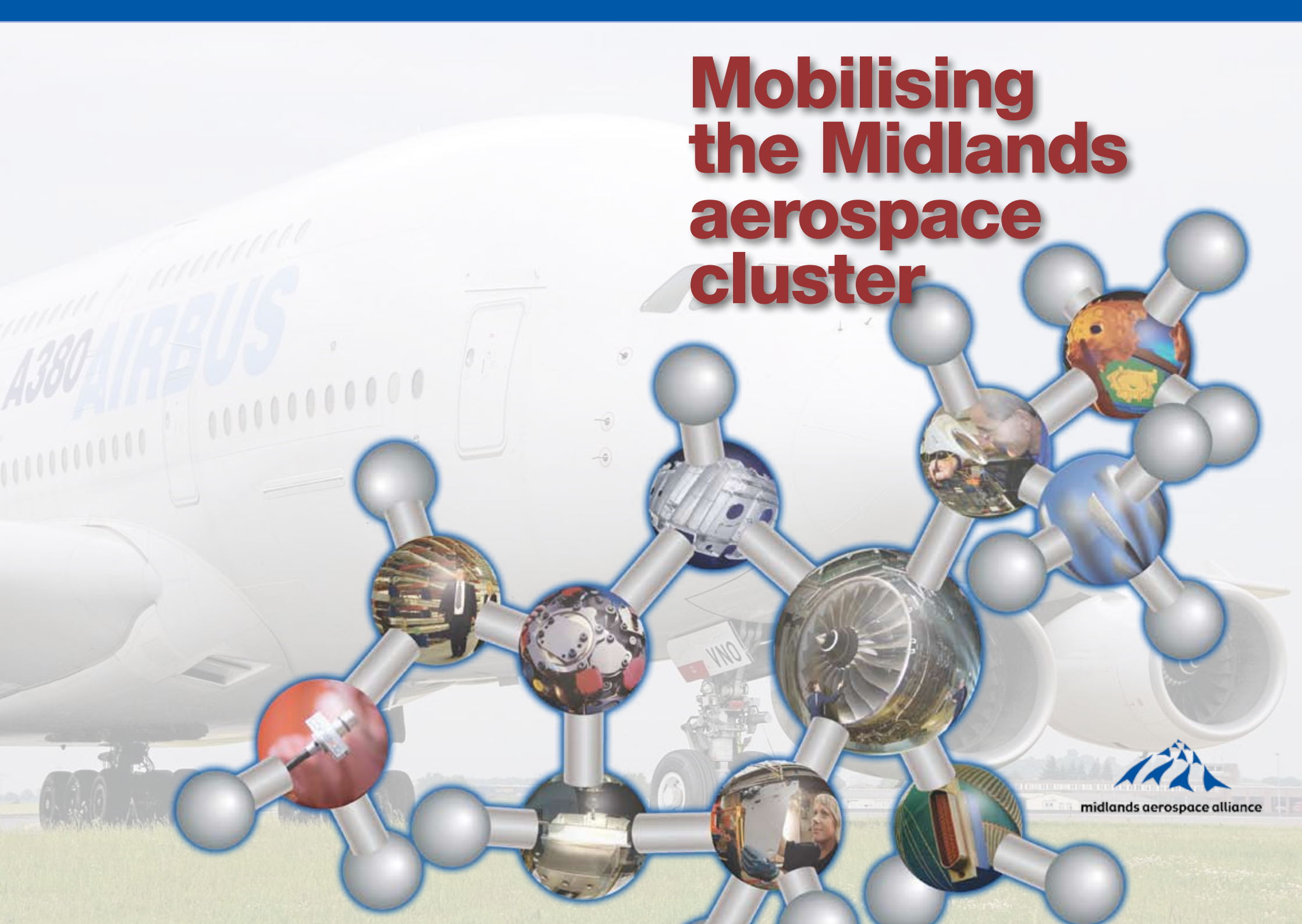
Mobilising the Midlands aerospace cluster



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The Midlands Aerospace Alliance (MAA) is the voice of companies in the British Midlands supplying global aerospace. It was set up in 2003 to improve wealth creation and employment for companies and people involved in the aerospace industry across the Midlands. The MAA is supported by Advantage West Midlands and the East Midlands Development Agency.

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How do aerospace companies exploit the resources of the Midlands aerospace cluster to improve their performance and increase their prospects for success in global markets? Drawing on the ideas of cluster guru Michael Porter, we look at the cluster's key strengths, analyse the challenges its companies face, and show how its business leaders mobilise the cluster to create competitive advantage. We also explore how astute public agencies can multiply the effectiveness of their policies by aligning their productivity, innovation and business support interventions with the dynamics of the cluster.

This 'white paper' has been written to help Midlands Aerospace Alliance members extract the most value from their home region when they compete in global aerospace markets. Business and policy leaders should find it of equal interest. It has also been written to stimulate discussion and action; to do any of these, contact Andrew Mair, Chief Executive, Midlands Aerospace Alliance: *andrew.mair@midlandsaerospace.org.uk*.

CLUSTERS IN GLOBAL CONTEXT

Geographical concentrations of economic success dominate great regions of the world — from high-tech Silicon Valley to film industry Bollywood, from fashionable Milan to financial London. In a globalising economic system companies continue to add extra value to their products and services by exploiting the unique knowledge networks, specialised inter-firm links and supportive business environments they find in their home region. Business leaders multiply the effectiveness of their own firm's processes and people by nourishing external links to local firms, research institutions, labour pools and business support agencies — in short, by mobilising the resources of their cluster in the pursuit of competitiveness. Far from divorcing themselves from the region as they globalise their business operations, astute competitors cleverly position themselves in global markets precisely by exploiting specialised resources only accessible deep within their host regions. As cluster guru Michael Porter of Harvard Business School puts it: "Paradoxically, the enduring competitive advantages in a global economy lie increasingly in local things — knowledge, relationships, and motivation that distant rivals cannot match."

Are clusters as important to aerospace as they are to other industries? Today's aerospace companies strive to organise themselves across continents. Giant aerospace prime contractors and smaller agile suppliers seek access to new markets, lower costs, risk sharing partners, currency hedging and government support wherever in the world they find them; so much so that globalisation often dominates the strategic mindset of the aerospace business leader. For some, escaping the perceived constraints of the home base seems to be the very imperative. After all, in an era of global reach, surely any company can access the same advantages as any competitor anywhere?

Yet if this is so, why are the capital regions of the aerospace world — Toulouse, Kansas, Seattle, North West England, and others — so entrenched and so persistent? Globalisation may tug at their industrial fabrics. Factories in far flung locations may emerge as new competitors. But these leading aerospace clusters continue to attract massive investments in new production capacity for new aircraft programmes. Traditional clusters may see some of their native companies follow the tide of globalisation, and in some cases they lose traditional work offshore. Yet in the swirling global economic geography of aerospace they continue to attract new investors — some acquiring existing companies, others setting up greenfield units — as their economic threads are re-woven to create new patterns. Aircraft like the Boeing 787 may increasingly be designed and manufactured across vast global production systems, but each trans-continental logistical link still connects concentrated nodes of investment, expertise and capability. Indeed when some of those nodes fail, the entire system comes crashing down, as the delayed, stuttering launch of the 787 programme showed only too clearly. And what goal is common to many emerging economies? From Dubai to Singapore, governments are investing substantial resources in their own aerospace clusters to capture revenues from rapid growth in the global market (*see box*).

The global aerospace economic opportunity

- Global air traffic rose from 0.5 trillion revenue passenger kilometres (RPK) per year in 1972 to over 4m RPK in 2007.
- Airbus and Boeing predict that it will rise at 5% per year over the next 20 years. By then traffic could reach 10 trillion RPK.
- Over that 20 years, airlines will need to more than double the world's aircraft fleet size.
- This will require manufacture of more than 24,000 new large aircraft (over 100 seats), valued at $2.8 trillion.
- $2.8 trillion is the annual production of the German economy, the world's fifth largest. Airbus has only delivered 5,000 aircraft since it started over 30 years ago.
- And this is just for the biggest sector of aerospace, large civil aircraft. There are also regional, business and military aircraft to be made.

Clusters are all about the business environment of companies located in a geographical region. Dynamic clusters can be resources for operational capability and well-springs of continuous innovation. They offer direct access, on the very doorstep, to stimulating customers, suppliers and competitors. Their research institutions focus technical skills to solve industry challenges. Their skilled workforces concentrate intellectual effort to find novel solutions. Their support agencies strive to maintain the cradle that industry needs to operate smoothly, from college courses to transport networks. By fully exploiting the competitive advantages of their cluster, alert business leaders can actively counter much of the perceived competitive disadvantage their companies may suffer in pure piece-part price terms compared to a low-cost economy or a larger integrated competitor. By promoting their cluster's development, leaders can build on its natural economic foundations and create an even more effective platform for improving their company's performance. And by exploit-

ing the catalytic power of the cluster, government can exact maximum results from policy interventions.

How can forward-thinking business and government leaders mobilise an existing aerospace cluster in North America, Europe or elsewhere? In bygone days clustering was more art than science. The art was practiced by experienced managers and skilled workers who, once inculcated in the ways of the industry at the big companies and education institutions, left to set up or work at local sub-contract suppliers. It was practiced in cosy relationships between seasoned buyers at large companies and their favoured local suppliers. And it was practiced in wage agreements forged by businessmen in the smoke-filled rooms of the region's private clubs or in head-to-head battles with regional union chiefs who allied themselves with local politicians.

Some recoil from anything that might smack of returning to such a past. Yet in an era where the global mindset threatens to dominate thinking, there is a bigger risk, that of throwing out the regional baby with the local bathwater. The old black arts of running a regional economy are in any case irrelevant in today's competitive environment. Astute aerospace business leaders look at clustering with fresh eyes, as a sophisticated and effective business tool. The more successfully they exploit the resources of their cluster, the more they can improve the performance of their companies — and their prospects in global aerospace markets. And the more carefully atuned is public policy to the dynamics of the cluster, the more widely spread the benefits for the region as a whole.

