Making a Success of the UK Industrial Manufacturing Base: The Impact on Defence and Aerospace

by Professor Andrew Graves

Andrew Graves is Director of the Innovative Manufacturing Research Centre in the School of Management at the University of Bath. Here he explains the importance of manufacturing in the UK economy, current weaknesses and foreign successes, and lays out a blueprint for a successful manufacturing base in the future.

This paper examines the current state of the UK Manufacturing Sector, with particular reference to the Aerospace and Defence Sector, and its prospects for survival against increasing global competition. The challenge for the sector is not only to compete against established competition from the United States, Japan and mainland Europe, but also against the increasing penetration by developing Asian and transition economies.

It is often argued that service sector growth and the ‘knowledge economy’ will replace traditional manufacturing as the key ‘engine for growth’ of the UK economy during the 21st Century; however, it is unclear exactly how these activities could possibly replace existing high-value jobs and create significant growth for the future.

The importance of manufacturing is often dismissed or marginalised when future industrial strategy is being formulated, and its crucial role in providing sustained growth is not fully appreciated. Manufacturing provides five key areas for wealth creation and growth by:

- Creating an infinite demand for manufactured goods.
- Driving innovation and technical change.
- Driving other sectors – powerful internal dynamic.
- Generating exports – balance of payments.
- Creating high-value jobs and support industries.

These wealth-creating attributes were the cornerstone of the British economy from the 19th Century through to the 20th. However, since the 1950s, Britain has been outperformed, first by the United States, Germany and Japan and recently by increased competition from Korea, China and, in the near future, by India and the transition states. Manufacturing as a percentage of GDP has declined from over 30% in the 1970s to under 14% today (see Figure 1).

The resulting crisis for innovation, high-value skilled jobs, support industries and the UK balance of payments should not be underestimated. The balance of payments deficit, once the obsession of politicians and industrialists, is now at record levels (see Figure 2).

World-Class Manufacturing

During the early 1980s, both the United States and Europe were threatened with increased numbers of manufactured goods from Japan. The Japanese industrial base was beginning to dominate key sectors such as consumer electronics, watches, cameras and...
motorcycles. It was clear that the European and US automobile industry was the next sector to be targeted, and to this end a programme of research was established entitled 'The International Motor Vehicle Programme' (IMVP), at the Massachusetts Institute of Technology (MIT). Funded by the EU, DTI, Department of Commerce and all the leading automobile companies, it set out to benchmark western performance against the Japanese auto manufacturers and suppliers. Metrics for factory operations, product development and supply chain performance were developed and by the late 1980s a ‘two to one’ performance gap was exposed between the Japanese producers and the rest of the world (see Figure 3).

These Japanese manufacturing techniques, pioneered by Toyota, were given the name ‘lean production’ to differentiate them from the existing best practice of ‘mass production’ as carried out by western manufacturers. Over the past 15 years western auto firms have focused upon closing the gap with considerable success. The rise of lean production has led to:

• Higher productivity.
• Reduced costs.
• Improved quality.
• Reduced cycle times.

However, whilst lean production has enabled western manufacturers to survive, the profitability of the industry is a significant concern. Most western firms have concentrated on improving their operations to the exclusion of optimising the whole supply and order chain. This has enabled them now to assemble a vehicle in a day, but the average order-to-delivery time is about 50 days. Clearly the customer cannot get the car they want when they want it!

Aerospace and Defence: Learning From the Auto Industry

Lean production, utilising only half the number of engineers and half the time to design and assemble an automobile, has been viewed by other sectors as a key management tool to effect change. In particular, the US Aerospace and Defense Sector, faced by the threat of decreasing defence budgets and escalating procurement costs, approached MIT in the early 1990s in order to establish a parallel programme of research led by the US Air Force and Department of Defense (see Figure 4).

Increased outsourcing of capacity, partially to low-cost regions, has led to the loss of core competence and knowledge. What may be a powerful business case, in the short term, will have significant consequences for capacity in the long term. In addition, western firms are actively helping to build potential competitors’ core competences, as design authority follows manufacturing capability. The consequence of this strategy is a reduced skill-base, as firms find increased difficulty in attracting both engineers and managers from the intellectual supply chain.

At present, China has labour costs which are a fraction of those in the West (see Figure 6). It is one of a number of countries that is developing aerospace excellence with the help of outsourcing from western firms.

China’s strategy is to compete in the civil aircraft market with Boeing and Airbus in the near future, and to this end it is utilising partnering agreements to access western technology and production capability. Japan also views both aerospace and defence as the next high-value sector, with Toyota and Honda recently becoming ‘new entrant’ players.

The Clockspeed Dilemma

In addition to the threats and weaknesses outlined above, the Aerospace and Defence Sector faces a fundamental problem when attracting both capital and human resources. Research undertaken both in the United States and the UK has recently focused upon cross-industry benchmarking, i.e. learning
This research has attempted to transfer ‘best-practice’ knowledge across sectors, particularly from the auto industry with lessons from the ‘lean producers’. Research from MIT by Professor Charles Fine highlights the competitive advantage obtained by firms who can demonstrate the fastest ‘clockspeed’ (see Figure 7).

