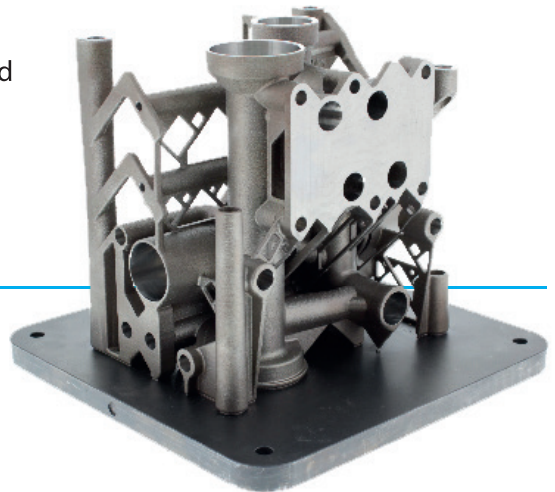

Future State Workshop of UK Advanced Machinery Manufacturers

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Images courtesy of industrial participants.

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Executive summary



The majority of accurately manufactured goods – used in almost every imaginable application for everyday living – are produced by high-technology, advanced computer numeric controlled (CNC) machinery. Such machines are generally classed as CNC Machine Tools, and they provide the foundations upon which an advanced manufacturing sector is built.

Modern CNC machine tools are typified by highly sophisticated computer-controlled systems; with increasing levels of built-in “intelligence and automation”, they provide the critical production processes used to make all manner of present-day products. Without advanced CNC machine tools, there would be no planes, trains or automobiles, ships, MRI scanners, computers, mobile phones, satellites or televisions, and no robots to assemble these products.

The global advanced machinery sector is valued at ~£125 Billion. Significant producers are Germany, Japan, China, Korea, Switzerland, and Italy. The UK holds 0.5% of the global market. Digitisation in manufacturing will be a disruptive force presenting this sector with both opportunities and risks. To a great extent the sector remains aligned to high cost countries.

With this in mind a group of senior representatives from the UK Advanced Machinery sector met for a ‘futures workshop’ on the 15th November 2017. They reviewed the Industrial Digitisation “Made Smarter” report and considered actions necessary for the UK advanced machinery sector to grow and prosper. This short report captures the challenges, opportunities and recommendations that were raised.

The three headline opportunities considered as being realistic within 10 years are:

- **Grow by 4-fold the UK Advanced Machinery sector to £2 billion pa creating 20,000 jobs (Target would bring the UK to the same level as Switzerland)**
- **Stimulate UK advanced CNC control systems manufacturing to £1 billion pa creating 5,000 jobs**
- **Stimulate UK industrial robots manufacturing to £1 billion pa creating 5,000 jobs**

Delivering on the above would yield a significant bolstering of the UK’s manufacturing supply chain during a sustained period of increased digitisation in manufacturing. Indirectly this achievement would lead to a significant improvement in productivity levels of our blue chip companies and larger SMEs and indeed improve our balance of trade by approximately £6 billion.

Three key recommendations were proposed:

1. **Establish a UK Advanced Machinery Institute with a clear agenda to support growth of the UK advanced machinery sector. Anticipated cost of £50m over 10 years.**
2. **Operate a targeted ‘business-to-business’ innovation programme for UK advanced machinery and automation (robot) manufacturers with blue chip companies. Set unambiguous emphasis on productivity growth from new digitally enabled production machinery. Anticipated cost of £100m over 10 years.**
3. **Encourage development and adoption of UK Advanced Machinery within existing UKRI funded programmes and centres. This recommendation needs only a redirection emphasis from UKRI for it to start.**

Advanced machinery manufacturing in the UK

Functional components of most high value products, whether they be cars, aeroplanes, trains, white goods, power stations, heating systems, electrical devices, white goods, etc. are produced using advanced computer controlled digital machinery (CNC machine tools). Almost every manufactured product we come into contact with is produced by advanced machinery.

The Advanced Machinery sector represents some of the highest technologies that are applied in manufacturing. Machinery products are highly sophisticated high performance, computer controlled systems having advanced motion control and process monitoring that frequently incorporates in-situ robotic systems, advanced sensors and in-built knowledge based systems. These machines form the backbone today's production systems of modern manufacturing.