ANATOMY OF THE MIDLANDS AEROSPACE CLUSTER

Porter defines clusters as "geographic concentrations of interconnected companies and institutions in a particular field." Interconnections can extend vertically — up and down supply chains — and laterally — spanning a range of sectors that use similar inputs or supply similar customers. In some clusters government-funded agencies play significant linking roles by furnishing education and training or specialised transport infrastructures that resolve structural market failures. In some, regional industry bodies provide vital organisational glue. The precise anatomy of each cluster is different, and so are its dynamic forces.

The Midlands aerospace cluster

The world's big aerospace clusters are organised around large manufacturing plants where intricate precision assemblies — aircraft or their component systems — are designed and assembled from thousands of precision parts made internally or by supplier firms. Large labour pools support the factories, and the large anchor companies employ local research institutions to help them develop advanced technologies. Aerospace regions are not the type of cluster that is made up of groupings of collaborating small companies or commercial spinouts from university intellectual property.

The dynamics of aerospace clusters reflect the structure of the industry. With the development and manufacture of technologically sophisticated aircraft as its raison d'etre, aerospace is fundamentally a collaborative venture. Cooperation is driven by technology intensity, safety considerations, and the long life of each aircraft programme – often 50 years or more in this low clockspeed industry. A competitor for position on a new aircraft programme may simultaneously be a collaborator on an existing one. Aerospace suppliers adhere to rigorous customer-approved production and quality inspection procedures to assure aircraft safety; a regulatory regime that inherently restricts market entry, especially for what the industry calls *flying parts*. With long timespans and tight regulation as powerful determinants of industry dynamics, companies and employees form natural professional communities over whole careers — and geographical clusters amplify the sense of belonging.

The structure of supply chains and their performance are fundamental to competitiveness in the industry. Virtually all companies succeed only by finding a niche in supply chain structures as complex as the aircraft itself. Performance improve-

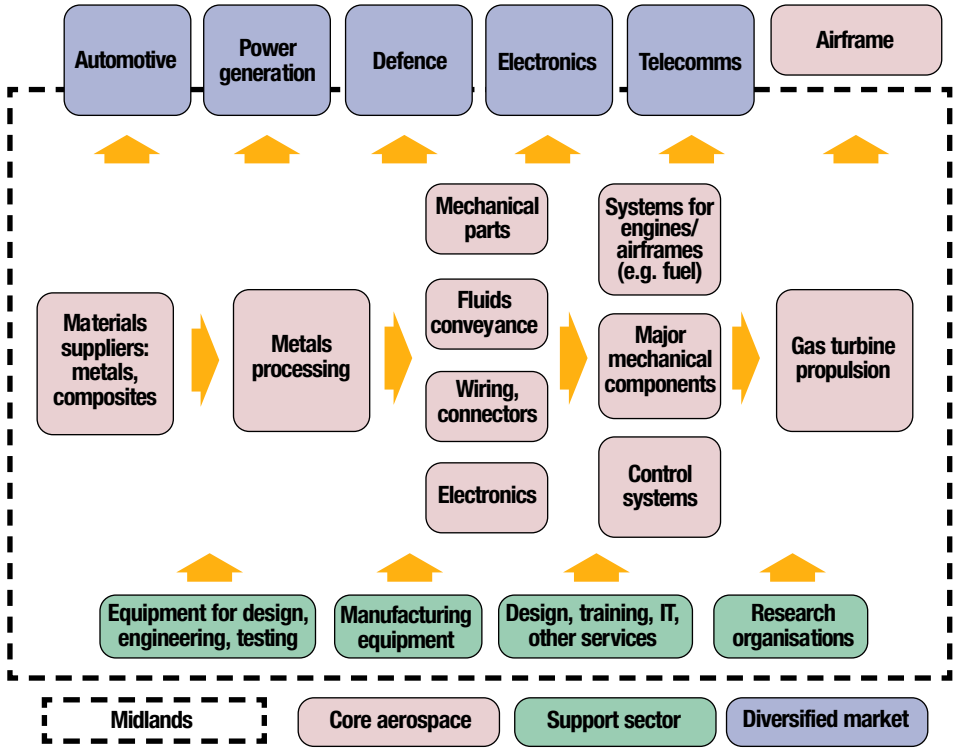
Key global players in Midlands	Focus of activity
Rolls-Royce	heart of large civil aero-engine technology development, manufacture and assembly; engines sold to global airlines for their Airbus and Boeing aircraft
Goodrich	HQ of global engine controls and electrical systems business, traditionally major Rolls-Royce supplier
Goodrich	HQ of global actuation systems business making mechanical parts for wings, traditionally major Airbus supplier
GE Aviation	development and manufacture of actuation systems, significant Boeing supplier
Meggitt	divisions developing and manufacturing wheels and brakes, seals for engines and airframes, anti-icing structures, fluids management, heat exchangers
HS Marston	heat exchangers and fluids management products
Thales	development and assembly of military unmanned aircraft (UAVs)
Timet	manufacture of titanium for aerospace use
Alcoa	manufacture of aluminium for aerospace use

ment and innovation must be coordinated across tiers of thousands of companies. Bringing a new aircraft like the Airbus A380 super jumbo to market requires a massive and coordinated investment in new technology, new factories and new skills over a development programme that itself can last for the best part of a decade before the aircraft is introduced into airline service. The effort is so intensive that Boeing and Airbus, with annual commercial aircraft turnover in the order of $25-30bn each, can only manage one big new programme at a time. For each they have to bet the company's survival, risks that are transmitted down the supply chain. When the industry suffers one of its periodic cyclical downturns, caused by external shocks to the airlines like 9/11 or rocketing oil prices, cashflow becomes critical as the new aircraft development programmes proceed apace.

And this is only one facet of low clockspeed. The aircraft model and its spare parts may be in production for decades, exceeding the career spans of all those involved. Regulation requires every precise manufacturing process to be certified and approved, a substantial cost barrier to physical relocation. The very nature of the aerospace industry tends to glue plant, processes and people in place. Entrepreneurialism becomes the buying, improvement and selling of existing capabilities and business with customers.

The Midlands aerospace cluster is located at the centre of England (*see map*). It does not produce aircraft, but several significant global aerospace players have operations in the region (*see table*). The principal hub of the cluster is the heart of civil aerospace operations at Rolls-Royce, the world's Number 2 manufacturer of aircraft engines, in the town of Derby. Rolls-Royce accounts for one in four of the 45,000 Midlands jobs due wholly to revenues from manufacturing for global aerospace markets (excluding airports and defence bases). Radiating from the hub are the supply chains that define the cluster's nerve system, linking the local nodes where aero-engine parts are made and the electro-mechanical systems that control how the engine operates are designed and built (*see chart*).

Traditionally, government statistics based on Standard Industrial Classification

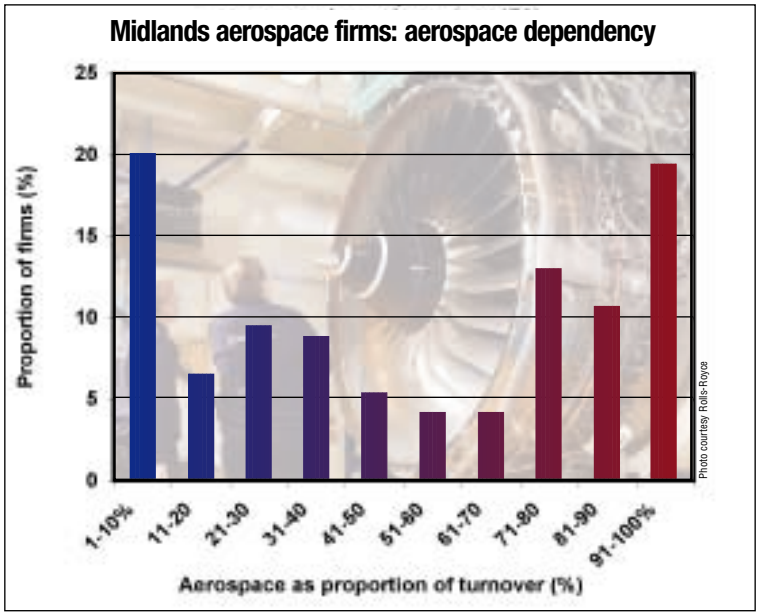


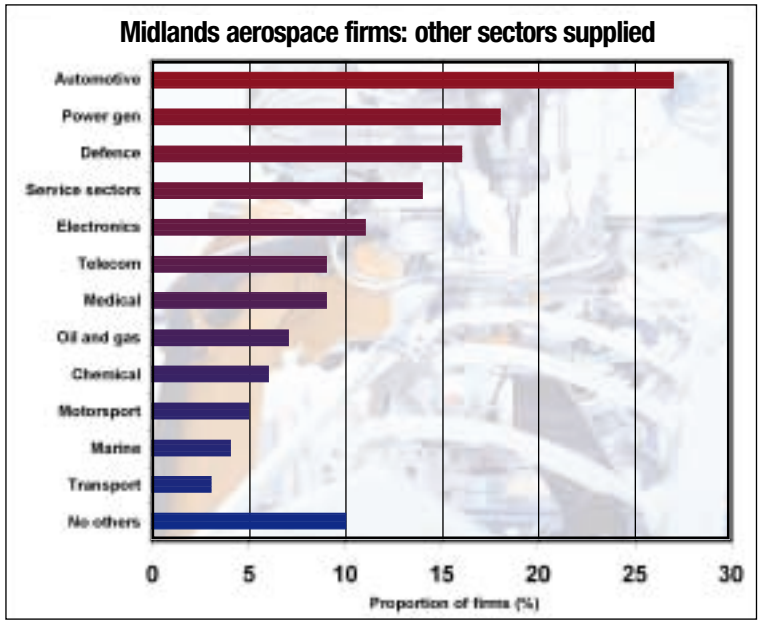
Structure of the Midlands aerospace cluster

(SIC) codes have obscured much of Midlands aerospace from official view, disguised as 'metal working' or 'electro-mechanical equipment'. The economic contribution the cluster makes to the region has only been fully grasped by policy makers in recent years. The government's two regional development agencies set up in the 1990s — East Midlands Development Agency and Advantage West Midlands, respectively covering the Eastern and Western halves of the region — both identified the aerospace cluster as a key facet of their advanced engineering or transport technologies economy and helped establish an industry-led Midlands Aerospace Alliance as a strategic partner for developing it.