Firms at the ‘slow end’ of the chain, for example the civil engineering sector (which spends more on litigation than R&D), find great difficulty in attracting both capital and world-class managers and engineers. Aerospace and defence, the next slowest sector to develop new products, has similar problems. Investments for new programmes usually have to be financed by government, through launch-aid agreements. Attracting engineers is difficult due to the often long gestation periods for new products. Engineers need to be in an exciting environment and see the results of their labours rewarded quickly. Automobiles have shown a significant improvement over the past decade, with model replacement cycles down from about 10 years, on average, to 18 months – thanks to the implementation of lean techniques pioneered by Toyota.

The fastest clockspeed industries are clearly information systems, i.e. Microsoft, Intel, etc. This sector produces new products and processes at an astonishing rate and can therefore attract global investment, which is returned to the markets with high returns for investors. In addition, it can attract world-class managers and engineers to the sector through its dynamic capacity for innovation.

The dilemma for the slow clockspeed firms is that they are not just competing against each other (e.g. Airbus v. Boeing) but against Dell or Microsoft for resources. This has been a wake-up call for many firms who believed they only had to achieve ‘best in class’.

What is to be Done? The Knowledge Economy Delusion

Many economists and policy makers now believe that the service sector and the ‘knowledge economy’ will replace manufacturing as the main engine for growth during the 21st Century. It is clear, however, that service sector jobs, financial services excluded, do not create wealth, but only redistribute existing resources. They are usually low-paid, requiring only semi-skilled capability, and often rely on government, through tax breaks or income support, to survive. This would be the road to a low-wage, low-growth economy.

The ‘knowledge economy’ is predicated upon the idea that the UK will somehow be able to compete globally through its excellence in design and innovation, while the rest of the world manufactures the products for our consumption. It is clear from the past that countries such as the United States, Germany, France and Japan have not been satisfied to be assemblers, but have climbed the value chain to command the high ground of research and development. Virtually no R&D has been transferred by the Japanese to the UK to complement their assembly plants, for example. The UK Government has recently declared an ambition to raise the level of R&D to 2.5% of GDP over the next decade; however, this will still leave the UK behind its major competitors. The emerging transition economies, and particularly China, do not intend to be low-cost producers, and to this end China is investing substantially in R&D across all sectors. It is therefore unclear why some economists believe that these emerging economies will need to access design and innovation from the UK particularly, as it has been demonstrated by the Japanese that innovation and technical change is a by-product of manufacturing.
Both are needed to progress to the next and higher level of performance. The UK still has great strength in its design and engineering consulting sector, but most of these firms are engaged in helping overseas competitors through technology transfer. This, at the present time, results in better and faster product development for firms that can then export high-value goods to the UK, thereby increasing the balance of payments deficit.

Manufacturing is therefore the key for sustained economic growth and to select only the high-value parts in an attempt to find competitive advantage is doomed to fail. So what is to be done?

Sir Richard Evans, ex-chairman of BAE Systems, addressed the key issue when he stated, ‘Productivity must be improved . . ., investment in research and development needs to be refocused on technologies in which Britain can lead the world, and greater effort made to “pull through” from basic research into leading-edge producers’.

More recently, a Deloitte report, entitled ‘The Ball’s in our Court – the UK Technology Sector at a Crucial Juncture’, argued that the UK has the potential to become one of the world’s pre-eminent technology nations. However, the research observed the lack of communication between different groups in the UK’s technology sector and the fact that universities have insufficient dialogue with large technology companies. Deloitte concluded: ‘Communicate, co-operate, collaborate’.

Recent research undertaken in the UK shows that the science base, largely represented by 128 universities, and the industrial base undertake little relevant research compared to our leading competitors. There exist few mechanisms to encourage universities, whose research agenda is largely determined by the Research Assessment Exercise, to engage with industry. The percentage of science and engineering graduates has been falling and an alarming skills shortage has been identified. The UK will soon be producing less than 20,000 engineering graduates per year (many will also be overseas students who will return home) against China’s 300,000 target. In addition, the numbers of mathematics, physics and chemistry graduates are now in serious decline.

‘Most of these firms are engaged in helping overseas competitors through technology transfer’

Research indicates that the UK’s major competitors do not suffer from this lack of capability. Mechanisms have been developed in order to access the science base in a structured and coherent way. Japanese manufacturers, for example, spend up to 15% of sales on R&D and have close relationships with regional universities. They can attract high-level students to work and be trained within the firm, in an exciting and rewarding environment. These on-line streams of the brightest students are highly regarded as professional engineers working at the forefront of innovation. They have access to state-of-the-art technology and use the ‘factory as a laboratory’ to innovate new products and processes. The results are self-evident in the world market.