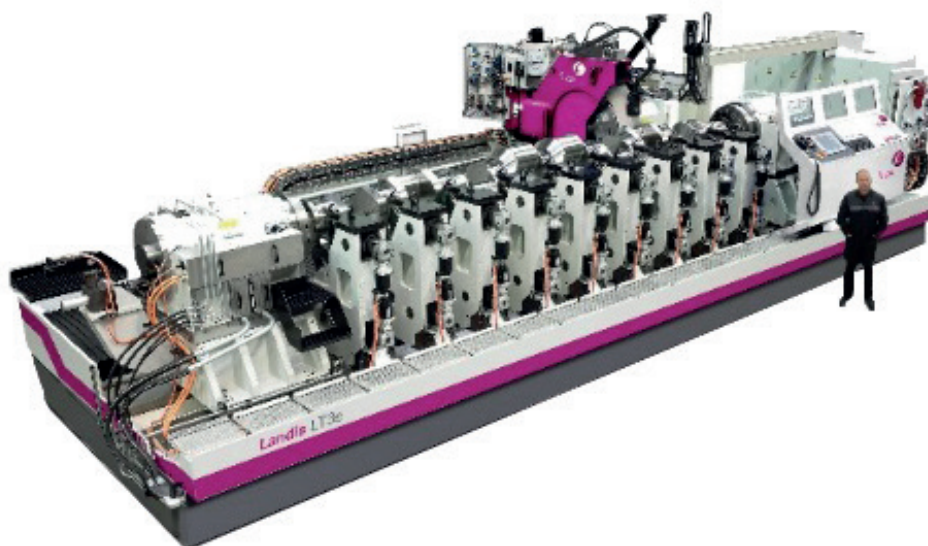
Advanced machinery is one of the major capital investments of a modern manufacturing company. It represents a +10 year commitment towards improved productivity in manufacturing. Leading edge advanced machinery is a "key enabling technology" of modern manufacturing and as such it is pivotal in gaining internationally leading levels of productivity.

Globally the advanced machinery sector is valued at over £125 billion pa. The major manufacturers stem from high wage economies. Today the UK produces approximately 0.5% of global output. This figure has been substantially higher, ~2% in 1985, and our share of the world's advanced machinery market has reduced in step with a sustained period of declining investment and national focus.

However, the UK remains home to some extremely successful leading brand, advanced machinery companies. They succeed through outstanding innovation, insightful investment and early adoption of rapidly-advancing, computer-based digital systems, and by focusing on niche market segments where technical prowess, agility and deep understanding are essential to overcome international competition.

UK successes in the advanced machinery have been achieved by overcoming elements of in-built disadvantage due to UK skills shortages, limitations of local supply chains and limited – historically - support from UK government and the research and innovation community.

Given the importance of advanced machinery and its significance on productivity, reversing the declining trend of UK Advanced Machinery manufacture is considered an important national need. Acknowledging the sector challenges and addressing them through a co-ordinated national initiative is proposed.



Recognising UK successes

It is important to appreciate that the UK is home to highly successful companies that demonstrate significant growth in the Advanced Machinery sector. Two examples illustrate that the opportunities outlined in this document are attainable and realistic.

RENISHAW 
apply innovation™

Renishaw is a ~ £0.5 Billion pa company with approximately 95% export business level. Renishaw have established a world leading position in metrology systems manufacturing over many years. Their metrology, machine and robotic products are of high value creating significant high wage employment and shareholder value. Renishaw's products are complex mechanical-electrical- electronic based systems that employ many of the key enabling technologies of future digital advanced machinery systems. Renishaw's R&D capacity is exclusively based in the UK and Ireland.

Renishaw have tremendous growth and wealth generation credentials, and they also demonstrate that precision machinery including additive manufacturing technologies can be cost-effectively produced in the UK.

Mazak
Your Partner for Innovation

Mazak UK is a Japanese-owned machine tool company whose European production facilities are in Worcester. It is a thriving business of £0.34 Billion pa having well-established production and assembly capacity and a growing in-house design and technology centre. Impressively, Mazak UK competitively manufactures "mainstream" machine tool products and they have secured future skills through a well-established and comprehensive engineering apprentice training programme.