Research centres located at the main Midlands universities in Nottingham, Loughborough, Birmingham, Leicester and Coventry play an important part in the cluster, with aerospace companies including Rolls-Royce, BAE Systems and GE Aviation sponsoring long-term programmes at seven distinct technology centres devoted to aerospace. These and other universities and colleges also run technical and management courses to support the skilled workforce in aerospace and advanced engineering.

A second cluster hub overlaps with the engine supply chain but is organised around the companies Goodrich, GE Aviation and Meggitt which supply the electro-mechanical systems that control an aircraft's moving parts — wing flaps and slats, landing gear, wheels and brakes — to airframers like Airbus, BAE Systems and Boeing. At the base of the supply chain, the Midlands hosts a number of specialist aerospace materials producers including Alcoa (aluminium), Timet (titanium), Special Metals Wiggin (specialised alloys) and Advanced Composites (carbon fibre materials).





In total, the Midlands aerospace cluster encompasses about 300 companies making flying parts and extends to as many again, depending on how far along the supply chains we follow the root system. Supporting these is an array of companies whose work is generated by the 30-40 per cent of aerospace purchasing made up of non-flying parts and services: specialist design, manufacturing and test equipment, and a host of general industrial services. Almost all these companies are located within one to two hours travel of each other at the heart of the Midlands region.

The cluster extends laterally into other sectors, principally the power generation industry via shared gas turbine technologies, and the automotive industry for which the Midlands is better known. Many aerospace parts manufacturers and support companies also supply motorsports and other advanced engineering sectors in the Midlands and elsewhere, especially where related power and control technologies are deployed and similar materials are used. These lateral links are

an important feature of the cluster. While two in five firms are very dependent on aerospace, the average aerospace supplier derives half its turnover from other markets, and one in three are less than one-fifth dependent on aerospace (*see charts*).

Just how significant is the Midlands aerospace cluster in the global context? It makes up just under one quarter of the UK aerospace industry, six per cent of Europe's and two per cent of the world's.

HOW THE CLUSTER ADDS VALUE

Sustained success in the global aerospace industry requires strong operational performance, innovative technology, and business strategies precisely tuned to the requirements of new aircraft programmes. Companies in the supply chain have to upgrade their operations and technologies repeatedly, and continuously adjust their strategies as the shape and structure of the global industry evolves. Yet the organisational tools many business leaders actively deploy to create and enhance the capabilities they need tended to be limited to a combination of hierarchical control within their company and arm's length relations between companies; make — or buy. In aerospace the choices at a manager's disposal are further restricted by the procedural rigidities that accompany a highly regulated industry, and in many cases the confrontational commercial relations some companies foster to try to mitigate their technical reliance on suppliers.

Mobilising the cluster gives Midlands aerospace companies a distinct additional box of tools to boost their performance in operations, innovation and strategy. How does the cluster do this? At the most basic level, it does so automatically. Geographical proximity, repeated transactions with competitors and collaborators, and career paths that zig-zag from one company to another foster a foundation of communication, coordination and trust as a basis for increasing the sophistication of management and behaviour. Repeated personal interaction encourages networking, learning, and information flow. Benchmarking good practice along and across supply chains becomes spontaneous. Skills and production capacity are effectively transferred between companies for added flexibility. Human and physical infrastructures are shared, and this generates the economies of scale and scope that permit specialisation to flourish. Companies plugged into the cluster gain these benefits at no cost or effort.

Being in the right place matters. Access to a pool of well-educated engineers is essential for technology innovation. On-time delivery requires an efficient transport system. A culture of excellence in regional manufacturing can foster improved performance standards. By contrast, a geographically isolated company will find it difficult to attract and retain bright young engineers and may have to maintain its own training and support infrastructure. Managers will have to go out of their way, literally, to benchmark the performance of competing and related companies and learn from others. The level of stimulation to stay competitive and the level of resources that can be mustered and deployed are simply lower.

Aerospace companies that take a proactive stance towards the Midlands cluster create significant further opportunities to improve their operational capability, invest in new technology, and create patterns of company ownership under which new business strategies can flourish. They can gain some of the advantages of greater scale that larger organisations enjoy, without losing the dynamic flexibility that is often the burden of full-scale vertical integration or merger. They can access some of the capabilities other companies can offer, without entering into binding and complex procurement relationships.

RESOURCES TO BOOST OPERATIONAL CAPABILITY

Participating in the Midlands cluster helps aerospace companies build supply chains intelligently, learn from good practice wisely, and monitor trends in the business and technology environments to align their own strategies with those of customers.

A combination of intimate collaboration and intense competition drives cluster dynamics. Cooperation is fundamental to creating aircraft systems. Yet Midlands aerospace companies also compete vigorously not only with global rivals but with each other. Goodrich and GE Aviation, both situated in the localised aerospace cluster in Wolverhampton, go head to head to supply ever more sophisticated control systems to Airbus, Boeing and other aircraft makers. HS Marston and Meggitt subsidiary Serck are intense rivals in the development of new heat exchanger technologies designed to dissipate the excess heat increasingly generated by more powerful aero-engines and electronic systems. Metals manufacturers in the Rolls-Royce supply chain are only too aware of their local rivals and compete head-to-head for work on a regular basis. During periods of industry growth, many of the leading companies vie to secure the services of highly skilled design staff and specialist suppliers alike.

Competition drives performance improvements. Companies in the same supply chains know precisely who their rivals are and strive to outperform specific competitors. First-rate aerospace managers and engineers are lured from one company to another, and as they do so the experience and knowledge they put to work grows apace. Loss of a major contract or key employee to a local rival spurs reflection and drives change. Benchmarking the regional competition can be done formally, but is also an informal process of continually observing, noting and implementing. Operating in the same geographical business environment holds constant many of the factors that might otherwise explain performance differentials, such as costs for labour, sites and services. Within the cluster, superior performance must be down to better management or more effective utilisation of cluster resources. Business leaders can do something about these.

The cluster's fibres naturally transmit knowledge about aerospace technology trends, market conditions, and the latest practices of competitors and potential collaborators. This knowledge accumulates and circulates every time people meet and exchange information. Personal links create the trust necessary for companies to work together effectively, whether as customer and supplier or in complex partnerships.

What economists call the positive externalities of clustering can be identified and built on. Company investments have regional spillovers which other firms can exploit: whether research facilities at universities that educate students, or training courses that other companies can share. Lead companies encourage their suppliers to use the same cluster resources, which smaller firms could not invest in themselves. Companies benefit from the reduced transaction costs and lower risks associated with a strong regional supply base. When companies win significant new contracts on major aerospace programmes they can confidently outsource smaller current work packages to a regional supply chain network they know intimately. And when government agencies grasp the significance of the cluster, public support programmes can be designed to offer specialised support for the industry knowing there will be a ripple of benefits for the region as a whole.

Proximity encourages Midlands aerospace companies to partner with erstwhile competitors to offer their technical capabilities and solutions to their ever more demanding customers. They already know their new partner well through years of interaction. Project managers who lead complex partnerships can meet face-to-face on a regular basis — a boon to small firms especially (*see case study*).

Case study: Midlands firms collaborate to compete

A traditional Midlands mechanical machinist has diversified in recent years to offer services to an aircraft manufacturer that significantly reduce the weight of parts used in the aircraft wing. Meanwhile, a second supplier has expanded its work for the same aircraft manufacturer on the same product group, sometimes in competition with the first firm. The two companies recently joined forces to win a new package of work. Each would specialise in a different type of part, and working together they could offer the aircraft manufacturer better service. Critical to making the new partnership effective was a good relationship between the project managers each company assigned, including regular meetings to address issues before they become barriers. The second company worked with the Midlands Aerospace Alliance to enhance its network of local subcontract machinists and offload work on existing smaller contracts. It was important to find local suppliers to be able to monitor the work and retain the confidence of the final customers.

Being positioned within a larger regional engineering cluster is a continuous source of new operations capabilities for aerospace. Firms combine employees who have unique and hard-won aerospace experience with fresh blood transfused from the region's other advanced engineering sectors by hiring employees uniquely placed to import performance-enhancing innovations — from automotive for lean operations, or motorsports to accelerate the pace of new product introduction. The cluster of employment opportunities across advanced engineering is a magnet for the best employees nationally and internationally, those who consider this job offer and prepare for their next move simultaneously.

The most dynamic Midlands engineering companies are constantly seeking new markets, and in recent years aerospace has seen a spate of new entrants (*see table*). These companies range from rapid turnaround motorsports machinists to niche automotive technical design houses and to specialists in interior design, and they bring new capacity, fresh capability, and a culture of excellence to their work with aerospace customers. Some of the lean manufacturing consultants now supporting aerospace trace their origins to the automotive sector, especially Toyota's UK factory located at the heart of the Midlands.

