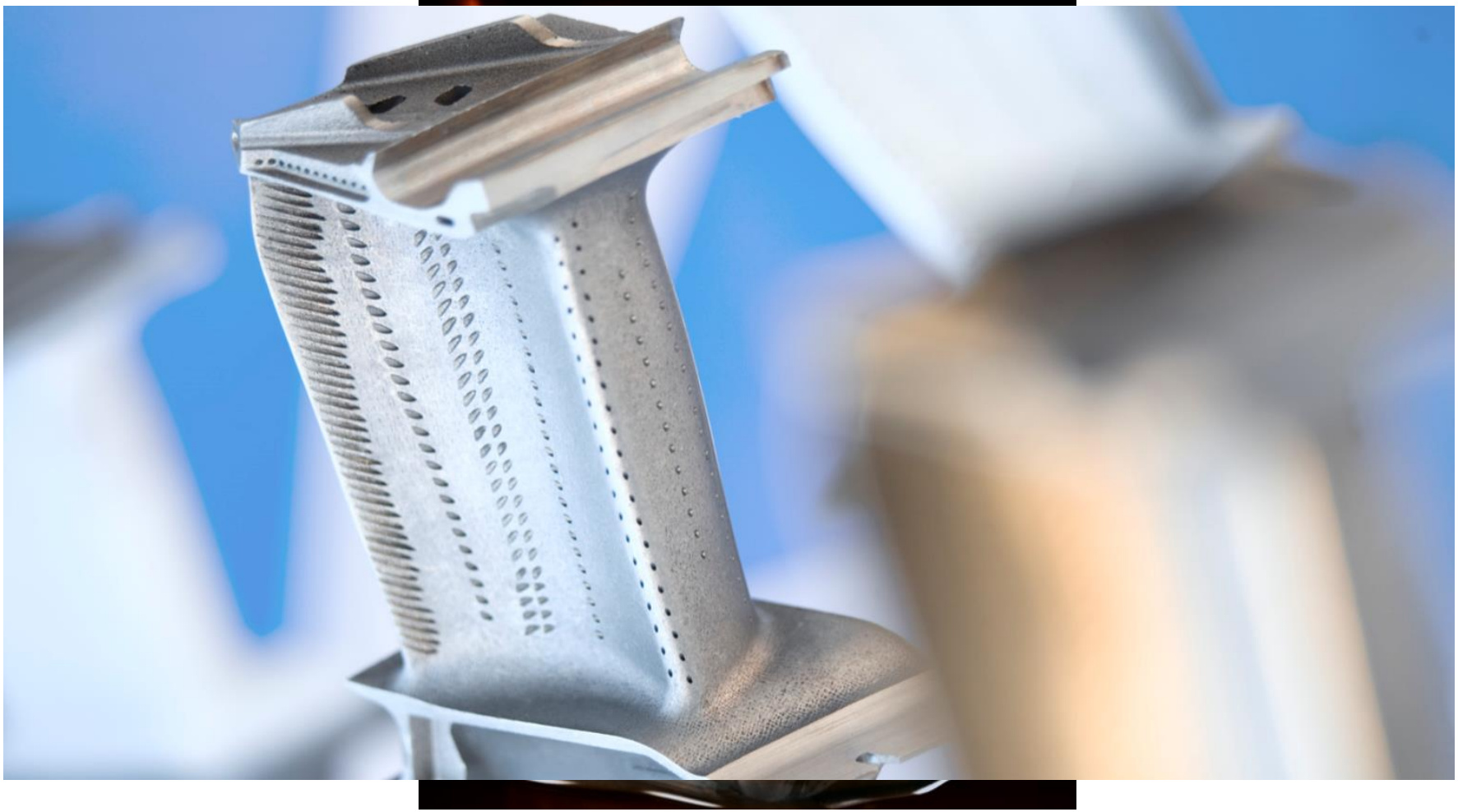
Our challenges require innovation



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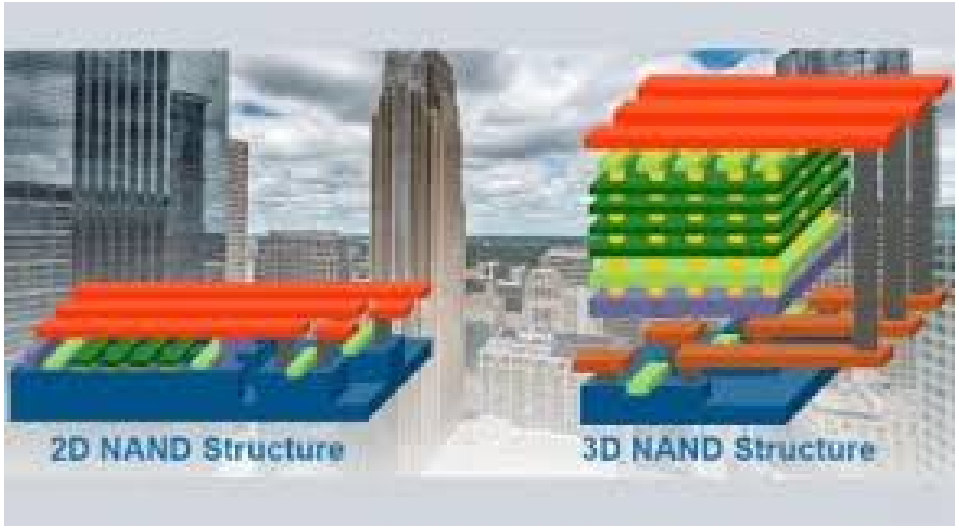
Our challenges require innovation

