Advanced Manufacturing for Complex Aviation - AMCA

Partners:

GE Aviation – Cheltenham

Based in Bishops Cleeve, Cheltenham is part of the GE Aviation electronics value stream, with 1800 staff the site is responsible for design and manufacture of avionics control and power systems for both military and commercial programmes

Tannlin

A privately-owned company based in Prestwick, Scotland Tannlin's capabilities include; customised laser cutting systems, high accuracy laser processing and electronic assembly support products.

Manufacturing Technology Centre – MTC

Established in 2010 at Ansty Park Coventry the MTC is committed to bridging the gap between academia and industry and accelerate UK' industrial growth. The MTC provide integrated manufacturing system solutions for customers large and small, across sectors as diverse as automotive, aerospace, rail, informatics, food & drink, construction/civil engineering, electronics, oil & gas and defence.

Omega Engineering Services

An SME based in Cheltenham, Omega provide specialist power systems engineering services that include design and manufacture and testing of highly specialised assemblies

Speciality Coating Systems – SCS

Based Woking, Surrey and part of a Global specialist coating company with over 40 years of coating and applications expertise. SCS are integral part of GE supply chain providing Parylene coating services.

Project overview:

The next generation digital and "all electric aircraft" will require increasingly capable, complex and affordable avionics systems to operate in increasingly harsh environments. To meet this challenge and be competitive in the world market, avionics equipment manufacturers must leverage new technologies in their designs and manufacturing processes. This project has brought together a UK supply chain in a collaborative consortium, to undertake research which will enhance the UK ability to manufacture certifiable complex avionics for future aerospace systems.

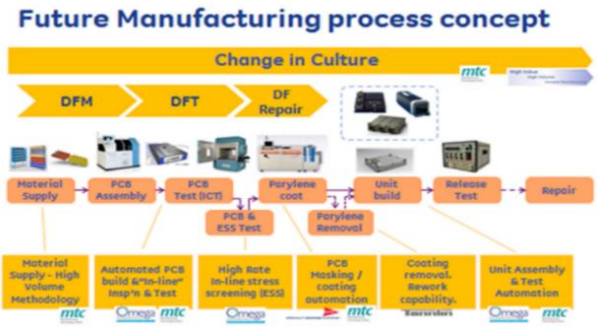


Fig. 1

The project researched new technologies to enhance the design and manufacture of new and existing product ranges with a particular focus on a new Remote Electronics Unit (REU), that had significant design and manufacturing challenges. There is a need to make the printed circuit board (PCB) significantly smaller, capable of operating in harsher environments while maintaining certification, this drives complexity and the need to adopt new electronic component technologies in the design. Manufacturing capability must be developed to enable the manufacture of complex PCBs for high value, low volume high mix applications against increasing pressure to outsource assembly operations.GE Aviation, as a leader in safety critical aerospace product design and manufacture, led the project consortium from the manufacturing supply chain.

Table 1: Summary of the project grant details

Project	Funding	Lead Partner	No. of Partners	Partner Composition	Duration
113032 AMCA	Total: £5.6m Grant: £3.3m	Company Name	4	1 Large companies, 3 SMEs 1 Catapult	01 2015-09 2017

Table 2: Summary of the project focus areas

ATI Value Streams		ATI Enablers		ATI Attributes		Strategic Horizon	
Whole Aircraft		Aerodynamics		Safety		Secure	x
Structures		Manufacturing	x	Cost	x	Exploit	x
Propulsion		Materials		Environment		Position	
Systems	x	Infrastructure		Fuel Burn			
		Process and Tools	x	Operational Needs			
				Passenger Experience			

Technology Achievements:

3D Inspection

During the project, 3D inspection technology was highlighted as step change process from the incumbent 2D standalone process that existed. Working closely with MTC, GE drew up an in-depth specification requirement document covering both solder paste inspection (SPI) and component inspection (AOI) criteria. This allowed a shortlist of potential equipment to be identified and series of bench tests conducted. Koh Young equipment was identified as the preferred option for both 3D Solder Paste Inspection (3DSPI) and 3D Automatic Optical inspection (3DAOI) machines, sourced through their UK distributor Altus who provided technical support through the commissioning phase. With inspection equipment now in line and reporting live data to the operators, real time improvements and corrections can be made; this has resulted in significant reduction in post Surface Mount (SMT) rework and a reduction in Work in Progress (WIP) as the inspection now happens as an in-line auto process.