Of course, companies must retain key capabilities in-house to protect their strategic positions. And setting up long-distance links to suppliers in emerging markets may prove attractive if new markets can be accessed, direct labour costs reduced, and currencies hedged. But clusters offer benefits over vertical integration for many aerospace products and services. A division of labour between co-

Injecting Midlands automotive and motorsports capabilities into aerospace	
Advanced Composites Group	Supplier of high-technology composite materials to the Formula One industry continues to diversify into advanced aerospace applications including materials for SpaceShipOne and the Global Flyer programme (below) and new Airbus projects. 
Airbus	Locates new aircraft systems design centre at heart of Midlands to draw on automotive & motorsports expertise (*see also main text*).
Burcas	Small automotive machinist runs successful diversification drive and now supplies a series of Japanese and European aerospace customers.
Cosworth	Motorsports engine specialist launches engine for unmanned aerial vehicles (UAVs) and diversifies to provide its advanced machining capabilities to aerospace customers.
Design Q	Leading designers of car interiors for Jaguar and Aston Martin move into designing and prototyping innovative 'upper class suite' for Virgin Atlantic and interiors for business jets.
PDS Consultants	Strategy implementation consultancy with roots in automotive supply chain diversifies to make aerospace a second pillar of its business.
Penso Consulting	Niche automotive computer aided design (CAD) specialist targets and wins new contracts from aerospace customers including major suppliers of aircraft structures.
Premier Group	Sheet metal company with automotive roots wins new business with GKN to make parts for Airbus military aircraft.
Visioneering	Automotive toolmaker designs and makes tools and jigs for aerospace composite parts.

located companies means expensive functions no longer need to be duplicated across many organisations but can be outsourced to independent specialists that not only generate economies of scale but are driven to innovate to win business. And compared to the cluster, the total cost of acquisition from an extended global supply chain can be high, with restricted flexibility to manage complex aerospace projects. A network of local specialists can offer the customer enhanced responsiveness in dynamic market and technology environments vital for aircraft development, initial production and repair and overhaul. In an industry where true mass production is rare, sheer technical complexity is high, and product development cycles can be lengthy and unpredictable, collaborating companies located in the same cluster can create distinct advantages for themselves.

The importance of location to operational capability in aerospace can be brought home inadvertently when corporate executives decide to restructure operations. Aerospace companies discount the clusters around their operating units at their peril. Ambitious leaders for whom it made paper sense to rationalise and relocate production lines have been ambushed by the substantial hidden costs of uprooting and recreating whole production systems including multiple local cluster links – costs that were not factored into the sums that justified the original decision. Worse, when the move is from an apparently costly cluster location to a supposedly low-cost geographically peripheral one, the company's most dynamic skilled employees, whose technical and process knowledge is the hardest to replace, may choose to remain attached to the advantages of the cluster rather than follow their aerospace employer.

STIMULUS TO INNOVATION

Many of the factors that boost operational capability also enhance the capacity to innovate. The long and proud history of technology innovation in Midlands aerospace is testimony to the power of the region's people and companies.

Innovation in aerospace is dominated by significant new technology programmes in which networks of organisations collaborate systematically on large-scale projects to develop new aircraft and their systems over many years. The Midlands is the hub of Rolls-Royce's large Trent civil engine programmes: in recent years the Trent 500 for the Airbus A340-500/600, Trent 800 for the Boeing 777, Trent 900 for the Airbus A380, Trent 1000 for the Boeing 787 and Trent XWB for the Airbus A350 XWB. At what the industry calls lower technology readiness levels are multi-year, multi-partner technology demonstrator programmes, like

Environmentally Friendly Engine, centred in the Midlands, that ready and test technologies for insertion into new aircraft engines for aircraft such as the planned replacements for the high-volume Airbus A320 and Boeing 737 models that may be introduced in the later 2010s.

Here too the cluster plays its role. To run new engine development programmes, Rolls-Royce deploys its own substantial engineering resources in combination with a web of suppliers and research institutions, many in the Midlands, which come together to work on each new project, furnishing services ranging from trial parts production to components testing and the design of new engineering and testing equipment. Key suppliers like Goodrich Engine Controls in Birmingham organise their own research and product development cycles to be synchronous with the engine programmes. The university technology centres feed in their advanced ideas and focus their expertise to solve problems as they arise. Rolls-Royce supports four of the seven Midlands centres, sponsoring advanced research on metals that can perform at very high temperatures, combustion systems that can reduce pollution, transmissions systems that efficiently connect the different moving parts of the engine, and new manufacturing technologies to make these and other innovations.

To direct their own innovation efforts, astute supply chain companies use the cluster to access multiple sources of information about future customer requirements, current research institution opportunities, competitor behaviours, and the new tools and techniques on offer from suppliers of specialised equipment and

Rolls-Royce Trent 900 engine for the Airbus A380. (Photo courtesy of Rolls-Royce)

Goodrich actuation system wingset module for Airbus. (Photo courtesy of Goodrich)

services. The value of having world-leading aerospace players located in the region cannot be underestimated. Close access to aerospace customers that are themselves world-class competitors gives Midlands suppliers a steady stream of insights into trends in aerospace design, technology and management. Frequent interaction with designers and equipment providers enables manufacturers to keep abreast of developments and adopt new production techniques early. Midlands universities and private consultants employ a cadre of technology experts many of whom received rigorous management training and followed successful engineering careers at companies like Rolls-Royce and Goodrich before taking on new career challenges. These experts may have built long-term friendships in the aerospace community over many years and several job moves, links they now put to use to support the cluster from new angles.

The cluster offers the organisational flexibility required to exploit innovations where several parties are collaborating. To provide the right framework to guide the relationship, long-distance suppliers often have to be formally contracted, and that contract can become a constraint when a project moves in unpredicted directions. Working in an integrated firm can prove a bigger challenge than might be expected when it comes to obtaining specialist expertise and resources — access to testing facilities, producing trial parts — at the right time, as layers of management control become barriers to responsiveness. By contrast, in the cluster, groupings of regional customers, suppliers and partners can be consulted all along the innovation process so that relationships can evolve and other players can be brought in to make their contribution as and when required.

Case study: entrepreneurship at the origins of the cluster

The successful family-owned Midlands precision engineering company JJ Churchill makes parts for aerospace, defence, and diesel engine customers. The firm was originally established in Coventry in 1937 to provide sub-contract machining to the aerospace industry. From 1947 the gas turbine blade became the principal product and the basis for the company's subsequent development. A 1937 local newspaper reported the company's founding and that it was now seeking business, noting that Mr WM Churchill was formerly Technical Representative to the aircraft industry of large local manufacturer Armstrong Siddeley, that another director had previously been assistant works manager at two other Midlands manufacturers, and that both were members of the Auxiliary Air Force.

ENCOURAGING ENTREPRENEURSHIP

The core flying-parts aerospace industry is a hard one to enter, and business start-ups and spinouts play a lesser role than in some sectors. Yet key features of the spinout process make important contributions to reinvigorating the supply chain web. A steady stream of managers and engineers have parted with Midlands aerospace firms over the years to find their own niches elsewhere in the cluster. Many of today's smaller metal processing companies were founded by managers trained by Rolls-Royce, Goodrich, Meggitt, GE Aviation or their predecessor companies, insiders with intimate knowledge of aerospace customer requirements but keen to follow their own entrepreneurial path (*see case study for an early example*). Later generations have traced the same route out of an aerospace leader, or out of another Midlands engineering sector when fresh ideas are required, to exercise their business ambitions in the aerospace supply chain.

Some of these business leaders have moved on to form larger groupings through acquisition and organisational restructuring — a key feature of entrepreneurship in the cluster. Aerospace supplier groups headquartered and running key operations in the Midlands include Avingtrans, CommaTECH, Doncasters, Gardner, Hampson, Nasmyth and UMECO. Through acquisition, business leaders seek the financial strength and the economies of scale and scope to invest in the more sophisticated management skills that are increasingly demanded in the industry.

The Midlands aerospace cluster is fertile ground for the regular sprouting of innovative support firms that core aerospace suppliers draw on to boost their own competitiveness. Complementing companies from other engineering sectors that enrich the cluster when they diversify into aerospace, new support companies are set up to offer innovative expertise in engineering, design, quality management, lean operations of recruitment (*see case study*). The cluster offers these firms too additional markets in a range of sectors.

For new companies, the cluster overcomes barriers to entry and reduces risks. The industry knowledge that budding entrepreneurs bring with them creates the confidence that there is a market niche. Established relationships ease direct market entry. The previous employer may offer tacit support to the new entrepreneur. The cluster makes it easier to recruit colleagues with complementary skills. And start-up risks — if the business should fail — are reduced by opportunities to re-enter the labour market elsewhere in the cluster. This entrepreneurial activity benefits the cluster as a whole, providing a range of specialist capabilities and deploying the region's aerospace management competencies to best effect in the right organisational environment for individuals to flourish.

Case study: an entrepreneurial spin-out boosts the cluster's operational capabilities

Integrated Process Improvement (IPI Solutions Ltd) is a classic cluster spin-out company. IPI software products are designed to simplify the often top-heavy reporting systems traditionally accepted as the price to pay for aerospace quality. The company's first product automatically delivers 'First Article Inspection Reports' (FAIRs) compatible with the requirements of different aerospace customers, and provides automatic error checking, significantly reducing the time it takes to produce documentation. IPI was set up by a 20+ year aerospace engineering veteran who realized that FAIRs could be streamlined whilst leading a 6-Sigma project on the topic at a Midlands aerospace supplier. He partnered with a small software company based in Birmingham, showcased the application at an aerospace quality conference in Canada in 2005, and launched it in 2006. As a partnership between software developers and experienced engineers who understand the market, IPI typifies the advantages of a cluster spin-out. The company built an initial customer base including Meggitt in Coventry and GE Aviation in Wolverhampton, both of which subsequently invited their suppliers to look at the product. The software is also being incorporated in a Birmingham University investigation into a new technique for shaping metals sponsored by Rolls-Royce and the regional development agency. IPI's innovations are contributing to the competitiveness of the cluster as a whole, and the company is now building an international client network with direct support from the Midlands Aerospace Alliance at major aerospace exhibitions.