3D NAND



Engineers getting creative

Source: EE Times

Nature still the best engineer

2012

4.5 kCal 30g

255 kCal 49g

2018

6.5kCal 30g

255 kCal 49g

Certain material courtesy of ARM and Rolls-Royce

Not for the faint hearted

- 70M$ - initial estimate
- 1.3Bn – Development cost (~8Bn in 2018)
- 650M – production cost (20)
- 300M – sales and support revenue

Certain material courtesy of ARM and Rolls-Royce

Nor in semiconductor technology

Top 10 Semiconductor R&D Spenders
(Companies with ≥$1B in Spending)

2017 Rank	Company	R&D Exp ($M)	R&D/Sales (%)	17/16 % Chg in R&D
1	Intel	13,098	21.2%	3%
2	Qualcomm	3,450	20.2%	-4%
3	Broadcom*	3,423	19.2%	4%
4	Samsung	3,415	5.2%	19%
5	Toshiba	2,670	20.0%	-7%
6	TSMC	2,656	8.3%	20%
7	MediaTek*	1,881	24.0%	9%
8	Micron	1,802	7.5%	8%
9	Nvidia	1,797	19.1%	23%
10	SK Hynix	1,729	6.5%	14%
	Top 10 Total	35,921	13.0%	6%

Source: Company reports, IC Insights' *Strategic Reviews* database
*Sales and R&D spending of acquired semiconductor supplier are included.

Total ~60Bn

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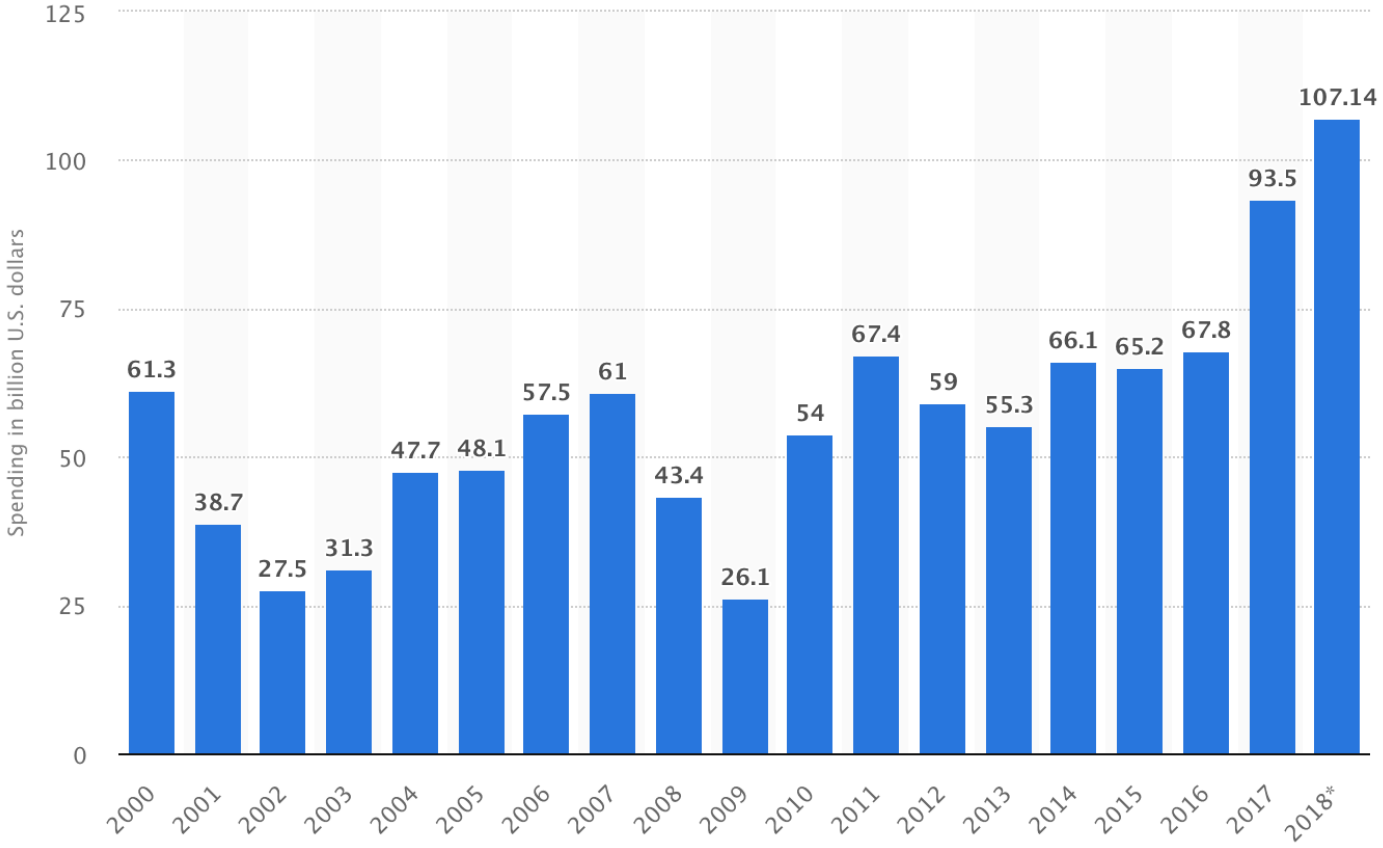
WW Semiconductor capex