Challenges of the UK Advanced Machinery sector

Perhaps most significant of all is the misguided general public perception of the Advanced Machinery sector. The consensus of the Workshop team was that the public's perception is not aligned with the advanced technology so clearly obvious from the UK-produced machine systems illustrated throughout this document.

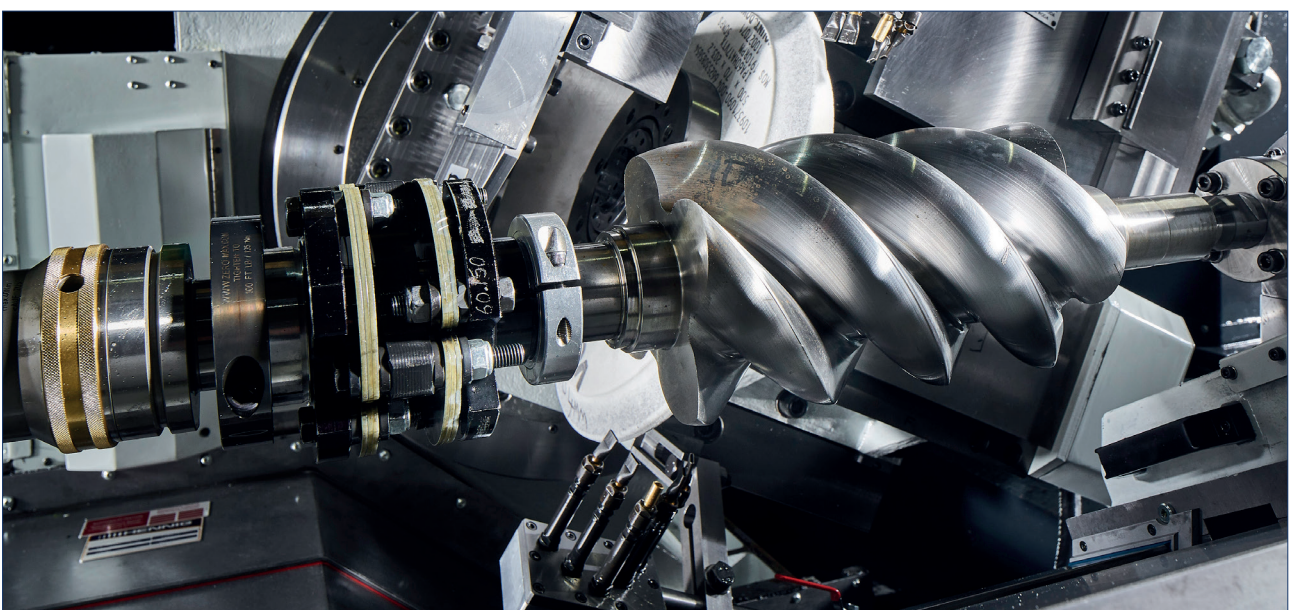
Advanced CNC machine tools are high complexity precision mechatronic (mechanical – electrical – electronic-optical) systems. CNC machinery will be pivotal in the application of artificial intelligence and adaptable automation; these are key aspects of increased digitisation in manufacturing. Advanced Machinery is also a mechanism to unlock the industrial potential of new materials (e.g. graphene, composites) and product enhancements made possible by function integration / component miniaturisation.

Growing the UK Advanced Machinery sector demands a comprehensive manufacturing supply chain from research, new technology proving, precision component manufacture, machinery production and optimisation. This represents a significant challenge as there is presently a lack of adoption of UK produced Advanced Machinery within the UK Innovation centres. This issue is worrying as growth of innovation programmes tends to disadvantage UK machinery manufacturers as machinery and robot selection is often based on "Blue Chips" immediate priorities and suppliers. Compounding this issue is a similar lack of development of UK machinery within the UK's research (university) community. Here it appears the format of EPSRC programmes (Calls) and associated purchasing practices hinder incorporation and joint development with UK machinery companies.

From the UK's Advanced Machinery sector point of view the UK's research and innovation landscape is ill-tuned to their needs. It is this situation has resulted in successful UK Advanced Machinery manufacturers finding niche markets where their own concentrated R&D efforts yield business advantage.