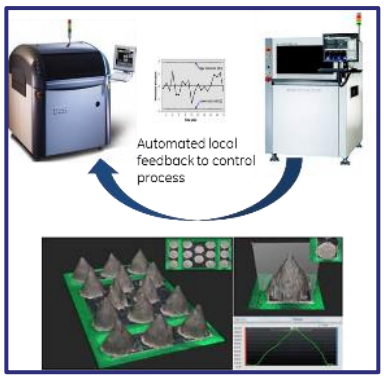


Fig. 2 process control between machines

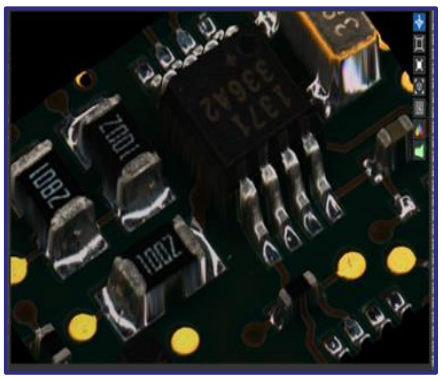


Fig. 2 Hi res 3D image of every component

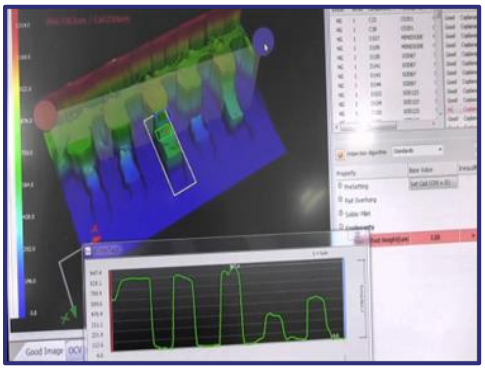


Fig. 4 Extensive data and measurement analytics

Process Mapping and shop layout

Following a series of process data capture events, a series of process simulations run by the MTC, using Tecnomatix Plant Simulation software, a number of potential bottlenecks were identified as well as areas in need of process improvement as volumes increased. The simulations helped unlock latent capacity and provided vital input to optimising the shop layout. Relaying a live production cell presents a number of challenges with maintaining output being a primary driver even while layout changes are made, much more difficult than laying out a new factory. The layout aided by a 3D map of the current cell (fig 5) developed by MTC partner company OR3D, brought alternate layouts to life and gave good visualisation of new layouts helping identify optimum route for reducing product travel from almost 900metres to 513 metres and reducing WIP lead time from 7 to 2 days.