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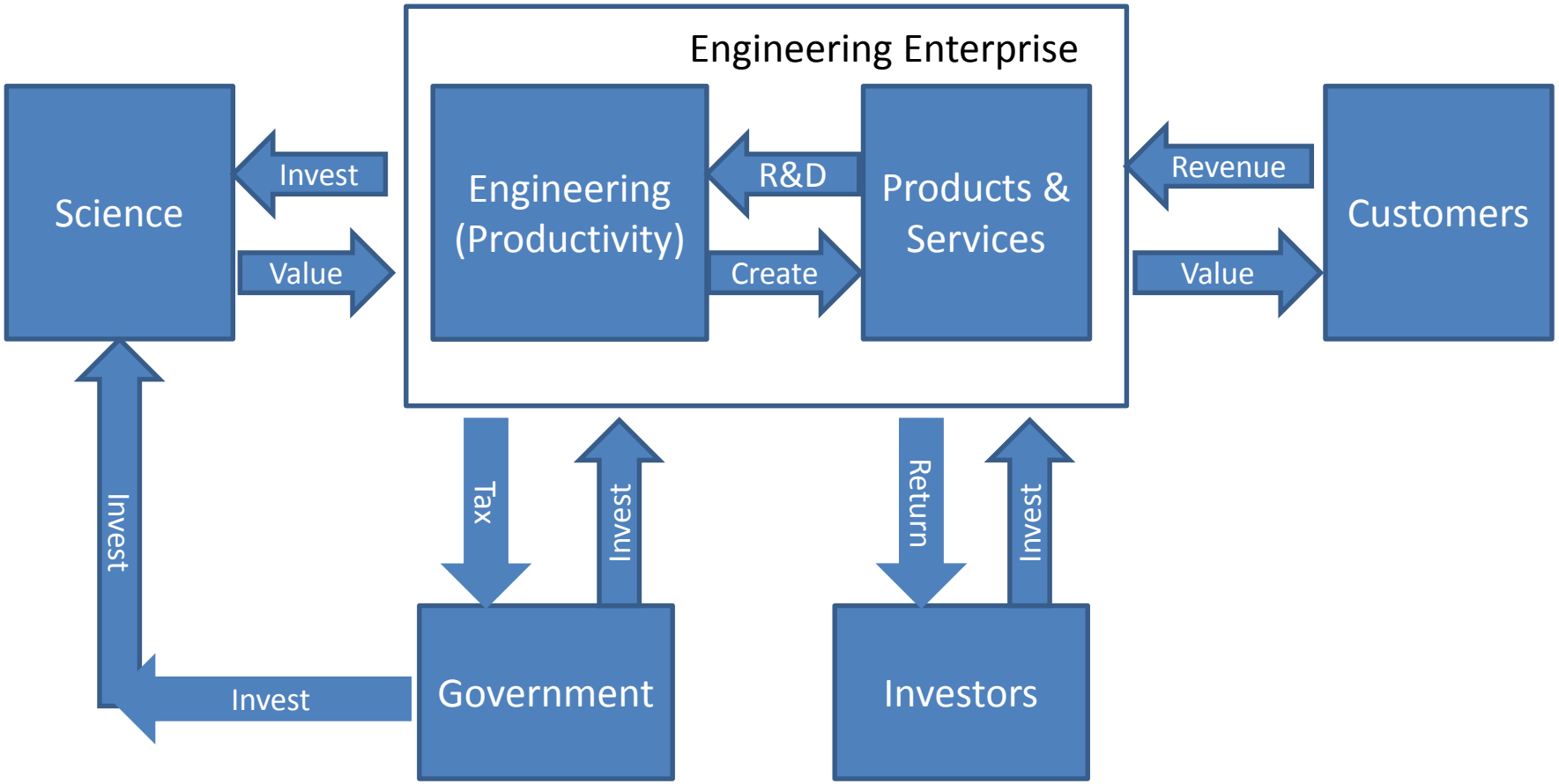
Why business?