The UK Research and Innovation support for advanced machinery is in stark contrast to that in Germany and Japan where national programmes have been long-established. It is noteworthy that these countries' own research and innovation centres most often employ only domestic produced machinery.

Now at a time of potential disruption from increased digitisation there is no UK Research or Innovation Institute aligned to the needs of the UK's Advanced Machinery sector.





Digitisation of manufacturing will raise the importance of control systems, sensors, robots and AI. Control systems for advanced machines, so-called CNC's (computer numerical controllers), can be considered the brains operating manufacturing infrastructure. CNC systems are pivotal in the effective adoption of the Digital Revolution in manufacturing. Today's CNC systems are predominantly of German and Japanese origin.

Recognising the pivotal role of CNC in Digital Manufacturing the US and China have both established significant research, innovation and industrial development programmes in intelligent CNC control. The UK has no such national programme.

Today UK Advanced Machinery manufacturers create their core control competence in software and employ German and Japanese control system hardware. It is considered that this encrypted software approach for securing "key competence" will be challenged as digitisation in manufacturing gains pace.

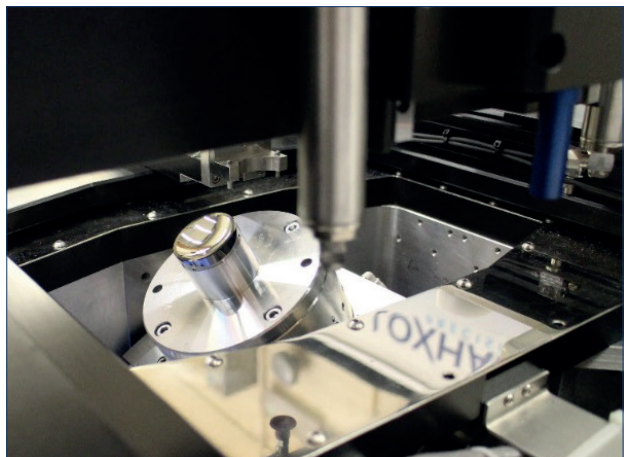
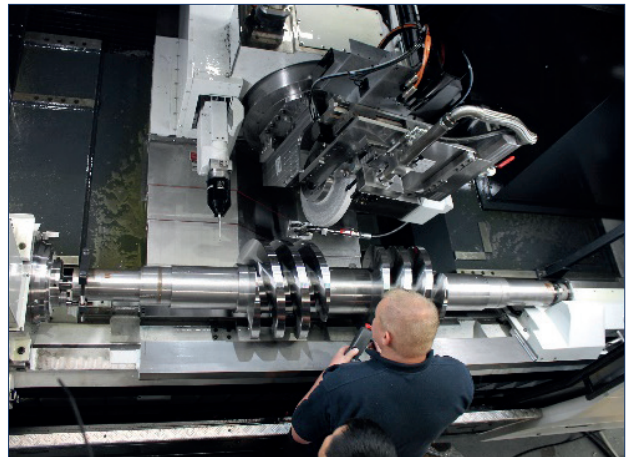
The benefits of digitisation of manufacturing are considered to be closely tied to automation of processes. In high value production this is often linked to robotics and advanced machinery seamlessly operating through advanced CNC's. Industrial robots are becoming more sophisticated – although they have remained operational specific systems for many years. Industrial robots have surprisingly simple electro-mechanical complexity but this is about to change. Today's leading industrial robot manufacturers are Japanese, German and Swiss-Swedish. Niche market robots are being produced in the UK. For example, Renishaw produce medical sector robot systems. There is however no UK industrial robot manufacturer and no obvious stimulus for that to come about.

Much of the UK's Research and Innovation (UKRI) manufacturing activities are directed (often indirectly) by leading blue chip manufacturing companies. UKRI projects often perform important applications engineering developments employing incumbent foreign advanced machinery and robot manufacturers' products. Whilst recognising the value of these programmes for the end-user they hamper UK based production of advanced industrial machinery and robotics. Unaddressed it is considered this situation has far-reaching consequences for UK wealth growth from manufacturing in the face of increased digitisation and automation.

