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ADVANCED ENGINEERING (TRANSPORT) HORIZON PANEL REPORT

WINNING WAYS TO ENGINEER OUR FUTURE

PREPARED FOR MATRIX BY

PA Consulting Group

MATRIX PANEL MEMBERS

Alan Blair
Albert Sherrard
Bryan Keating
Clare Passmore
Colin Elliott
Damien McDonnell (Chair)
Ed Vernon
Frank Bryan
Gerry McCormac
Bernie Hannigan
Jim McLaughlin

ADVANCED ENGINEERING HORIZON PANEL MEMBERS

Colin Elliott (Chair)
Catherine Jones (Michelin)
David Beatty (Thales ADL)
Graeme Thompson (Schrader)
Julian Hine (UU)
Mark Nodder (Wrightbus)
Michael Maguire (Datum Design)
Patrick Hurst (Munster Simms)
Tim Brundle (UU)
Tom Edgar (QUB)
Tom Millar (QUB)
Gavin Campbell (Bombardier)

WINNING WAYS TO ENGINEER OUR FUTURE

NORTHERN IRELAND HAS A RICH AND OFTEN UNDERESTIMATED ENGINEERING AND INDUSTRIAL HISTORY.

Over many years, we established a vibrant manufacturing sector, designing and producing products for export all over the world, including complex machines for the processing of fabrics, state-of-the-art ships and aircraft - and even buses and cars.

Whilst the number of people employed in the engineering sector has reduced significantly over the last few decades, the fundamental skills and expertise base - which created the sector in the first instance - remains strong, with small and large companies producing increasingly more complex and higher value-added products.

However, it is widely recognised and accepted that Northern Ireland cannot compete with emerging economies in this sector on the basis of cost. The only way to ensure survival and create the opportunity for future growth is through increasing our value proposition, not only in the product itself, but in our support services also. Our future therefore rests in our ability to build a knowledge-based economy, placing our skills, creativity, expertise and innovation at its heart.

The Advanced Engineering (Transport) Horizon Panel brought together a number of experts from business and academia - many of whom are already involved in the exciting transformation that is already taking place in engineering and manufacturing - with the objective of identifying the means by which Northern Ireland can reclaim its position as a global leader in engineering.

Our opportunities are significant and our engineering entrepreneurs should seize on this report and support its proposal for a framework that will put business in the lead and ensure that our excellent research capabilities are successfully exploited and commercialised.

Crucially, if we get our strategy for Advanced Engineering right, the majority of future employment in this sector will be at the higher value-added end of the spectrum, not only in terms of the innovative new products designed, but by ensuring that we adopt state-of-the-art manufacturing technologies while making optimum use of automation and robotics to improve our efficiency, performance and competitiveness.

I would like to thank all the individuals and groups who provided expertise and time to assist with the production of this report. I would also like to acknowledge the work of Frank O'Donnell and Colm Reilly from PA Consulting, who diligently and enthusiastically co-ordinated industry consultations and ultimately played an important role in its production.

Colin Elliott
Advanced Engineering (Transport)
Horizon Panel

STRATEGIC
TECHNOLOGY
FORESIGHT
PROGRAMME

HORIZON

ADVANCED ENGINEERING (TRANSPORT) EXECUTIVE SUMMARY

EXECUTIVE SUMMARY

Context

Manufacturing makes an important contribution to the UK economy, accounting for 17% of GDP and about half of all UK exports. Northern Ireland has a strong tradition of manufacturing, in particular in the transport sector, such as ship, aircraft, bus and car production. While total employment in manufacturing has fallen in recent years (primarily as a result of cheaper international labour costs), the sector has increasingly engaged in high value-add areas such as innovation, design and development. It has begun to move from a focus on manufacturing capability that has been a traditional strength in Northern Ireland to a broader focus on 'Advanced Engineering'. For the sector to continue to develop, suppliers must continue this move up the value chain and embed advanced engineering capability across the sector to a point where competitive strength arises from integrating design, development and manufacture in a commercially effective manner. Further, it must use this capability to focus on key market opportunities of a global nature.