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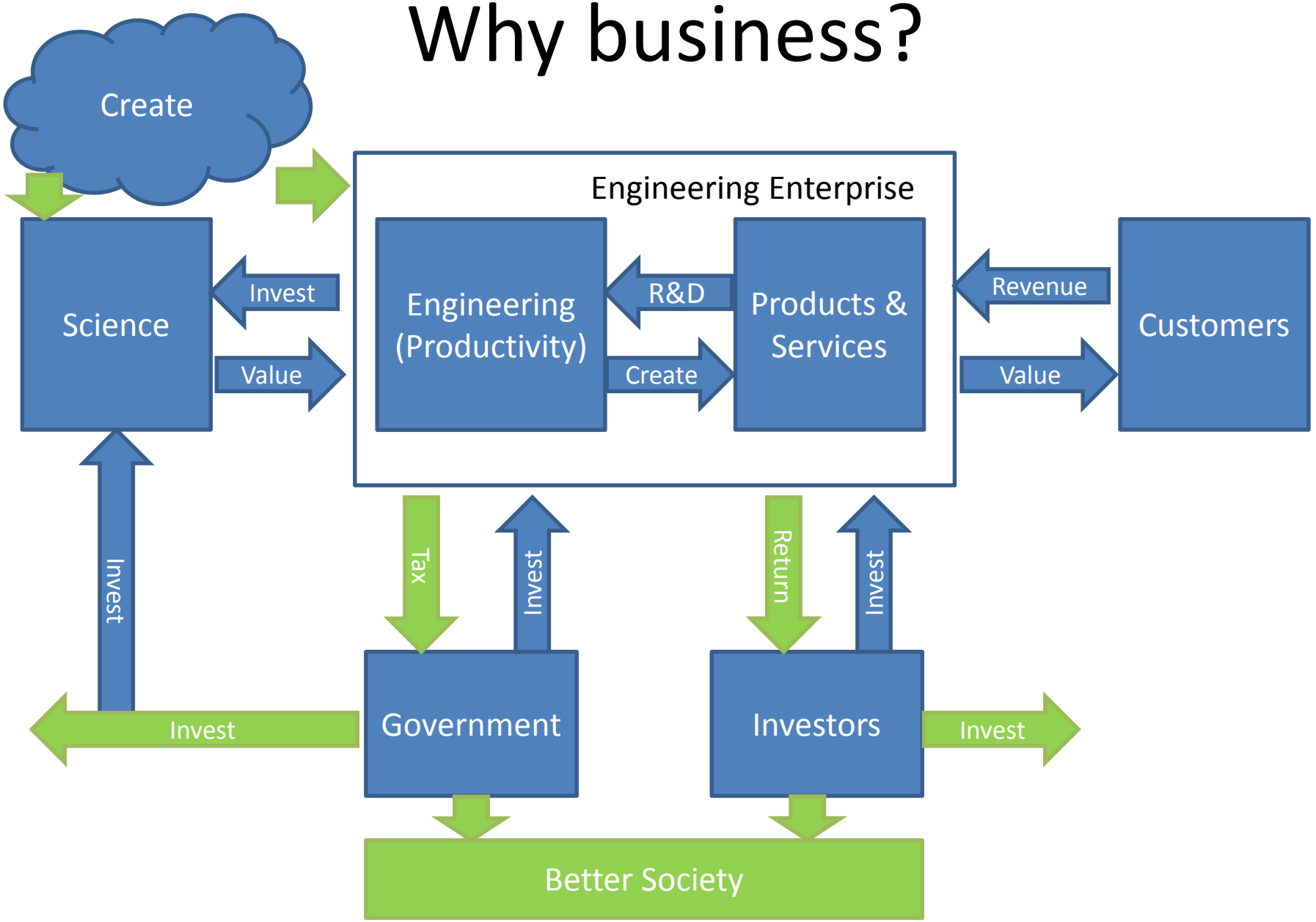
Why business?