Engaging the brightest individuals into engineering is a difficult task for the UK. For medium sized companies typified by the Advanced Machinery sector this is a major challenge. UK children's education in engineering is lacking, with poor co-ordination, zero exposure to advanced manufacturing technology and with limited imagination as to how to enthuse youngsters into the profession. This problem is very much recognised by many of the prominent professional engineering institutions. However, although well recognised there is no single authority appointed to deal with the issue. There are many excellent ideas but they seem to "come and go", with no formal national programme to enthuse youngsters into Engineering.

Opportunities

- Support growth of the UK Advanced Machinery sector (from 0.5 to 2 % of Global sales within 10 years)
- Stimulate a UK CNC control system manufacturing capacity
- Stimulate a UK industrial robot manufacturing capacity
- Stimulate broadening of UK advanced machinery manufacturing beyond the strong niches
- Stimulate UK machinery development and adoption within UKRI programmes
- Stimulate UK machinery manufacture for post additive manufacturing processing
- Stimulate UK Machinery manufacture to align with electrification of transport
- Stimulate fun / rewarding engineering educational experiences for 10 - 12 year olds using small scale CNC machinery, e.g. Watch It Made



Recommendations

1

Establish a UK Advanced Machinery Institute with a clear agenda to grow the size of the UK advanced machinery sector within 10 years. Possibly establishing this institute under the auspices of Innovate UK it would be responsible for sector innovation and its adoption of next generation digital technologies for a thriving UK Advanced Machinery sector. This institute should address critical UK weaknesses in advanced machinery and broaden beyond its present niche market focus. It should also establish a sector skills development programme.

2

Create a targeted 'business-to-business' programme for UK advanced machinery and automation manufacturers. Set clear and unambiguous emphasis on innovation to drive productivity growth from new digitally aligned machinery. This B2B programme should build on Innovate UK's previous Advanced Manufacturing Supply Chain (AMSCI) Initiative which was singled out as being helpful to the Advanced Machinery sector. This programme should help prepare the UK's Advanced Machinery sector for the significant changes that new legislation may bring about, for example the electrification of transport and demise of the internal combustion engine.

3

Convene a group of industrialists and academics and form an Initiative task force actioned to undertake feasibility studies into the development of a UK industrial robot manufacturing capacity.

4

Encourage the development and adoption of UK Advanced Machinery by existing and established resources – including the Catapult centres and recently created EPSRC Manufacturing Hubs. Provide an adoption metric indicator for the UK's Research and Innovation manufacturing centres to stimulate more engagement with the UK's Advanced Machinery sector.

5

Provide support for the UK's Advanced Machinery manufacturers, possibly through the Manufacturing Technologies Association (MTA) and National Physical Laboratory, to help with the international promotion of UK produced machinery, overseas regulation compliance and new standards adoption.

APPENDIX 1 UK Machinery Manufacturing (SWOT)

Strengths

- Vast experience with significant innovation capacity
- Agility and flexibility
- Cost effectiveness
- Excellence in specific areas:
 - lasers, metrology, additive manufacturing, high precision, complex geometry, air bearings, ultra-precision, inkjet printing
- Unrivalled research and 'test pilot' innovation infrastructure
- Universities, Catapults, EPSRC Manufacturing Hubs
- Huge 'end user' markets (RR, Airbus, JLR, JCB, BAe, etc.)
- Manufacturing Technologies Association
- Robotics and automation research

Weaknesses

- Perception of sector
- Limited adoption of UK advanced machinery within UK research and innovation centres
- Lack of a National Advanced Machinery R&D Institute and no national funding programmes accessible to medium and small company's
- Critical UK manufacturing "voids"
 - cnc control system, robot, linear and direct drive motor manufacturers
- Lack of national training programmes aligned to sector
- Poor UK collaboration across sector
- Skills shortage
- Software: Generally students not prepared to handle in-depth apps

Opportunities

- Increasing the present 1% of the huge market – broaden beyond Niches!
- Develop a significant UK advanced machinery and automation institute
- Create a significant UK advanced machinery and automation R&D programme with outputs adopted by already established R&I centres
- BREXIT
 - encouragement of UK supply chains
 - encouragement of UK R&I chains
- MTA / NPL facilitating UK national programmes
- Disruption
 - manufacturing digitisation (I4.0)
 - electrification of transport
 - manufacture close to point of use
- Collaboration across the sector to move faster
- Publicity/marketing to promote the sector