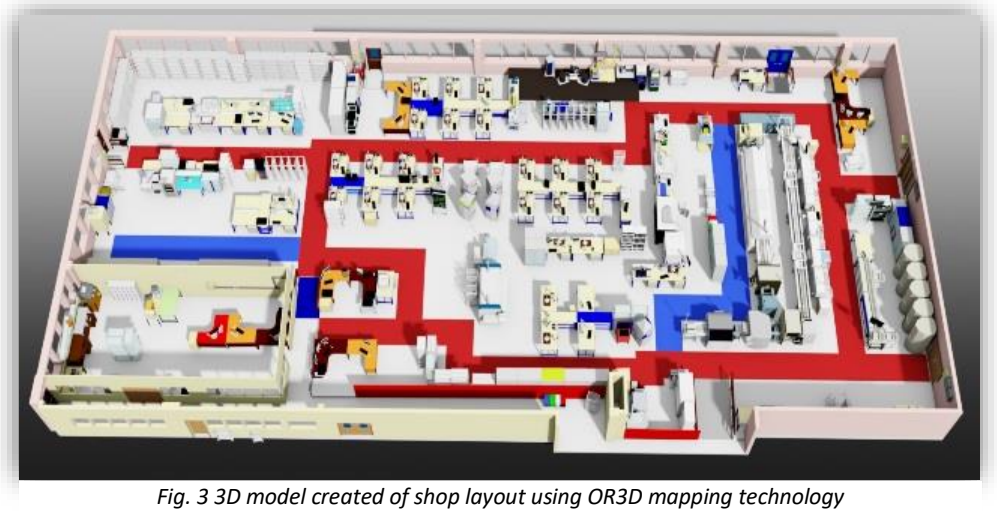


Fig. 3 3D model created of shop layout using OR3D mapping technology

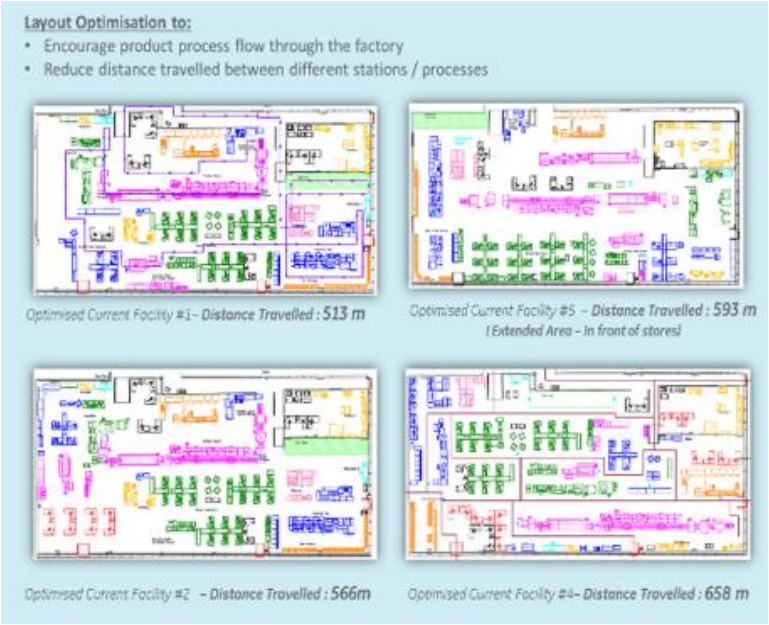


Fig. 4 Multiple layout iterations to optimise product / process flow.

Industry 4.0 meets GE Brilliant Factory

Industry 4.0 has become a common place term across the manufacturing sector. Using digital information to drive improvements and decision making in real time offers many benefits in any production facility. Similarly, GE refers to this as 'Brilliant Factory' with cross sector drives to digitise a traditional industrial business. The new technology equipment investments as part of AMCA have created a strong foundation for digital development. The 3DSPI for example, is providing real time feedback to the operators and can link to upstream equipment to make automatic corrections in the process. Data collection and connecting machines to networks and business systems will further streamline operations allowing longer term analysis to help future process and product developments as engineers learn to interpret and understand the data gathered. Connecting machines to business systems will unlock real time tracking of product and negate operator inputs further improving efficiencies and reducing non-value add time.