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Excellent Engineering

Must provide excellent solutions

Must ALSO make sound business sense

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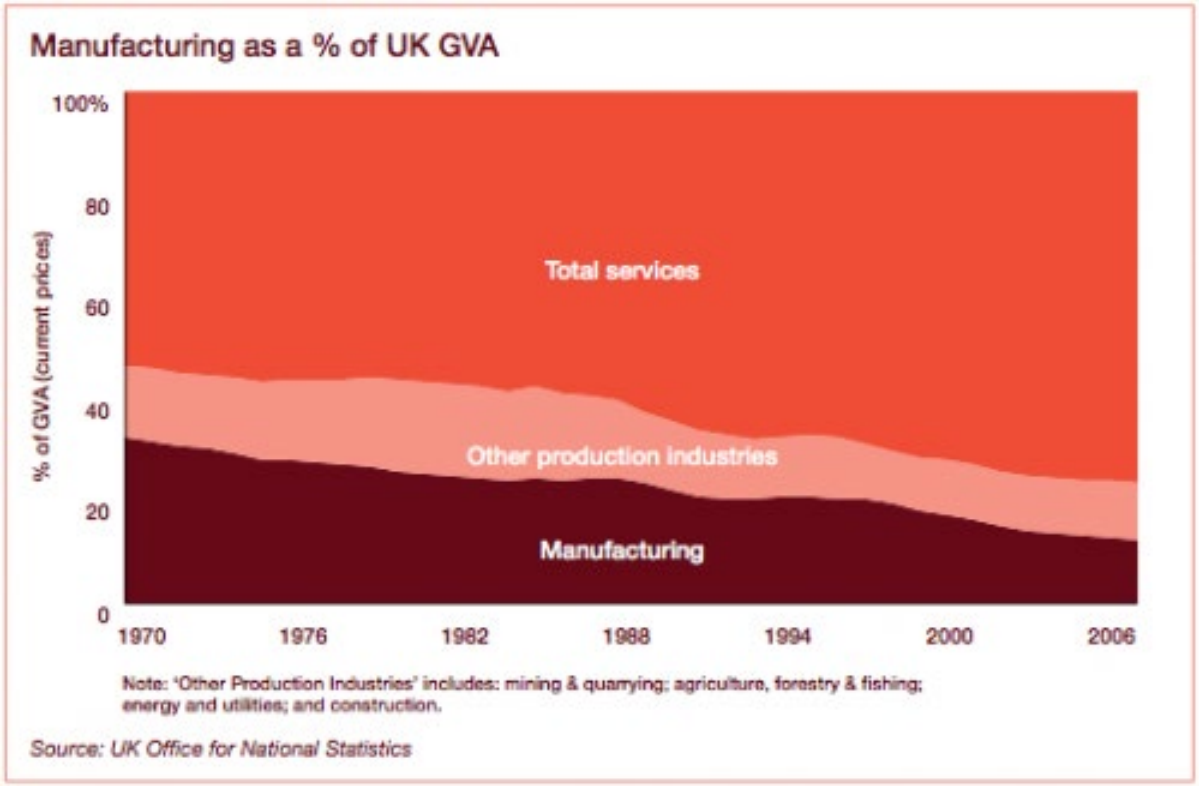
UK Manufacturing



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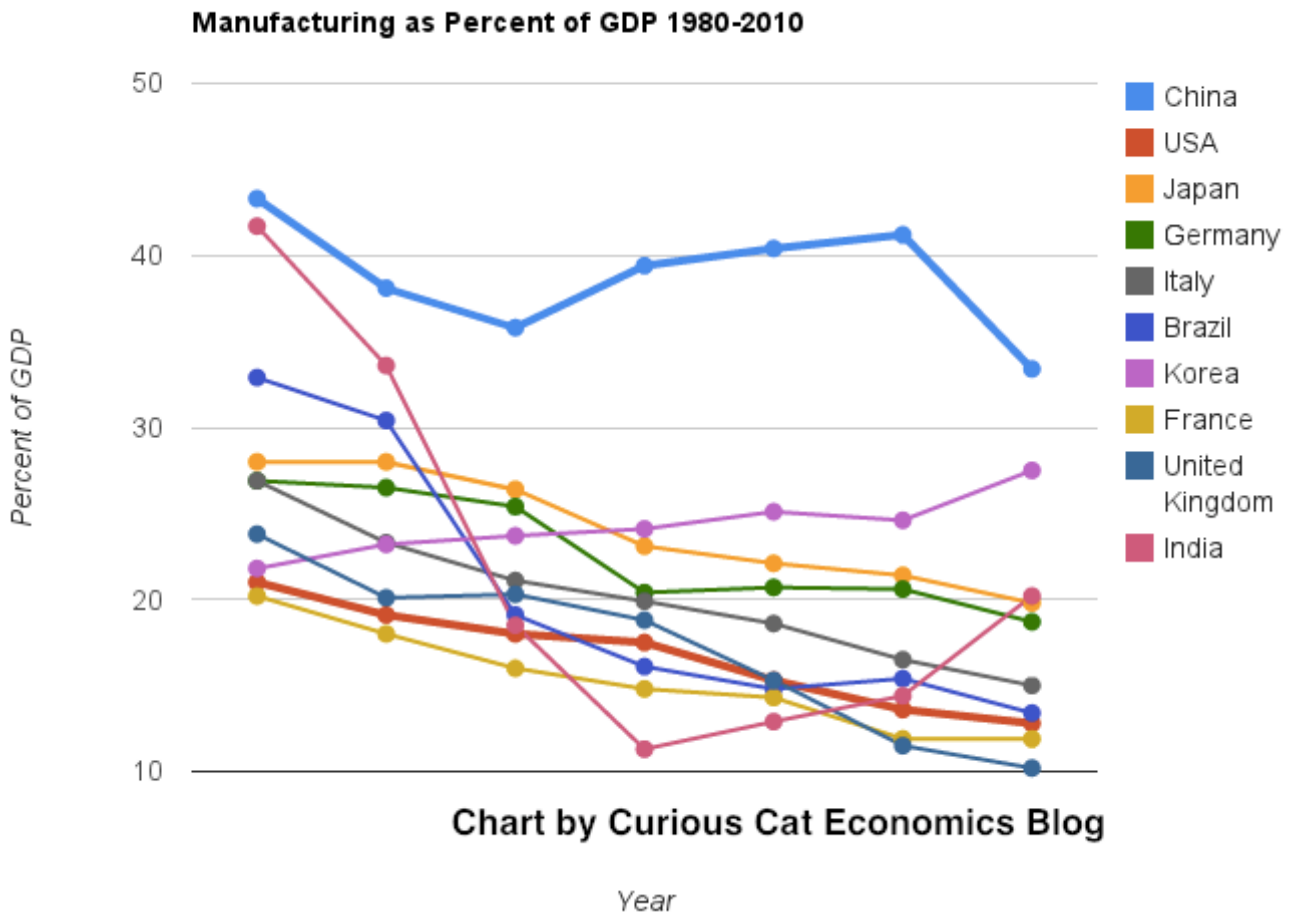
Manufacturing by country