Threats

- Misunderstood sector may lead to no intervention and a slow (hidden) decline
- Lack of strategic sector plan
- Continued prominence/promotion of foreign machinery within the UK's Innovation flagship centres
- Greater reliance on overseas pivotal digital technologies (e.g. control systems, robots)
- Strengthening global competition
- Lack of appropriate funding mechanisms
- BREXIT
 - Isolation from EU R&I programmes
 - Separation from EU man. supply chains
- Image of our industry (poor awareness)
- Technical education in competitor markets (e.g. CHINA)
- No sector specific training (machinery / mechatronics)

APPENDIX 2 Challenges in Growing UK Machinery Manufacturing Sector

C1. What is necessary for UK based machine tool manufacturers to prosper, especially considering increased digitisation of production systems?

- Make it understood at government level that advanced machinery produce everything and hold major impact for productivity gains especially for high value activities
- A UK wide initiative as a co-ordinated sector response to the Made Smarter report
- Increased engagement of UK based machinery manufacturers in addressing the digitalisation of production systems.
- Establish a UK Advanced Machinery Institute that create next generation production systems and provide critical technical competence for the sector
- A champion who can magnetise the UK Sector and align Government manufacturing programmes and funding
- Leverage off the established “niche” capabilities in UK
- Promotion of UK advanced machinery in the impressive UK Government funded Research and Innovation Centres
- Build on new processes such as Additive Manufacturing, realising AM is only part of a production capability and it requires post processing machines.
- Establish UK based manufacturer of an open architecture control system
- Establish UK Branded robot manufacturer (e.g. partnership with JCB)
- Develop new advanced machinery for emerging sectors
- (printed electronics, new energy systems, new transport, biotech, pharma)
- Engage/learn from existing successful UK companies (Mazak, Landis, PTG Holroyd, etc)
- Specific training for the design and production of advanced machinery.

C2. Do existing control system manufactures provide the products and services that will ensure growth of the UK based machine tool sector?

- No, international suppliers are not prioritising UK sector needs, they have a “supplier knows best mentality” and operate “knowledge gaining” processes that dilute UK “core competence” build up
- Need to build a UK control system manufacturing capability that supports the needs of UK advanced machinery and production system manufacturers
- Renishaw thought to have a working business case for open architecture system
- Needs internationally agreed communication protocol (open)
- “Analytics” suppliers that understand M/T
- Control systems with high preference fundamentals including communication at low cost and size. As opposed to high intrinsic intelligence

- Advanced machinery control systems research centre that deals with IoT agenda for the sector.
- Control engineering experts
- Lack of joined up UK capability development in this area

C3. Beyond existing government stimulus what else might support the growth of UK based machine tool manufacturing?

- GCSE Engineering curriculum to include Digital Control, machinery design
- Pre -GCSE “positive exposure and experience” to engineering
- Gender balance initiatives
- Increased academic engagements (from UK companies).
 - Schools
 - Colleges
 - Universities
- Support (encouragement) of JV UK based enterprises in advanced machinery
- Use success of Renishaw as a means to convey to UK government attributes of the sector
- Co-ordinated funding for the sector as opposed to “leap of faith” approach applied to additive manufacturing
- Specific adoption targets for UK sourced machinery and production systems within UK Innovation centres
- Gov-based provision of key tech support niches e.g module design or prototyping
- Grants from UK government to fund UK machine tool manufacturers to attend trade shows
- UK funding for sector specific trainings
- Specific B2B calls from Innovate UK for new machinery and production systems
- Scrapping scheme on machinery to improve productivity and bolster UK investment
- Specific calls from Innovate UK from projects to development open access technologies for printed/ flex electronic device manufacturing.
- Funding for the UK sector to be present at International shows.
- I/P always an issue if M/C tool co provided M/S funds.
- Grants from BEIS/IUK to support UK machinery manufacturers in building up UK supply chains (e.g AMSCI)
- Funding support for UK participation in defining international machinery standards
- M/C tool research centre that disseminates achievements to UK manufacturers
- Provide clear leadership on the national direction setting for the transport (automotive) sector
- Foster better understanding of the vital importance and ubiquitous/ influence of production systems. Sector public champion.
- Machine tool specific apprenticeship training centres.

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