In support of this, the Advanced Engineering (Transport) Foresight panel was tasked with the identification of the sustainable market opportunities and the associated priority technologies in the Northern Ireland aerospace, automotive and transport sector. As a first stage, the panel identified the key challenges facing the sector. These included:

- Environmental considerations around reducing the energy and material costs of design, production, distribution, use and disposal of products
- Increasing passenger safety and security
- Continued economic pressures, including pressure to reduce costs in the supply chain
- Greater customer demand for the faster supply of more complex, customised and innovative solutions combining products and services.

The response

In response to the above challenges and having reviewed the capabilities of the Advanced Engineering (Transport) sector in Northern Ireland, the panel developed an overall vision for the sector in moving forward:

'WE WILL BUILD UPON EXISTING CAPABILITIES AND RELATIONSHIPS FOCUSING ON THE AEROSPACE AND AUTOMOTIVE INDUSTRIES TO TRANSFORM THE NORTHERN IRELAND ADVANCED ENGINEERING (TRANSPORT) SECTOR INTO ONE THAT IS FOCUSED ON HIGHER VALUE-ADD ACTIVITIES.

THE SECTOR WILL RESPOND TO THE KEY CHALLENGES AND IN PARTICULAR FOCUS ON THE MARKET OPPORTUNITY CREATED BY THE NEED FOR ENVIRONMENTALLY OPTIMAL PRODUCTS AND SERVICES WITHIN AUTOMOTIVE AND AEROSPACE SECTORS. THIS VISION WILL BE ACHIEVED THROUGH:

- GREATER EXPLOITATION OF INDUSTRY-LED APPLIED INNOVATION
- BETTER COLLABORATION ACROSS THE PRIVATE SECTOR, ACADEMIA AND GOVERNMENT, AND
- AN INCREASED FOCUS ON NICHE MARKETS TO DELIVER WORLD LEADING SOLUTIONS AND SERVICES FROM NORTHERN IRELAND.

The panel recognised that realising this vision required a focus on the key areas of science and technology that are most relevant to the sector and the challenges that it faced, and an integrated effort to ensure that the Northern Ireland sector was capable of exploiting this science and technology for commercial value.

Development of specific science and technology areas

Key to delivering high value-add activities will be the continued development and exploitation of genuine science and technology expertise in Northern Ireland. Given the diversity of the sector, the panel did not identify a single 'big bet' technology on which to focus; rather a number of core science/technology areas were highlighted, which can form the basis of the future for world class Advanced Engineering in Northern Ireland. These include:

- Technologies and approaches to support a cleaner, safer environment
- Advanced Materials, including biomaterials, nano-structured materials & composites
- Microsystems, embedded sensors and computational science
- Use of robotics/automation in the manufacturing process

Further detail on aspects for development in science and technology would be highlighted via the development of sectoral route maps and in collaboration with other Matrix panels. These would need to be reviewed on an on-going basis to test their relevance for the sector.

Delivering key capabilities to generate commercial value

The panel recognised that the expertise in science and technology was not enough to transform the industry. It identified a range of supporting actions that would ensure the transformation journey was achieved broadly across the sector without compromising the desire of any individual company to take their own specific route through this transformation process.

- **Creating and supporting the development of new business models**
  End-customers are becoming less interested in products and more engaged by overall solutions (often combining products and services). To deliver this type of thinking and action within the industry requires a range of mechanisms to be set in place to help integrate business, academia and Government on the focused delivery of relevant courses supported by leading research on the area.
- **Building advanced design and development capability**
  There is recognition of the need to move the Northern Ireland engineering sector up the value chain to allow it deliver 'knowledge-based engineering solutions'. To do this will require collaboration on the design and development of fully integrated engineering solutions, in particular effective knowledge management, driving excellence in optimising design for the complete product life cycle and prioritising investment on high value-add activities aimed at creation of Intellectual Property in Northern Ireland.
- **Fostering a globally ambitious SME base**
  There is a need to support the Advanced Engineering SME base in Northern Ireland in exploring possibilities outside of their traditional customer base. This will require mechanisms to ensure ambitious SMEs are engaged with the wider recommendations of the panel. In particular they need to be made aware of the threats and opportunities to the sector and the wider support programmes, including those that have been successful elsewhere in the UK.