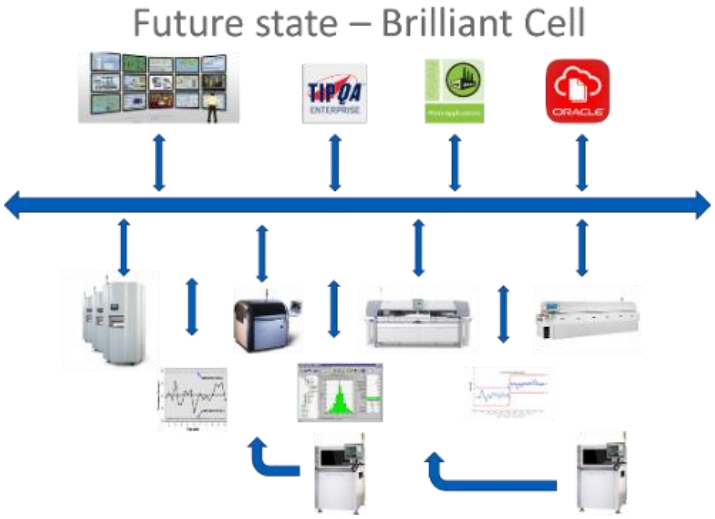


Fig. 5 Future state connectivity of business systems and machines

Auto Coating

With almost every PCB requiring a form of coating the in-house (at GE's Cheltenham site) coating process came under review as an output from the process mapping work. A manual process with time consuming masking operations carried out in different building to the PCB assembly accounted for thousands of man hours, and process waste in the form of travel between the separate buildings. With equipment chosen through bench tests against defined specifications, the Asymtek solution with technical support from UK based Anglo Production Processes (APP) automated the coating application process, reducing throughput time from hours to minutes. This resulted in over 6000 hours (80%) labour saving and by locating the equipment alongside the PCB assembly line a saving of over 19000km of PCB travel per annum across the site. This step change process development was a highlight of the AMCA project and the automated coating line is now a best in class facility.

Fig. 7 Fully in line automated coating system

Fig. 6 Automated coating application

In line ESS testing Concepts

Environmental Stress Screening (ESS) testing is a big part of production test strategy not just at GE but in large parts of the aviation industry. Time consuming and difficult to diagnose failure modes (e.g. only fails at -50 degrees) makes ESS is not the most production friendly process. Alternate concepts that challenge industry norms were investigated and concepts ideas including in line testing were developed led by research at the MTC.

Within GE work has continued to further develop in line and alternate ESS ideas and this could be an excellent arena for wider industry and ATI support as low TRL level and legacy thinking prevails.

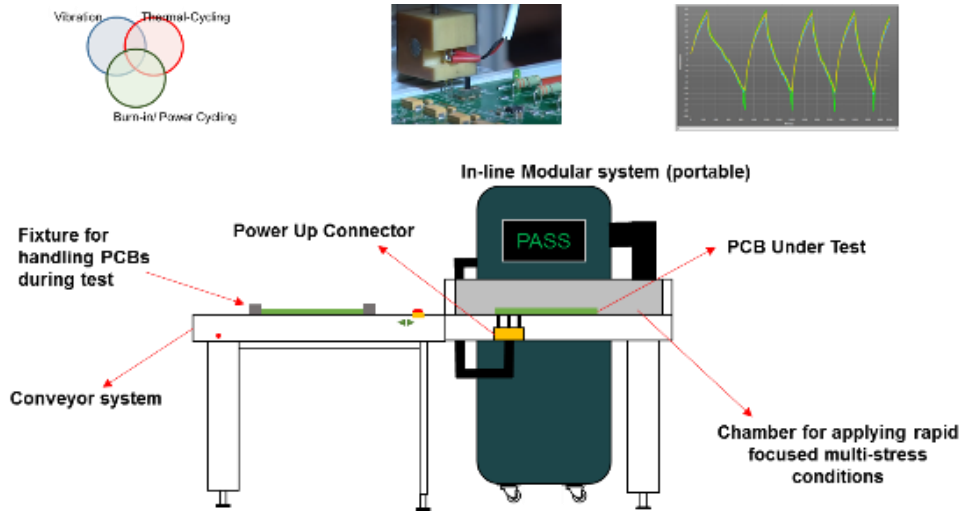


Fig. 8 in line stress screening concepts

Parylene Removal using Laser techniques

Investigating an alternate method of Parylene removal was a research element of the project. Taking Tannlin's expertise in laser control and looking for exploitation of laser technology for parylene removal and concluded;

- Excimer laser (266nM) proved highly effective in removing parylene - but process too involved and neither flexible, industrial or affordable
- Absorption by 355 not as good as 266nm - but encouraging and suitably useable lasers available
- Tannlin elected 2 possible laser suppliers and visited to do initial tests. However, neither laser manufacturers were able to demonstrate capability
- Tannlin switched to known laser process specialists PMI where reasonable results were achieved.
- Concluded that the 355nm 18W was the most affordable laser that will remove parylene in some way