CLUSTER LIFE-CYCLE: FROM TAKE-OFF TO CROSSROADS

How did the Midlands aerospace cluster first emerge, how has it evolved, and what are its prospects for the 21st century? Like the aerospace industry in many countries, the Midlands cluster owes much to the war-time years around 1940. The region was the birthplace of the allied effort to develop the gas turbine jet engine, a breakthrough technology first applied to military aircraft. Frank Whittle's Power Jets company was located in the Midlands towns of Rugby, Lutterworth and Whetstone near Leicester from the late 1930s onwards and the first flight of an aircraft powered by the new engine took place at a nearby RAF base in 1941. Whittle's W2/700 engine would be the basis for the adoption of gas turbine technologies by Rolls-Royce (Welland and Nene engines), General Electric (1-A, based directly on W2/700), Pratt and Whitney (J42, based on Nene), as well as Soviet producers. The established Rolls-Royce company, a few miles away in Derby, was already mass-producing Merlin piston engines for Spitfire fighter aircraft. Led by Ernest Hives, Rolls-Royce adopted the new technology in the late 1940s, and the company grew to dominate aerospace in the region from its Derby base, building or buying additional factories in Coventry, Warwickshire, Leicestershire and Nottinghamshire. The direct legacy of Power Jets can also be seen today in the gas turbine industry of Leicester (Alstom Aerospace, on the Power Jets site), Lincoln (Alstom and Siemens Industrial Gas Turbines) and Rugby (Alstom), in an entire manufacturing supply chain spread across the region, and in the research expertise of the region's universities.

Manufacture of military aircraft, piston aero-engines and other components had taken over the motor industries of Birmingham and Coventry during the war. The industrial city of Wolverhampton joined a string of aircraft and component manufacturing centres the government set up dotted in a north-south line right along the western side of England – out of range of enemy bombing raids. The manufacture of military aircraft continued at Coventry until the 1960s, although the region was more of a branch plant location than a major aircraft design and manufacturing centre like Bristol or Manchester (with some exceptions in Coventry and Wolverhampton). The wartime legacy remains particularly strong in Wolverhampton, at GE Aviation (originally Boulton Paul then Dowty then Smiths), Goodrich (originally Hobson then Lucas), and HS Marston (now part of United Technologies' Hamilton Sunstrand division).

Sixty years of technology development: Left – A cutaway General Electric J31 (I-16) turbojet engine based on Frank Whittle's W.1/W.2B (1940s). Right – Rolls-Royce Trent 1000 (2000s).

Diversification by motor industry companies completes the picture of the aerospace cluster's birth. As early as the 1920s, Midlands companies had applied technologies from the equally new automotive industry and other sectors to aerospace: to the conveyance of fuel and other liquids around the engine and aircraft (Marston and Serck for heat exchangers, other makers of pipes and hoses); to hydraulic and mechanical actuation systems to control the moving parts of aircraft wings as well as engines (Hobson/Lucas and Boulton Paul/Dowty); and to wheels, brakes and tyres (Dunlop (now part of Meggitt)). The Birmingham company Lucas, main provider of electrical systems to the British car industry, designed a new fuel injection system for the Spitfire's Merlin engine, and went on to become Rolls-Royce's 'in-house' — yet in classic cluster fashion independent — provider of gas turbine electrical and later electronic control systems, now as Goodrich Engine Controls. Aircraft manufacturers elsewhere in the UK, forerunners of today's Airbus and BAE Systems, found in the Midlands a rich vein of engineering resource willing to diversify into the growing industry on the basis of their capabilities in precision machining and hydraulic, mechanical and electrical engineering.

The prosperity of the Midlands aerospace cluster as a whole owes much to daring strategic moves made by leaders at Rolls-Royce like Sir Ralph Robins from the 1960s onwards in a bid to create a global aero-engine competitor, including commercialisation of the company's novel three-shaft turbine technology in the RB211 engine, the decision to risk competing head to head with global market leader GE, and the purchase of the Allison Engine company in Indiana to secure a US foothold. Much of the Midlands supply chain was pulled along in the Rolls-

SWOT analysis for Midlands aerospace cluster

Strengths	Weaknesses
1 Global market access and reputation of key companies	**1** Traditional supply chain companies unprepared to compete in global markets
2 Expertise in design, manufacturing, materials, strong research base	**2** Fragmented support for technology innovation along supply chain
3 Broad range of flexible supply chains	**3** Deficits in operations management capability
4 Strong skills base with active labour market	**4** Ongoing skills, capability and knowledge gaps
5 Active regional clustering to build on	**5** Clustering weakened by poor vertical supply chain relationships
Opportunities	**Threats**
1 Global and inter-industry business opportunities across the sector	**1** Growing threat of developed economy and emerging market competitors across the board
2 Innovation of new products and services using customer needs and major national programmes as drivers	**2** Technology base in competing regions is increasingly capable as governments strategically target aerospace
3 Participation in industry supply chain improvement programmes	**3** Lean global competitors address quality, cost, delivery with increasing effectiveness for superior performance
4 Potential to continue to draw young people into high-tech industry	**4** Low cost of overseas labour and investments in growing large engineering cadres
5 Application of best practice in clustering within region and from other regions.	**5** Competitor regions invest heavily in widely agreed cluster development strategies

Royce slipstream during a boom period in the late 20th century that drew in engineers from across the UK and fed off supportive training institutions at the region's universities and colleges as the scale of production at Rolls-Royce and supplier sites grew steadily. In parallel, the cluster diversified into steam and industrial gas turbines for electricity power stations and marine versions for ships, and even nuclear propulsion systems for submarines.

Yet the internal and external factors that govern the competitive success of clusters shift over time like tectonic plates, sometimes imperceptibly, sometimes seismically, creating weaknesses and threats as well as strengths and opportunities. Threats and weaknesses must be addressed even as the cluster plays on its strengths. The Midlands is by no means immune (*see table*).

In aerospace, disruptive new technology can pose a significant radical threat that potentially undermines an established cluster's position on new aircraft programmes because it greatly improves aircraft performance for airline or defence customers. Yet even here turning points in a cluster's lifecycle can be difficult to pin down. The long service life of each aircraft continues to earn companies revenue from overhauling products launched decades previously, giving a cashflow platform for new research and development efforts to help them make major technology leaps themselves. This same low clockspeed can equally disguise decisive shifts in the geographical centre of gravity of aerospace innovation, leaving a complacent cluster living off past glories if it fails to invest in its future.

The Midlands made the technology leap from piston engines to gas turbine jets during the 1950s. As of the 2000s, no technological successor to the gas turbine is on the horizon even if radical reconfigurations in its deployment on the aircraft are being developed, and metal alloys capable of performing at extreme temperatures remain its basic material. The still-significant technology effort now focuses on myriad innovations to improve environmental performance by reducing the consumption of fuel and the emission of pollutants, but even today's new design concepts depend on established technologies within the engine (*see illustration*).

Technology ruptures that require major research and development effort have continued apace for the Midlands companies that specialise in the other moving parts of aircraft and their control systems, with the introduction from the 1970s of electronic management for fuel, actuation and braking systems, and the advent from the 2000s of electrical power units distributed across the aircraft to gradually replace centralised hydraulic systems. Yet the Midlands does not currently face quite the same scale of technology challenge as clusters where many years as a centre of expertise in manned fighter aircraft is under threat from the emergence of unmanned aircraft, or where traditional strength in making aluminium aircraft structures is under threat from the increasing use of carbon fibre composites which require radically different competencies.

Each regional cluster has its own competitors, equally eager to service global markets. Just as Rolls-Royce competes directly with GE and Rolls-Royce's supply chain competes with the entire GE supply chain, likewise the Midlands aerospace cluster competes with its global rivals. The main competitors are its closest counterparts, North America's old industrial New England, and the Great Lakes aerospace cluster extending from Illinois through Indiana, Ohio and to the southern parts of Michigan, Ontario and Quebec. Like the Midlands, these

regions are not generally thought of centres of aerospace. The Great Lakes is better known for its automotive tradition, yet it is home to GE and other gas turbine engine makers: Rolls-Royce Corporation (formerly Allison), Pratt & Whitney Canada and Williams. It also hosts a cluster of aerospace electro-mechanical equipment plants owned by companies like Goodrich and Eaton. In Europe, the Midlands' closest competitive counterparts are the industrial regions around Paris, Turin, Stuttgart and Munich.

The most significant external economic threat to the Midlands currently may be intense competition from these northern hemisphere economies where national and regional governments are making substantial investments to build up their aerospace clusters. Whole modules of Rolls-Royce Trent engines (modules the company deems least critical to its competitive advantage) have increasingly been outsourced to countries from Spain to Japan where governments are buying their way into global aerospace — initially, at least, as junior partners. Whole Rolls-Royce engine programmes (mid-sized civil engines) have been relocated from the Midlands to Germany or the USA following the same logic. For Rolls-Royce, such risk-sharing provides the finance for growth and in some cases (Japan) may open up new markets. Yet while Rolls-Royce's overseas sites and global partner companies may continue to procure engine components in the Midlands if their own clusters are under-developed, this global-scale industrial restructuring may be chipping away at the region's competitive position in a way hidden by the overall dynamic growth of aerospace markets.

The parallel but distinctive threat from emerging markets like China and India is a significant issue across the cluster, as leading companies like Rolls-Royce, GE Aviation and Goodrich outsource the manufacture of sub-components even for critical core technology systems. The weak case for off-shoring low-labour-content automated machining work on cost grounds is buttressed by large government subsidies for capital equipment, a realisation that governments are investing in future skills on a massive scale, and strategic considerations of future market entry in the politicised business environment of aerospace. Revenue from series manufacture of parts over many years has been central to the business model of many Midlands supplier companies as it permits them to support the technology development work of their customers at less than its full economic cost. When the customer off-shores volume production this business model is placed under strain, with unintended consequences for the vitality of the cluster. While the leading company's procurement department meets its immediate cost-reduction targets, the same company's engineering department later discovers

that the local suppliers it relied on for expert and responsive support in new technology programmes are at best less willing to do the work for a customer now perceived to have broken a traditional covenant, and at worst have gone out of business. The same consequences hit the leading company's repair and overhaul departments by undermining its network of local suppliers that traditionally maintained the capacity to take on difficult 'aliens and strangers' (one-off parts often requiring quick-turnaround) work on complex components, work which does not travel well, on the back of volume production.

The Midlands cluster also suffers its share of internal handicaps, and these translate into many of the further challenges it faces today. Arguably, some companies have grown around the same business model common to much of British engineering that lay behind the decline of the Midlands motor industry; size without economies of scale. In the effort to attain higher output targets, growth was achieved by adding on more units of what remained essentially craft manufacturing, and companies lost a significant measure of managerial control over the entire production system as imperfect market signals were magnified when they were transmitted from unit to unit. Midlands supply chains continue to struggle with the legacy.