Creating a community of technology interest

The panel recognised that in spite of the potential synergies among advanced engineering companies, there was a lack of effective sharing of ideas and opportunities. The panel therefore recommended the establishment of a focused community of interest, based on the development of recognised technology roadmaps that would include the brokerage of technology and business opportunities across the sector. The actions outlined above must be further supported by developing the right framework conditions within Northern Ireland that ensure appropriate focus on education, skills and training, and on the importance of innovation within the wider economic development strategies of the region.

CONTENTS

INTRODUCTION

THE PANEL WAS BROUGHT TOGETHER BY DEPARTMENT OF ENTERPRISE, TRADE AND ENVESTMENT TO EXPLORE THE FUTURE CHALLENGES AND OPPORTUNITIES FOR NORTHERN IRELAND, FOCUSING ON IMPROVED PERFORMANCE IN RESEARCH AND DEVELOPMENT AND EFFECTIVE EXPLOITATION OF THE NORTHERN IRELAND SCIENCE BASE. THIS SECTION INTRODUCES THE WORK OF THE PANEL AND SETS OUT THE FOCUS OF THIS REPORT.

1

1.1 BACKGROUND

MATRIX, the Northern Ireland Science Industry panel, is a business led expert panel formed to advise the Department of Enterprise, Trade and Investment (DETI) on how Northern Ireland's research and development (R&D) and science and technology can be better used for maximum economic, commercial and social advantage. It is led by representatives from high-technology and R&D intensive industries and advises the Northern Ireland Government on the development of improved interfaces between business and the research, science and technology base.

'Horizon' is MATRIX's flagship strategic technology foresight programme. Horizon seeks to build on the successes of previous rounds of Northern Ireland foresighting and to identify the key technologies which will be of specific commercial value to the Northern Ireland economy in five, 10 and 15 years. It is a rolling programme to inform both Northern Ireland Government policy and private sector business planning to ensure that the region is best placed to exploit future commercial opportunities arising from its R&D and science and technology base.

The Horizon programme was established with five further Foresight Panels established along the same conditions as the Advanced Engineering (Transport) panel and covering:

1 Agri-food
2 Advanced Engineering (Transport)
3 Advanced Materials
4 Life and Health Sciences
5 Information Communication Technologies (ICT).

Each Panel was chaired by a member of MATRIX with the suitable experience and qualifications in the sector. Horizon Panels reported to plenary MATRIX meetings as they progressed, with MATRIX Panel members providing a broad base of expert quality assurance through debate and analysis to help shape overall findings.

1.2 TRANSPORT PANEL

The Transport Panel was established in June 2007. Panel members included:

- **Colin Elliot**, Vice President of Engineering and Business Development, Bombardier Aerospace (Chair)
- **David Beatty**, Vice President Strategy and Business Development, Thales Air Defence
- **Gavin Campbell**, Director Design Engineering & Technology Development, Bombardier Aerospace
- **Graeme Thompson**, Finance Director, Schrader Electronics
- **Julian Hine**, Translink Chair of Transport, University of Ulster
- **Kathy Jones**, Head of Quality, Michelin
- **Mark Nodder**, Group Managing Director, The Wright Group
- **Michael Maguire**, Joint Managing Director, Datum Tool Design
- **Patrick Hurst**, Managing Director, Munster Simms Engineering
- **Tim Brundle**, Director of Innovation, University of Ulster
- **Tom Edgar**, Director of the Northern Ireland Technology Centre, Queens University Belfast
- **Tom Millar**, Dean of the Engineering and Physical Sciences faculty, Queens University Belfast

The Panel was tasked with the identification of the sustainable market opportunities and the associated priority technologies in the Northern Ireland Advanced Engineering (Transport) area. The Panel were also asked to identify wider global science and technology innovations which will present genuine opportunities for exploitation or adaptation by Northern Ireland businesses, setting out future priorities in the context of short, medium and long term objectives, along with recommendations as to how these objectives can be achieved.

One of the first areas of consideration was the scope of coverage of the Panel. While initially established as a 'Transport Panel' with a focus on aerospace and automotive, it was recognised that many of the key issues affecting the sector (for example transport security, cost, efficiency and customisation) were common across all transport modes. Further the materials, design, development and manufacturing techniques used in one mode are being increasingly applied in other modes. Finally it was recognised that while manufacturing is important for Northern Ireland, this capability (particularly in the transport sector) does not sufficiently reflect the shift in focus from labour intensive industry to a knowledge intensive one. The future of the industry is going to be built upon excellence in design and development, where significant intellectual property is developed within Northern Ireland, and on integrating these with more advanced manufacturing techniques, i.e. Advanced Engineering. This both builds on existing capability and extends it to become a competitive strength on a global stage. On this basis it was agreed that a more appropriate panel title was the 'Advanced Engineering (Transport) Panel.'