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Manufacturing is and will continue to be a crucial component of the UK economy

Economic Capital

- **Absolute value**: over 10% contribution to GDP
- **Exports**: account for over 50% of UK exports
- **R&D**: over 75% of UK business R&D spend
- **Productivity**: consistently out performing overall UK productivity
- **Jobs**: high skilled and well paid
- **Resilience**: provides economic resilience

Social Capital

- **National pride:** national strengths reinforced by iconic brands
- **National sovereignty**: independence and security of supply in a changing world
- **Quality of life**: relieves people from mundane jobs
- **Innovation:** powerful driver and technology spill-overs

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The impact and value of Manufacturing Technology however has increased substantially over the last three decade e.g. Machining

Autonomous & Hybrids

- Autonomous operation
- Hybrid (e.g. additive/subtractive)
- Cloud knowledge sharing
- Real-time value-chain optimsation

Automated & Adaptive

- Fully adaptive 3D process
- In-cycle verification
- Digital sensing & control
- Fully enclosed & interlocked

Numerical Control

- Numerical 2.5D control
- Off-machine digital measurement
- Basic data for control charts
- Partially enclosed process

Manual

- Manual machine operation
- Manual measurement
- No data collection
- Poor HS&E

x10 plus

- Speed
- Lead time
- Capability
- Safety
- Reliability

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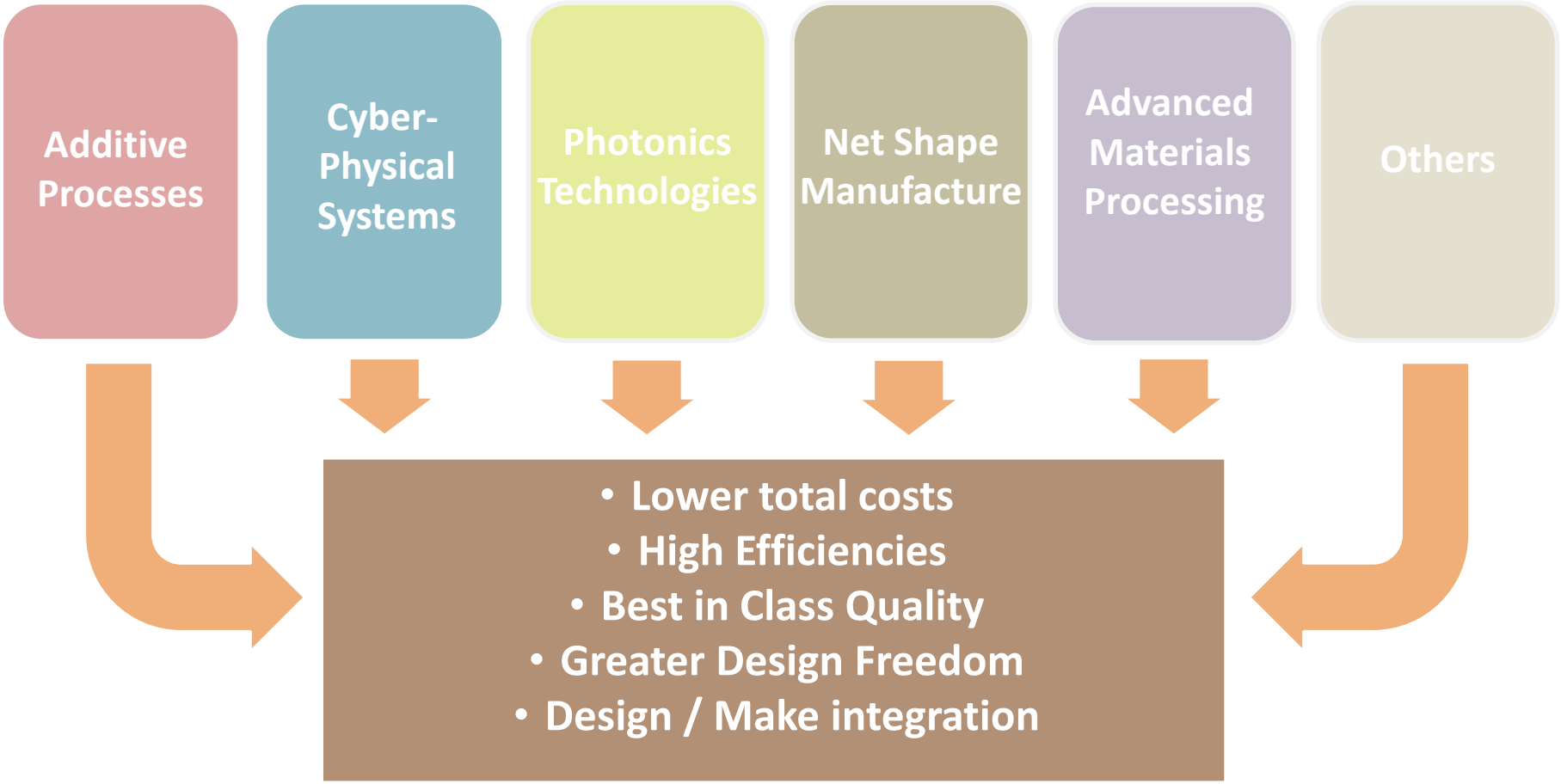
This combination of Modern Manufacturing Engineering & disruptive technologies offer unique capabilities for addressing historic weaknesses & future challenges