Other weaknesses stem from patchy strategic thinking about the role of the cluster by some of its leading companies. The way cyclical changes in global aerospace markets are managed has its effect. Swings in the business cycle have been amplified into severe booms and busts for the supply chain and workforces alike. A period of serious capacity and manpower shortage tends to be followed a few years later by one of sweeping cutbacks, imposed price reductions and mass workforce redundancies. It is argued in justification that this process prunes the weakest links — albeit brutally — leaving a healthier whole. But the pernicious long-term outcome is that some of the Midlands' most productive and innovative companies, employees, and support institutions steer clear of aerospace, and parents are tempted advise young people to look elsewhere for stable careers. Some in the industry prefer to ignore its own role in the skills and capacity shortages that appear in later growth phases when labour markets and supplier factories are placed under considerable stress. It does not have to be so; Airbus chose to retain staff and capacity across Europe through the industry's early 2000s cyclical downturn.

A related challenge is a culture of overconfidence in some middle management ranks derived from the industry's or their company's technological or strategic

achievements. Astute managers might turn positions of strength into long-term partnerships with other cluster companies and institutions so as to exploit their innovations and performance improvements. Some instead turn strength into strong-arm procurement practices or abrupt changes in direction without consultation with partners, tactics that may produce short-term results but which undermine confidence in collaboration.

Difficulties within the supplier base in turn frustrate the leading firms. Critical nodes in supply chains such as some of the specialist metals processing companies are one area of perceived weakness. Just as clustering can magnify advantage, weak links in the chain can undermine operational capabilities. Worse, these bottlenecks can threaten suppliers above and below them in the chain as customers eventually look to better performing holistic supply chain segments in other aerospace clusters.

Cluster positives also become negatives when shared values act as a drag on moving businesses and supply chains forward. It is particularly hard to change the mindset of a whole cluster when people some companies try to eject pop up elsewhere in short order, hired on the basis of their familiarity with the industry. As Porter argues: “If companies in a cluster are too inward looking, the whole cluster suffers from a collective inertia, making it harder for individual companies to embrace new ideas, much less perceive the need for radical innovation.”

A final challenge is finance. While leading aerospace companies across the world increasingly seek to fund expensive aircraft technology development by asking their suppliers to enter risk-sharing partnerships, Midlands finance markets tend to be less willing to support investments in the supply chain over the long haul of the typical aerospace programme. Smaller companies are increasingly squeezed, or have to try to rely for competitiveness on operational effectiveness rather than invest in new technology and product innovation.

Far-sighted business leaders compensate for the cluster’s weaknesses by using their Midlands competitive strengths to widen their business opportunities. They have traditionally sought a broader national customer base for Midlands technologies — Airbus civil aircraft wings or BAE Systems military aircraft, for example. They now diversify globally, targeting smaller North American aero-engine companies such as Pratt & Whitney Canada or Honeywell and in some cases GE or MTU in Germany. Several have followed Rolls-Royce and acquired their own subsidiaries in the world’s largest aerospace industry in the USA. And, bringing us full circle, companies may try to compensate for deficiencies by importing capability from other Midlands sectors.

The Midlands aerospace cluster may have been at a cross-roads for some years. Companies have to make significant investments in new technology and management capabilities if they are to secure their competitive position in the face of new global competitors and succeed in aerospace markets over the long term. To invest effectively, they can draw on the cluster’s inherent strengths in operations, innovation and entrepreneurialism. They can put cluster resources to work to help address their own internal challenges and unlock radical improvements to supply chain performance and innovation capacity. They can find new ways of working together to ensure the cluster is reinvented for a new phase of prosperity (*see chart*). Government bodies face their own decisions at the cross-roads. Will they help ignite new catalytic potential in the cluster? Will they intervene strategically to tackle some of the market failures that hold back change?

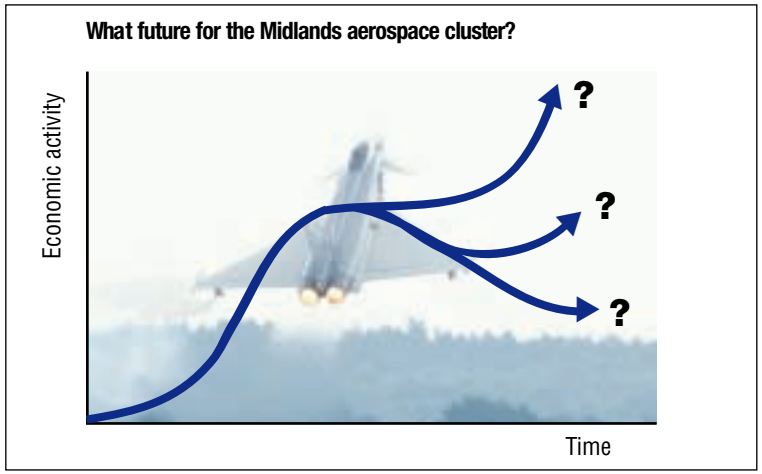
HOW COMPANIES PUT THE CLUSTER TO WORK

To remain competitive and successful in global aerospace markets, business requires sophisticated operations capabilities, continuous technology innovation, and management with strategic business acumen. Companies in the Midlands aerospace cluster can improve their performance on all these fronts by injecting fresh technology, better business processes and new skills. To access cluster resources, leaders across all management functions need to think outside the box of their own company and deliberately connect up internal structures, processes and people with complementary external resources. It is not enough to “think global, act local;” business leaders have to “think local” too.

To Michael Porter, the cluster creates four strategic agendas for firms.

BEING IN THE RIGHT PLACE

Properly exploited, a cluster location has clear advantages. The cluster remains the main hub for technology innovation even when some activities must be distributed



world-wide to benefit from lower costs and help penetrate markets. Strategic capabilities are often best kept close to the chest, and that means geographically close — where they can be controlled and shielded from the eyes of global competitors. As Porter argues, "every product line needs a home base," and that base is where a vibrant cluster offers a superior location. A critical mass of sophisticated market thinking, research and product engineering is supported by a mature business environment that feeds in resources, provides operational responsiveness and creates a culture of innovation to keep ahead of the competition.

Rolls-Royce has retained Derby as the home base of its flagship Trent engine product line, even as in recent years its globalisation strategy has distributed various manufacturing activities to locations where investment risk can be shared, markets accessed, and currency exposure reduced: Trent engine modules deemed less critical strategically to Japan and Spain, the manufacture of whole smaller engines to Germany and the USA, and support functions like engine testing and repair and overhaul to the USA and Singapore. Over the same period, the company has systematically upgraded its facilities at all its UK locations, especially Derby, with a massive investment programme that has rebuilt its entire UK factory system.

When Goodrich purchased the aerospace engine controls and actuation systems divisions of TRW-Lucas in 2002 it made their Midlands sites into headquarters for new global business units able to continue exploitation of their inbuilt cluster advantages. Indeed the region has attracted a host of aerospace inward investors, largely from the USA. As well as Goodrich, United Technologies/Hamilton Sunstrand owns Marston, GE purchased Smiths Aerospace to form GE Aviation, Precision Castparts Corporation has five Midlands metals production units (two SPS operations, AETC, Special Metals Wiggin, Wyman Gordon), Glenair runs an electrical connectors business, and GE also owns the Druck pressure sensors business and defence electronics company Radstone.

The best global companies buying their way into the Midlands aerospace cluster have learned to tap its competitive strengths whilst furnishing corporate resources to tackle its internal weaknesses. Some do both more effectively than UK companies. They not only bring a perceptive outsider's eye to the advantages inherent in their adoptive region, but inject significant corporate management capability. Other acquirers, however, neglect clustering in favour of a 'home country or international' global business framework. In these corporations clustering may be tacitly exploited at home but is neglected abroad in favour of central control over most decisions bar workforce hiring. Here the Midlands business is treated as a branch plant and sometimes little more than a revenue stream.

Airbus's decision to locate in the Midlands for the first time demonstrates astute cluster thinking par excellence. The global giant opened the Midlands Engineering Centre in Birmingham with design consultancy Morson Group as its partner in 2006 following lengthy internal analysis. The Airbus wing design centre in Bristol in South West England was experiencing continuing difficulties recruiting and retaining highly skilled engineering design staff as the city's aerospace cluster has been put under economic strain by rapidly growing service industries. Airbus opened a satellite aircraft structures design centre at the heart of a major US aircraft structures cluster, in Wichita, Kansas in 2002. Encouraged by the success of Wichita, senior managers at Airbus UK recognised they could access a fresh pool of talent by locating a parallel centre in Birmingham and recruiting engineering staff with automotive and motorsports backgrounds while improving retention of their own engineers already commuting up to two hours from the Midlands to Bristol. Clustering opportunities were enhanced by having the new centre specialise in the design of aircraft wing technologies including fuel and landing gear systems that fit Midlands aerospace core competencies. Morson Group plans to reap further benefits by offering the centre's services to other aerospace customers. The micro-locational choice of Birmingham Airport, adjacent to rapid road and rail links with both Bristol and Morson's Manchester home base, facilitates regular business meetings, short-term secondments and visits from international partners. Such sophisticated cluster thinking reduced Airbus's costs and risks and contributed to the new centre's operational capability.

ACTIVE PARTICIPATION

Recognising the advantages of a cluster location is one thing, but the cluster must still be exploited. Activating the resources of the Midlands aerospace cluster requires real participation. Personal networking by managers is the best way to access the kind of knowledge that circulates in the cluster, knowledge that will not be posted on a website nor divulged to junior staff at another company. To benefit from the information flow that accompanies clustering, business leaders and their functional chiefs must join the community and build relationships. Participation gives them trusted status as members of the cluster and provides a wide network of contacts to call on. The regular influx of information from the cluster can be triangulated with the sometimes-imperfect information business leaders receive from inside their own organisation and from meetings with customers and suppliers.