In parallel to this work and to support the wider work of all Panels, DETI undertook a review of the science and technology capabilities in Northern Ireland[1]. The report, resulting from this review, presents an analysis of key sector capability, assessing existing Northern Ireland research and technology strengths in terms of scientific capability and the potential for exploitation across six sector based technology areas.

The sectors[2] selected reflect the UK Technology Strategy that was launched by the Department of Trade and Industry, and considering the specifics of the Northern Ireland economy in terms of:

- Advanced Manufacturing;
- Advanced Materials;
- Sustainable Production and Consumption (including energy technologies)[3];
- Life Sciences;
- Information and Communications Technology (ICT); and
- Electronics and Photonics.

The work of the Advanced Engineering (Transport) Panel draws particularly on the review of Advanced Manufacturing and Advanced Materials sectors, but also on the other Panels as indications of capability that can be exploited in partnership with this sector and of opportunities that arise of a cross sector and multidisciplinary nature.

1. Technology Capabilities Study for Northern Ireland, MATRIX, 2007.
2. The classification of companies in each sector is relatively subjective as companies can be classified in many ways. However; the view of the Technologies Capabilities Report was that the capability is essential to be captured.
3. Energy technologies were included in the Sustainable Production and Consumption sector in relation to the activities carried out in those sectors.

1.3 THIS REPORT

This report presents the outcome of the Advanced Engineering (Transport) Panel's activities from June 2007 to February 2008 and reflects a number of specific tasks undertaken across seven workshops:

- The identification of Strengths, Weaknesses, Opportunities and Threats related to the sector reflecting on the Capabilities study's findings on specific scientific and exploitation strengths
- The identification of key market, policy, regulatory and local issues driving change across the sector and the implications for specific sector areas
- The identification of the overall vision for the sector and articulation of the high-level changes required to achieve this vision
- The development of key focus areas, based on the overall vision, that represent a common industry view and reflect the challenge for the sector over the next five to 15 years that present genuine opportunities for exploitation or adaptation by Northern Ireland's Advanced Engineering sector
- The development of key recommendations on how these focus areas can be addressed, in particular focusing on the capabilities that need to be developed. These capabilities will be related to the existing strengths as defined in the MATRIX Technology Capabilities Study.

This report is in three further chapters as follows:

- Chapter 2 presents an overview of the sector, including an assessment of the current sector capability.
- Chapter 3 identifies the key drivers and challenges facing the sector in Northern Ireland.
- Chapter 4 presents the vision for the sector and recommendations on how to realise this vision.

On the basis of the above, Chapter 4 sets out a number of conclusions regarding the current position of the Northern Ireland Advanced Engineering (Transport) sector and opportunities for development. Chapter 4 also identifies a number of actions (in terms of Panel recommendations) to help the sector develop these opportunities.

SECTOR OVERVIEW

WITHIN THIS SECTION WE CONSIDER MANUFACTURING AS A BROAD SECTOR, BOTH WITHIN NORTHERN IRELAND AND MORE GLOBALLY SETTING THE CONTEXT FOR THE WORK OF THE PANEL. WE REFLECT ON SOME OF THE KEY STATISTICS RELATING TO NORTHERN IRELAND AND THE WIDER GLOBAL CONTEXT, DRAWING OUT THE KEY TRENDS AND THE IMPLICATIONS FOR THE FUTURE OF THE SECTOR.

2

2.1 MANUFACTURING AND ADVANCED ENGINEERING

THE MANUFACTURING SECTOR IN NORTHERN IRELAND IS PERHAPS THE MOST DISPARATE, BOTH IN TERMS OF SIZE AND SPECIALITY, OF ALL THE SECTORS IN NORTHERN IRELAND, AS CLASSIFIED IN GENERAL INDUSTRY STATISTICS. THE GENERAL PERCEPTION OF A DECLINE IN MANUFACTURING MASKS A MORE COMPLEX STORY WHERE WE SEE DECLINE IN EMPLOYMENT BALANCED BY AN INCREASE IN OVERALL VALUE OF EXPORTS AND GREATER VALUE-ADD ACROSS THE SECTOR.