In the United States, the leading technical universities such as MIT and Caltech work closely with industry across all disciplines. The Bank of Boston economic report states that companies founded by MIT graduates out of Cambridge would form the 24th largest economy in the world, employing over 1.1 million people in high-tech jobs and worth over $232Bn – about the GDP of South Africa or Thailand. Large global research programmes are able to bring together researchers from both the management and engineering disciplines to solve common problems. By acting as an ‘honest broker’ these teams are able to access research data, often unavailable to consultants, in partnership with industry, in the pursuit of new industrial paradigms. Laboratories and workshops in collaborative joint ventures turn new materials, processes and skills into proof-of-concept and scale-up demonstrators for industrial application.

In Germany, the Fraunhofer-Gesellschaft, established after World War Two, undertakes applied research of direct relevance to their industrial manufacturing sectors. 56 Fraunhofer are located at 40 different regions across Germany and they employ approximately 12,500 staff. They also have research centres that actively engage with the international research community. They are strategically placed between the university sector (science base) and industry and have been a crucial link in the intellectual and physical supply chain, enabling Germany to manufacture high-value goods for export at a level that now out-performs both the USA and Japan.

Research of Practical Utility

The Fraunhofers develop products and processes right up to commercial maturity. Individual solutions are sought in direct contact with the customer. Extensive internal collaboration ensures that the customer can call on the specialised expertise of all of the institutes when required.

In 2005 Fraunhofer registered 384 patents, ranking as number 10 of the
organisations applying for patents in Germany – more patents than Audi, GM or Porsche. The most prominent recent success story is MP3. The MP3 compression algorithm was invented by the Fraunhofer Institute for Integrated Circuits. Its licence revenues generated €100M in 2005.

All these examples expose the lack of capability in the UK between the science base and industry. Each example is different, but has been developed to meet the long-term objectives of global penetration of markets, export success and employment of a highly trained and rewarded workforce.

For the UK to compete against this background it will have to bridge the gap between academic research output in science, engineering and management to meet future industrial requirements.

Meeting the Challenge
The UK needs to meet the challenge from existing and emerging economies through knowledge generation and implementation. Lessons learned from the above examples offer the UK the opportunity to radically rethink its industrial policy, not by copying its competitors, but by delivering lean and focused solutions that meet the needs of UK industry and world markets. At the present time, large amounts of financial and human resources are spent on thousands of initiatives which are usually short-term solutions to yesterday’s problems. A co-located, industrial/academic team approach will be required to bring together multidisciplinary skills, new materials and lean processes in order to deliver proof-of-concept, scale-up and real costing solutions, as illustrated in Figure 8.

The centres could be located regionally on the Fraunhofer model and based upon lean production principles as described earlier. It would be the first example in the world of the application of this new model of translating knowledge of engineering, science and management across sectors – learning from fast clockspeed sectors. This would cross the divide between industry and academia, creating a new type of problem-solving community. The philosophy would be one of high competition/high reward, with greater flexibility of employment contracts and management structures. It would operate at an inter-university level and be open to schools and colleges with the objective of raising the profile and professional status of engineering and manufacturing. The centres would also support fundamental research as it relates to current problems of innovation in design and manufacture and would be able to educate a new technologically-literate workforce, thereby partly addressing the skills deficit.

Centres would not need additional funding, but a redirection of existing resources that are often wasted on small initiatives with little or no value. It would take a concerted effort by central and regional government, industry and academia to provide a national capability, built upon the notion of ‘joined-up government’ focused on a new business model for the 21st Century.

The UK’s economic, social and military security will only be secured through a strengthening of its scientific, technological and manufacturing base. This paper has argued for a fundamental reassessment of the relationship between basic and applied research and its commercialisation of new products and processes. The development of a dynamic, high-value manufacturing system for the 21st Century will require far-sighted government action and long-term planning.

The UK’s industrial base is now not dissimilar to those of Germany and Japan in the late 1940s. Both of these economies restructured to meet the challenges of the late 20th Century with great determination and have built robust business models that have challenged the rest of the world. To grow as a world-class economy, the UK must invest in dramatic change by government, industry and the education sector in order to regain its competitive strength amongst the new order of leading industrial nations.

The author would like to thank the following colleagues for their help and assistance with this paper: Professor Charles Fine (MIT), Markus Witthaut (Fraunhofer, Dortmund), Dr Glenn Parry, Ron Humphries, Janice Legge and Max Dickson (University of Bath) and finally, Sir John Harvey Jones for all his enthusiasm and knowledge regarding the importance of manufacturing. Any errors or omissions are of course the responsibility of the author.
Rolls-Royce UT vessel designs are world leaders in the offshore vessel market. Designed to meet customers’ needs, our vessels operate in a variety of coastguard and pollution control duties, ranging from submarine rescue and oil recovery to emergency towing. Each vessel is equipped with Rolls-Royce propulsion, positioning, motion control systems and when required, deck machinery. Integrated solutions, based on leading-edge products and supported by the world’s most comprehensive support network. From vessel design to equipment supply, Rolls-Royce delivers the right solutions.  

Trusted to deliver excellence

www.rolls-royce.com