To make the most of the Midlands cluster, participation must be deliberate and strategic: not an extracurricular activity done on a manager's free time. It commits organisational resources, whether inviting regional visitors to tour the factory, or assigning internal experts to local advisory groups, or fostering long-term relationships with a local college or government body that lets both parties invest with increased confidence. Structured participation in the cluster naturally generates reciprocal support and resources.

Just how much benefit a company receives from other cluster organisations tends to depend on the perceived corporate commitment to the Midlands. It is harder for UK sales managers of overseas companies to become cluster insiders. Active participation does help them meet clients and take soundings and they are welcomed in their role of stimulating innovation and competition. But when they succeed at their jobs, the principal beneficiary is the home base in a competing aerospace cluster; and this is understood.

Some managers are wary of opening up their company to cluster participation. They may fear that encouraging external links will result in key members of their team leaving for greener pastures. They may be concerned that helping foster continued cluster growth will only attract new competitors, create skills shortages and prompt poaching of staff. True, enhancing personal networking and bringing in new players can cause disruptions some managers find hard to cope with. Yet, as thoughtful business leaders tune into the cluster they recognise that a culture of regular external exposure may be just what is needed to stimulate and thus retain valuable staff, and that while new investors may create short-term bottlenecks, they often pump in resources and soon create a fresh source of innovation and skills for the cluster.

BUILDING THE CLUSTER INTO INVESTMENT DECISIONS

The Midlands aerospace cluster is made up of a host of complementary and mutually dependent companies and institutions linked by shared supply chains, labour pools and overall business environment. The more successful is one node in the cluster network, the more other nodes can benefit from partnering with it. The more cluster partnerships and links can be fostered, the greater the chances of success for each node.

Companies can contribute to upgrading the Midlands aerospace cluster in the way they make their own investment decisions, and reap rewards as a result. The Rolls-Royce Hucknall site near Derby was once an airfield used for aircraft testing, and until recently served as the principal site for testing civil aero engines on outdoor rigs. Now, as part of the UK-wide investment programme, a new factory has been built to make Hucknall the centre of excellence for strategically important engine combustion system modules. The airfield is surplus to requirements and the company is working with local government bodies to develop an aerospace-related business park.

Business leaders need to consider how they can apply thinking like this to their own decisions. The Airbus Birmingham and Rolls-Royce Hucknall cases show how cluster thinking can be incorporated into strategic decisions. An emerging

Rolls-Royce's new combustion systems centre of excellence at Hucknall. (Photo courtesy of Rolls-Royce)

group of sophisticated third-party logistics specialists like UMECO subsidiary Pattonair is restructuring supply chain logistics systems for Rolls-Royce and now applying the same facilities and techniques to supporting Goodrich and others, offering a potential step-change impact on the management control and performance of a series of linked Midlands supply chains.

There is still work to do if the Midlands is to create and manage these positive externalities to best effect, especially compared to competitor clusters in Europe. It is difficult to convert promise into reality. In another part of the region, a localised grouping of aerospace companies, the regional agency and the Midlands Aerospace Alliance investigated a possible specialised shared services facility, but without finding a solution. Regional agencies invest in university aerospace technology centres sponsored by industry leaders like Rolls-Royce and BAE Systems partly on the premise of leveraging the involvement of these industry leaders to provide technology innovation opportunities for supply chain companies, though in practice the ambition is not always achieved. A provider of carbon fibre composite technologies has developed proposals how to build a centre of excellence for composites training on its site that is open to the region, to ensure industry-relevant training, generate economies of scale, and invest in a broader community of skilled employees to service a rapidly growing sector of the industry. Yet despite MAA support, with potential partners seemingly constrained by their own internal drivers, it has proved difficult to pull together the partnership required to turn an attractive concept into a workable plan.

These are examples of companies attempting to move beyond reliance on bilateral market links to pro-actively manage regional externalities in their investment decisions — the seeds of a new management understanding of how the cluster can be incorporated into business plans for new facilities. Yet the criteria on which companies make strategic investment decisions remain largely internal and 'hard'. The same holds for relocation decisions that neglect the cluster and low-cost sourcing decisions based purely on piece-part prices. Many cluster advantages, whilst they are vital enablers, seem intangible. And because they aren't simple to measure, they simply aren't managed. Government bodies equally recognise market failure as a justification for public sector intervention in principle, but can find it harder to translate the policy into practice. A cluster location offers companies myriad operational benefits that managers can learn to identify, apply, and measure, and government intervention can have significant catalytic potential. Yet more can be done to actively recognise, capture, measure and govern positive regional externalities and spinoffs.

WORKING TOGETHER

Creating collective regional assets and institutions in the Midlands is the responsibility of both industry and government. An active cluster organisation can be a catalyst for enhancing collaborative potential. A business-led body can support or lead cooperative initiatives, whether along supply chains, between competing companies that share key interests, or between mixed groups of aerospace companies and support institutions. In the Midlands the cluster body is the Midlands Aerospace Alliance. Formed in 2003 in response to industry demand and with strong support from the regional development agencies, the MAA strives to avoid being seen as a traditional trade association. While it is business-led, its members include a variety of organisations associated with the Midlands aerospace industry. The MAA Board balances senior managers from Rolls-Royce, GE Aviation, Goodrich and Meggitt with elected supplier company members and includes the universities, trade unions and the regional agencies.

The MAA's strategy is based on three kinds of activity: knowledge and networking, specialised direct help for member companies, and strategic development of the cluster. Work in each area is governed by four cross-cutting working groups based on management functions: business development, innovation and technology, best practice and skills. The MAA provides high-level networking opportunities to encourage information flow among cluster members. It delivers cluster support programmes directly to companies to improve performance in innovation and business strategy. It works closely with regional public sector bodies like the Manufacturing Advisory Service to ensure their work to upgrade operations performance and organise training fits with what aerospace requires. As a cluster body the MAA actively promotes links to other advanced engineering sectors, including two-way market diversification, technology cooperation, and support for shared education and training institutions (*see box*).

ALIGNING REGIONAL POLICY WITH CLUSTER DYNAMICS

The economic growth and wellbeing of regions is ultimately determined by a combination of business innovation and productivity. National governments provide the necessary stable macro-economic conditions. Investment-intensive industries like aerospace require the state to offer critical financial underwriting

The MAA: promoting clustering for member companies and the region

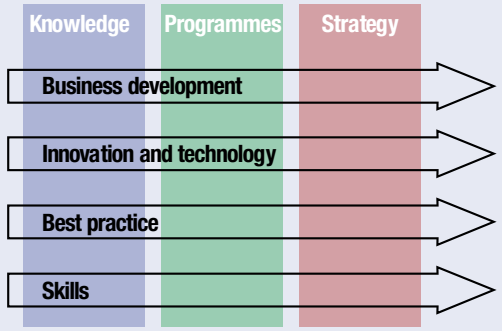
The MAA acts as a cluster catalyst to support the Midlands aerospace industry in business development, innovation and technology, best practice management and skills development.

In addition to a regular calendar of networking and knowledge exchange activities in each of these areas for its 250 member companies, the body provides expertise and advice for company initiatives that build clustering into business decisions. The suite of support programmes the MAA delivers is designed specifically to meet aerospace needs, funded by the regional agencies matched by significant industry contributions, and designed to harness the full potential of clustering. The MAA's technology exploitation programmes award seed funding to technology development projects run by partnerships of companies and universities that can show they have real potential routes to market in new aircraft programmes. Each project has generated an upward spiral of cooperative work with real momentum. A series of specialist business development activities gives expert guidance and support to supply chain companies to help them create sophisticated business strategies appropriate for global competition.

The MAA has sought partnerships with other Midlands agencies to help them target and improve the effectiveness of their own support programmes. The regional Manufacturing Advisory Service 'Lift-Off' programme was designed to boost operational capability for individual aerospace companies and supply chain groups. The regional trade promotion and inward investment agencies (UKTI, British Midlands) work hand in hand with the MAA to market the cluster's capabilities; such as flying in groups of 30-plus procurement managers and buyers from aerospace companies across the world for a day to meet face-to-face with more than 100 Midlands aerospace suppliers and thus expose both sides to new opportunities. The Midlands Engineering Industries Redeployment Group, a body associated with the MAA, worked for several years to retain valuable skills in the region by helping skilled employees move from sectors in cyclical decline to growth sectors, either permanently or on secondment. The MAA will be a key pillar in a new business-led regional 'innovation network' (iNet) designed to coordinate and focus regional innovation and technology investments. As representatives of a significant regional industry, the MAA Board and working groups are regularly consulted by the regional agencies on overall Midlands plans to promote innovation, skills and international trade.

In addition to these regionally inspired activities, the MAA helps filter national aerospace initiatives and policy through the cluster for maximum impact in the Midlands. In one example, MAA experts work directly with Rolls-Royce, Goodrich and HS Marston to grow Midlands supply chain participation in the national Environmentally Friendly Engine technology programme, in which the MAA has supported the regional agencies to make substantial investments. In another, the MAA actively participates in the '21st Century Supply Chains' programme launched by all the leading aerospace companies and run by the national Society of British Aerospace Companies to coordinate industry's actions to improve the competitiveness of UK aerospace and defence supply chains. Part of the MAA role in this is to work with the regional branches of the Manufacturing Advisory Service to align regional business support packages targeted at MAA members with the supplier development initiatives of the lead companies – again mobilising the cluster's resources to ensure the national effort delivers maximum impact and benefit for the Midlands.

Three types of action along four strands



Case study: the give and take of effective cluster partnership

HS Marston is part of the giant United Technologies Corporation's Hamilton Sunstrand division. The 350 employees of the Wolverhampton-based company engineer and manufacture heat exchangers and fluids management systems (hoses, ducts and pipes), primarily for aerospace structures and engines clients but also for the motorsport and electronics markets. The HS Marston ethos has encouraged the entire management team — from engineering to procurement, sales to personnel — to network externally. Hamilton Sunstrand is supportive and is in turn kept informed of regional opportunities — the divisional president has hosted a high-level visit to his Connecticut HQ by the MAA and the regional agency Advantage West Midlands (AWM).