Manufacturing in its purest sense refers to the transformation of raw materials into finished goods for sale, or intermediate processes involving the production or finishing of semi-manufactured items. Some industries, like semiconductor and steel manufacturers use the term fabrication. Competitive advantage in manufacturing has traditionally been defined by the capability to develop and deploy efficient and high quality manufacturing processes. However, this is no longer a differentiator on the global stage and the focus has shifted to deal with the range and integration of concept-to-customer processes involved in making a better product (in terms of function, sustainability, maintainability, lifecycle) suitable for more immediate use at a cheaper cost. This draws on a range of Advanced Engineering techniques such as Computer Aided Design, Concurrent Engineering, Design Coordination, Process Control and Instrumentation etc. It is a critical aspect of many industrial sectors. Generally, manufacturers must cope with rapid changes in markets including workforce, process, and technology changes while operating in a dynamic, competitive, and global environment. They deal with this environment by selectively focusing their resources and efforts to sustain competitive advantage. They pursue partnerships for research and development and for supply and production functions that they cannot efficiently accomplish themselves.

Manufacturing is, and will continue to be, of significance to Northern Ireland, despite recent public contributions that believe that manufacturing is not viable here. It is important to remember that manufacturing effectively enables the services sector. Hence, while direct manufacturing employment is likely to continue to fall, the nature of the remaining jobs will be of higher value as the manufacturing economy in Northern Ireland will have to change from one that competes on cost, to one that has unique innovation and technological strengths in key technology areas embedded within its supply chain[4].

4. Future of UK Manufacturing / DTI / 2005

2.2 THE NORTHERN IRELAND CONTEXT

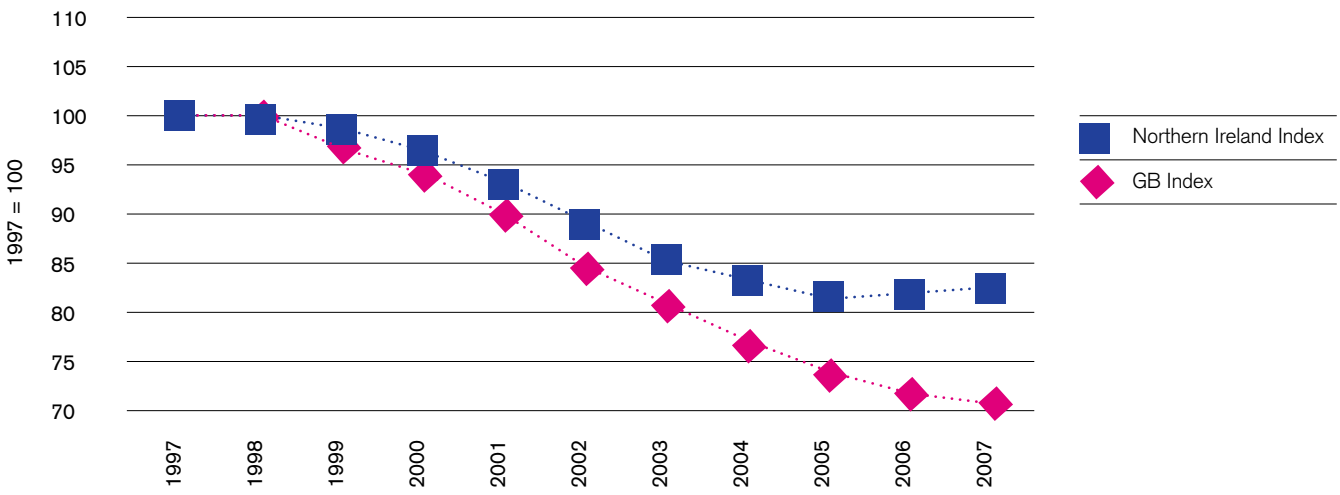
Northern Ireland has a tradition of strength in manufacturing, primarily based within the shipbuilding and textile industries, but the level of employment across the area has declined significantly since the early 70's[5]. This is reflective of the broader trend in manufacturing and the particular focus within Northern Ireland on shipbuilding and textiles. However, Northern Ireland has been successful in increasing employment outside of these traditional focus sectors and on average there have been 2000 manufacturing jobs created each year from 1998 - 2005[6].