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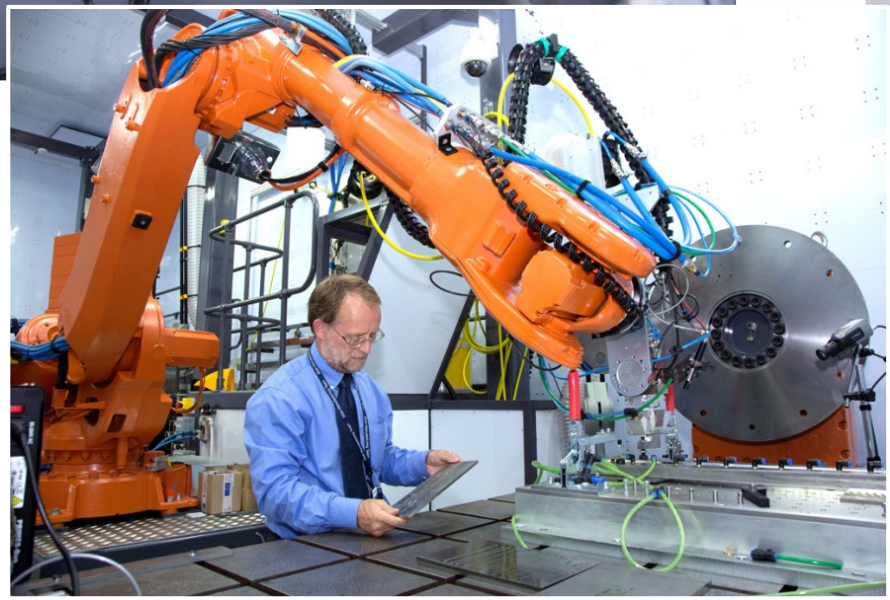
New Manufacturing Technologies – Photonics

Laser & structures light based processes



- **Laser Drilling & Welding**
- **Automated Visual Inspection**
- **Non-contact verification**

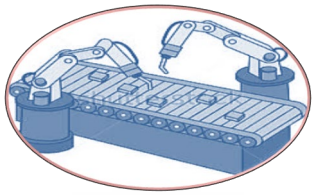
…..high capability & productivity

Certain material courtesy of ARM and Rolls-Royce

Looking ahead – Digital integration of intelligent machines, advanced materials, advanced processes, fast analytics & artificial intelligence

Advanced Material Systems

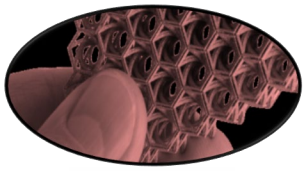
- Ceramic & Metalic Matrix Composites
- 3D Organic Composites
- Hybrid Material Systems
- Intermetallics
- Nano Coatings & Additives



Cyber-Physical Systems

- Mechatronics & Robotics
- Augmented Reality
- Collaborative Robotics
- Intelligent Automation
- Autonomous Processes
- Self monitoring & healing