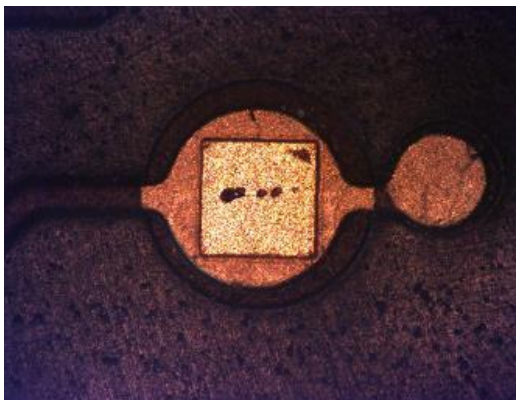


Fig. 9 Component pad with parylene removed by laser

Robotic Assembly Demonstrator

In a low volume environment automation is often overlooked as a potential solution with many assembly operations carried out by hand.

The MTC using one of GE's development project products demonstrated automation concepts and the identified a development path for automation of assembly operations. Assembling a complex two-part PCB (joined by flexi cable) into a case presented a combination of challenges in handling and repeatability. The demonstrator used a collaborative robot to successfully show a proof of concept. Learning and recommendations around designing for automation were identified and will be used in the next generation of product designs.

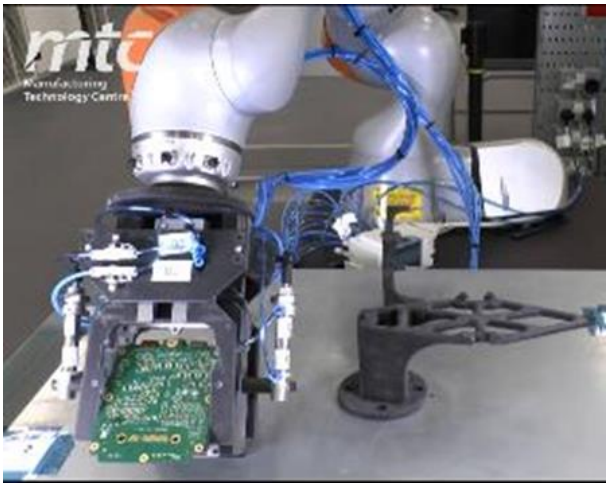


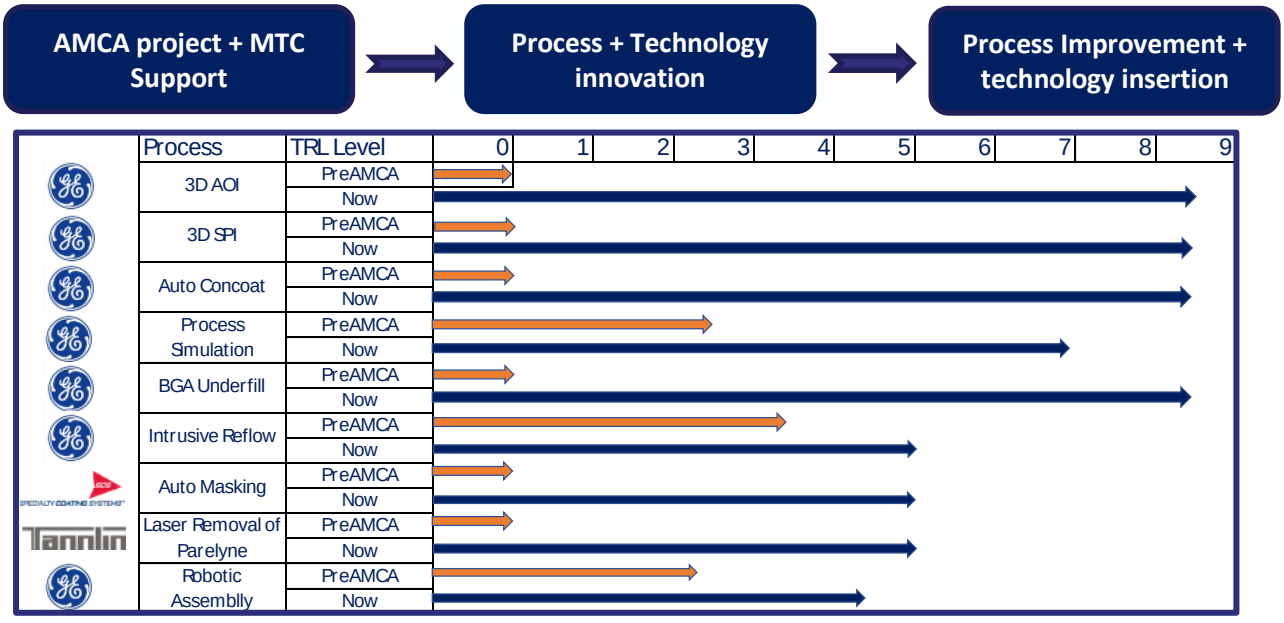
Fig. 10 Robotic assembly in action at MTC