Already very active in the region, HS Marston has been quick to participate in recent government initiatives to support aerospace, working closely with the MAA. The MD took his turn to chair the regional agency's aerospace advisory group, and the engineering director has been part of the MAA innovation and technology team. Long-term partnerships with a local network of specialist technology schools and colleges support a strong record of investing in training and skills. Adjacent Goodrich Actuation Systems partners with the same network. The HS Marston management team has arranged reciprocal exchange visits to Goodrich and their other aerospace neighbour GE Aviation. Through an MAA seminar designed to bring regional companies into the Rolls-Royce-led Environmentally Friendly Engine (EFE) programme, HS Marston became a formal partner in the multi-year technology demonstrator, matching its substantial investment with financial support from the UK government and AWM. Through a supply chain technology programme managed by the MAA with AWM funding, the company led a project to develop high-temperature heat exchangers that helped a small specialist supplier to develop an innovative manufacturing capability. In the same scheme the company volunteered to host the test rig for a University of Wolverhampton project to research novel processes to bond metals.

HS Marston also stepped forward to pilot a new regional programme to boost the region's leadership, management and enterprise skills at senior levels, and led a supply chain development project in a scheme funded by the Manufacturing Advisory Service, with nine of its suppliers grouped together to introduce performance improvement techniques. Top management has advised (non-competing) companies in an MAA collaborative business development programme on how best to approach new global customers. The company regularly exhibits with the MAA at international aerospace exhibitions, giving its business development team an independent presence that would be harder to achieve under the wings of the corporate parent.

Continuous investment in clustering with both industry and the public sector has reaped rewards for HS Marston and the region as a whole.

Three MAA members developed a new technology to help reduce aero-engine emissions under the MAA technology exploitation programme supported by Advantage West Midlands. HS Marston engineered this trial heat exchanger out of a tungsten-rich alloy that can perform in temperatures 300 degrees higher than previously achieved in the aircraft engine, but is very difficult to machine. Rolls-Royce partnered as the customer, and small company Advanced Chemical Etchings developed new technical processes to work with the materials.

for technology development and risk-sharing by the industry giants. Across the world, national and regional governments make these substantial investments to build up their own aerospace industries and acquire its high-value revenue streams and intellectually challenging jobs for their citizens for decades to come.

Regional agencies traditionally deliver public policy interventions matched to the needs of their regional economy in areas ranging from education and research institutions to industrial sites and transport infrastructure. Regional policy can also make a significant contribution to the micro-economic framework by promoting innovation and productivity, and regions are well placed to support technology development and risk-sharing at all levels of the supply chain. Some choose to build on these foundations by explicitly identifying, analysing and targeting their key clusters to provide the specialist business support services that fit the specific requirements beyond the generic support that high-technology industries rarely utilise. And regional agencies can be active catalysts for the effective strategic development of clusters, working in partnership with business-led groups.

Through their representative bodies, industry in turn can work directly with regional agencies. Shared cluster agendas, based on securing future global market opportunities for the region, can bridge the traditional cultural divide between business and government. Partnering promotes cluster development by encouraging industry participation and targeting government resources for greatest

Small toolmaking company Rojac engineered and made this composite component gearbox housing (exterior and interior views pictured above), weighing 35 per cent of its metal equlvalent (and therefore saving on fuel) under the MAA technology exploitation programme supported by Advantage West Midlands. Rojac worked with fellow MAA members Advanced Composites Group (materials) and Goodrich Actuation Systems (customer).

effectiveness. Industry bodies coordinate and communicate business thinking to ensure that government understands what companies in their sector must do to remain globally competitive, and what government can best do to upgrade the parts of the cluster that lie in its domain. Regional bodies responsible for promoting exports, attracting inward investment and upgrading manufacturing capability are able to work in close partnership with entire supply chains through well organised business-led groups. Specialised cluster support programmes are successful because they are directly aligned with the cluster's own dynamics and because they achieve critical mass by being delivered on a cluster basis. From a public policy perspective, the cluster can be a vehicle to deliver the region's specific innovation and productivity objectives more effectively than generic initiatives which can scatter small packages of support across the economy. From an industry perspective, government listens, commits, acts and invests — drawing the interest and support of the hard-nosed business sceptic. In this policy environment, firms can reap tangible business-level benefits from close interaction with government (*see case study*).

In reality, this model has not been fully adopted by all Midlands agencies. Commitment to investing in aerospace through targeted clustering initiatives varies across the Midlands, as it does across the United Kingdom. The result in the Midlands is a different aerospace regional policy environment in the West and East Midlands. Advantage West Midlands commits specific budgets to specialist cluster support and invites groups of regional industry leaders from distinct clusters into the heart of policy-making to advise on the design and deployment of specialist support for each — in the aerospace case one outcome is a clear focus on supporting supply chains. In parallel, the agency actively tailors then targets a number of relevant more generic initiatives on the identified clusters. The East Midlands Development Agency initially supported a range of cluster initiatives in key industries, but after a review settled on a policy of providing generic support products to individual small businesses, making significant investments to support the leading aerospace company, and introducing an innovation strategy which groups aerospace in with other transport sectors. All these are useful interventions which the MAA supports, but they tend not to take account of the potential benefits of business clustering in the aerospace supply chain.

National policy weaves its own weft through the regional warp. Government initiatives on regional policy alternately support or ignore cluster agendas. Yet the significance of national policy to global competition in the aerospace industry cannot be underestimated: whether establishing macro-economic conditions such as currency values in an industry where business is done in US dollars, implementing industrial policies to preserve and grow strategic defence industries with big technology spin-offs into civil aerospace, investing in technology development where civil aerospace serves as a growth pole, or making state loans to the big aerospace companies to underpin their massive investments in 50 year aircraft programmes. For many years the UK aerospace industry has voiced its view that current success owes much to historical government intervention and that support has gradually become less strategically focused while other states across the world invest more heavily into active development of their aerospace clusters.

In this context the Midlands aerospace cluster is redoubling its efforts to tap available national industry and government programmes to benefit the region. Both regional agencies are making substantial investments in the national aerospace technology programmes with most impact on the Midlands, the Environmentally Friendly Engine technology demonstrator and Next Generation Composite Wing programme, directly funding companies like Rolls-Royce, Goodrich, GE Aviation and HS Marston. The MAA works to channel regional Manufacturing Advisory Service resources into supporting the industry-led national supply chain performance improvement programme, multiplying the effectiveness of the regional intervention by pulling in the resources of the large national customer companies. And while some industry leaders hold that regional fragmentation makes less sense in an era of globalisation, the MAA actively collaborates with peer aerospace groupings in other UK regions and nurtures links to carefully selected aerospace regions elsewhere in the world.

INJECTING LEADERSHIP

The Midlands confronts the acute dilemmas of globalisation that all regions face. Will its aerospace cluster suffer inevitable decline in favour of adept and agile new competitors in countries across the world that invest in their own clusters and use global transport and communications systems and the opening of world trade to secure positions in global aerospace markets? Or can its business and government partners build on its core strengths and, where necessary, stimulate the cluster's reinvention to make it fitter for a new global era?

To compete in world-wide markets, business has to become ever more sophisticated — more efficient, more innovative and more responsive. Michael Porter's point is that these attributes are best achieved by being located in a dynamic regional cluster. The Midlands aerospace industry retains significant competitive advantages by virtue of its core technological and management capabilities and its structure as a geographical cluster of inter-related companies, capabilities, institutions and people who share a common business culture. Proximity enables cluster participants to plug their companies into a web of specialised regional resources. Interaction and access, close relationships, sophisticated knowledge transfer, the incentives of permanent benchmarking, all these give cluster firms additional advantages in operations, innovation and entrepreneurship.

MAA members visit the factory of fellow member Unimerco.

MAA members meet global customers flown in from around the world by MAA and UKTI.

Midlands aerospace business and regional policy leaders have the aerospace cluster high on their agendas. In thinking "cluster" they will recognise the mutual dependence of cluster organisations and the collective opportunity they share for creating and enhancing the regional business environment. Of course, thinking this way can prove challenging for business and policy leaders who have risen through the ranks of engineering or finance functions on the one hand, or administrations on the other, and are more comfortable with clear structures and well-defined processes — or find it difficult enough to steer their own organisation through rapid external change in the market and policy environments. Cluster ideas may be uncomfortable for business leaders with a jaundiced 'us and them' world view in which every other business is a deadly rival and government just doesn't get it, or for public servants who believe business doesn't need help and for whom directly supporting citizens is a higher priority. They may seem counter-intuitive to leaders who presume that globalisation is making regions into relics. And to some in the public sector, engaging with industry may appear — just too difficult. Yet many Midlands aerospace and policy leaders are quietly working away with cluster concepts and putting those ideas into practice. They are developing new forms of collaboration that complement market competition. And they are recognising the significant role the Midlands aerospace cluster can play in achieving their goals if they mobilise its resources to succeed in the global economy.

MORE ABOUT CLUSTERS

There is a vast academic and practical literature on clusters and clustering. Good places to start are:

Michael E. Porter 'Clusters and the new economics of competition', *Harvard Business Review*, (November-December 1998). Still the most accessible and the inspiration for this paper.

Örjan Sölvell, Göran Lindqvist, Christian Ketels *The Cluster Initiative Greenbook* (2003). A compendium of cluster policy initiatives.

Department of Trade and Industry. *A Practical Guide to Cluster Development, Ecotec Research and Consulting* (2004). Government document for the English regional development agencies.

There are few published studies of aerospace clusters:

Jorge Nioshi and Majlinda Zhegu 'Aerospace clusters: local or global knowledge spillovers?' *Industry and Innovation*, 12(1) (2005).

Lublinski, A. E. 'Does geographic proximity matter? Evidence from clustered and non-clustered aeronautics firms in Germany', *Regional Studies*, 37(5) (2003).

ABOUT THE AUTHOR

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