And there is a lot more to come



Advanced Processes

- Additive Layer Techniques
- Laser Processing
- Powder Consolidation
- Electro-Chemical Processing
- Radiation & Ultrasonics

Knowledge Based Systems

- Big Data & data analytics
- Internet of everything
- Virtual Reality & Simulation
- Genetic algorithms & Neural Networks
- Knowledge communities
- Cyber Security

Certain material courtesy of ARM and Rolls-Royce

The Future of Manufacturing

An integrated Manufacturing Value Chain

Integrated Design & Manufacturing, Technology Integration, Digitisation, Modern Skills, Leadership Ambition and an Innovative Culture

Additive Processes

Cyber-Physical Systems

Photonics Technologies

Net Shape Manufacture

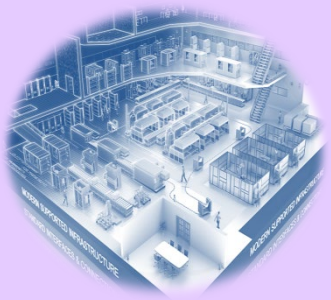
Advanced Materials Processing

Others

Digital Design & Manufacturing

Engineering & Technology Integration

Leadership & Digital Engineering Skills



Future Manufacturing Value Chains

£

Certain material courtesy of ARM and Rolls-Royce

Changes

- Increasingly global marketplace
- Comparative advantage is moving from labour cost to Innovation
- Integration and partnership are key
- It’s increasingly about behaviour
- Technology, Business, and Culture, bound together
- Levelling of the playing field is just that

Certain material courtesy of ARM and Rolls-Royce

Oxford ranked first in world for Computer Science and Engineering

PUBLISHED
30 NOV 2018

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RESEARCH SCIENCE UNIVERSITY

The University of Oxford has become the first UK institution to top the *Times Higher Education* Computer Science and Engineering and Technology global subject rankings.

Oxford overtook three US universities known for their strength in technology to lead the two tables.

Certain material courtesy of ARM and Rolls-Royce

World Universities

Times Higher Education ranking 2018

1. Oxford
2. Cambridge
3. Stanford
4. MIT
5. Caltech

4 in top 20, 5 in top 25 universities

Business schools similar story

Share of world GDP 2.5%

Share of world population 1%

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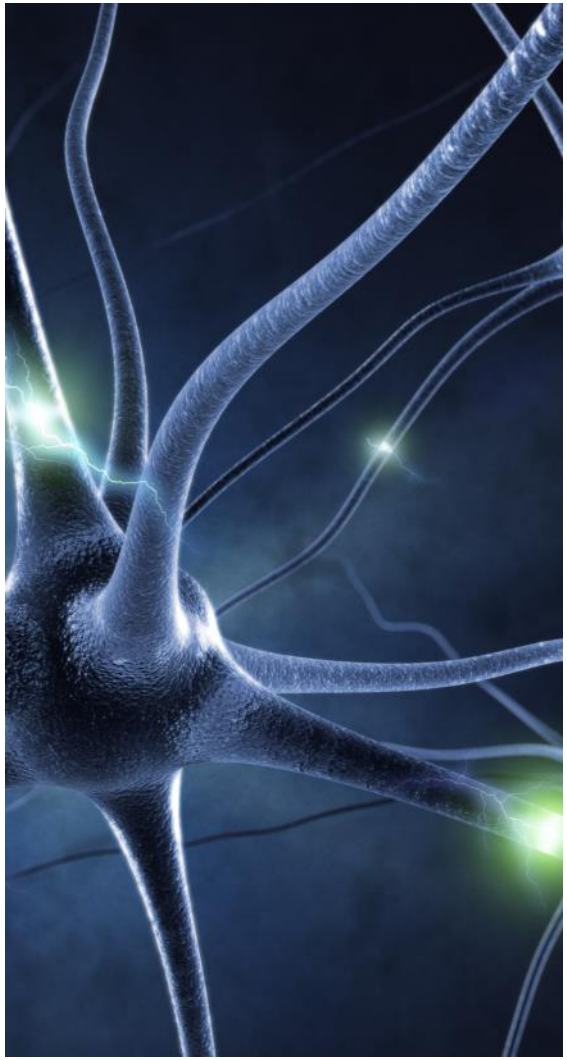
Successful engineering and technology companies….



- Move us up the value chain
- Advance manufacturing capability
- Attract inward investment
- Create supply chains
- Nurture transferable skills
- Boost local economies
- Provide well paid jobs for young people

Certain material courtesy of ARM and Rolls-Royce

Summary

- We have big global challenges ahead: Health, Food & Water, Energy, Poverty & Inequality
- Nature remains the world's best Engineer, sets the bar
- Science & Academic sector feeds Engineering & Industry
- Wealth generation enables Science & Engineering to deliver more than direct benefits to society
- Great Engineering must make Economic sense
- UK punches above its weight in Science and Technology
- As technology transforms manufacturing there is a playing field levelling opportunity

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