"The robotic assembly demonstrator has helped set the Multi-Generation Technology Roadmap for the assembly of our current and future products. The programme has allowed us to build awareness of more contemporary assembly technologies and methods and influence the design of the next generation of productises to maximise advantages in quality and business competitiveness. The support and expertise from MTC was invaluable in providing technology understanding and increasing the TRL level in the business"

Matt Lamb – GE Cheltenham Site Manufacturing Engineering leader

Summary TRL development and adoption

The AMCA project identified a number of gaps in technology understanding and deployment. Whereas some of these technologies were already in use in high volume commercial / consumer electronics sectors, applications in high mix / low volume sectors were less established. Tannlin's application of laser control pushed industry TRL levels forward and within GE the AMCA project shifted the paradigm on a number of technology areas.



Economic Impact:

In addition to the technology advances and implementations, the economic benefits have been significant. Focussed on the in-house PCB assembly cell, the competitive position has changed the business dynamic from one where outsourcing was a preferred option on both cost and quality, to one where previously outsourced work is targeted for bringing in house. With growth on a number of commercial and military programs, the additional capacity created has secured the UK assembly position and increased the customers confidence in GE's in-house capability.

- Increased labour productivity – PCB cell +16% since 2015
- Additional 18% capacity created through technology application helping retain work against outsource proposals
- Improved competitive position against outsource options demonstrated through recent outsource benchmark where in house was better in 70% of line items.
- Initiated culture of continuous improvement – multiple spin off projects already launched
- Technology insertion providing platform for future growth to supporting multiple airline programs with military and commercial customers

In addition to the quantifiable measures AMCA delivered benefits in customer confidence and perception.

"AMCA introducing 3D inspection technologies and an automated coating process has made a step change to our product quality. This has also resulted in increased confidence from our customers as they see the continual improvements post AMCA" Simon Wilson – GE Cheltenham Site Quality Leader

Next Steps: Exploitation opportunities

The exploitation opportunities are many with spin off projects underway. Developing alternate ESS strategies, further new equipment deployments and a drive towards greater digital integration are already examples of GE exploiting and building on foundations laid by the AMCA project. Design for Manufacture (DFM) learning in both PCB assembly and Robotics will deliver benefits well in to the future on new product developments. Exploitation opportunities across the partners are summarised below.

GE	MTC	SCS	Tannlin
Adopt digital platform to drive quality and productivity improvements	Conceptualisation of new processes and concepts for exploitation in aerospace and other electronics sectors	Implement Auto masker when critical volume point reached	Laser structuring
DFM techniques continue to support development of adjacencies product	Re-configurable collaborative robotic unit assembly cell	Build on continuous improvement culture	Parylene removal as a commercial service
Use or TRL assessments when introducing new technologies	Rapid In-Line Thermal Environmental Stress Screening (ESS) - Collaborative proposal under discussion with GE Aviation	Apply project learning to all other customers and products	Use software developed for laser processing of electronic assemblies
Use relationship with catapult to support spin off projects	Promote flexible PCB line concept to wider industry		
Build on continuous improvement culture	Re-configurable collaborative robot assembly cell		