Recent statistics released by DETI illustrate the overall employment trend (Figure 1) and show that Northern Ireland is comparing well, within a GB context, in terms of manufacturing employment. The reduction within Northern Ireland is lower than the GB average, although the large decline in Manufacture of Textiles and Wearing Apparel sectors has impacted on the structure of Northern Ireland manufacturing jobs. In 1997, just over 20% of manufacturing jobs were located in the Textiles and Wearing Apparel sectors; by 2007 this had fallen to only 4%.

The trend in output is more positive and although the increases have slowed in recent years, sales have continued on a positive trend (Figure 2) as illustrated in the recent results of the DETI Northern Ireland Manufacturing Sales and Export Survey (Dec 2007) where:

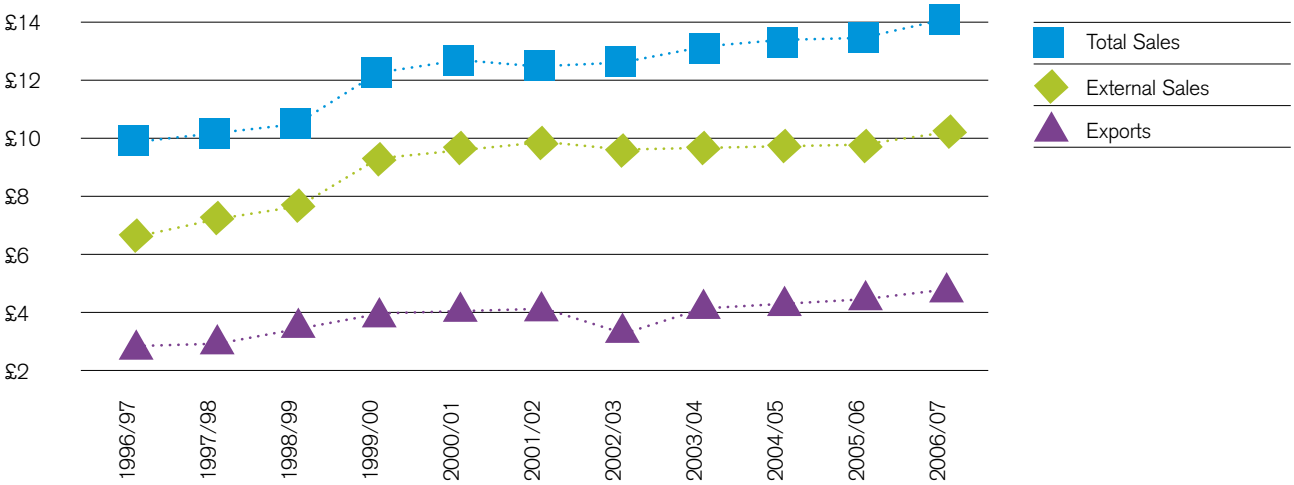
- In current prices: Total manufacturing worth £14.8 billion in 06/07: a current price increase of 6.3% (£866 million) over the year and rise of 12.3% over five year period 01/02 to 06/07.
- In 06/07, 76.0% sales made to customers outside Northern Ireland (external sales) - equates to £11.2 billion, an increase of £610 million over the year.
- Sales outside the UK (exports) worth £5.1 billion, increase of 6.2% over the year and 23.1% over 5 year period.
- In constant prices: when considered in real terms, has been an increase in total sales of 4.3% (£611 million), and increase of 4.0% in external sales (£435 million) whereas sales to GB declined (-0.2% over the year).
- Overall exports have increased by 9.6% over the year: to ROI, Rest of EU, Rest of World up 15.5%, 7.4%, 7.3% respectively
- However, rate of growth in exports slightly lower than three years ago when annual increase was 12.7%

FIGURE 1: MANUFACTURING JOBS FOR NORTHERN IRELAND AND GB INDEXED (SEPTEMBER OF EACH YEAR)[7]



5. Manufacturing employment in Northern Ireland has approximately halved between the early seventies and the start of this decade. (source: DETI, NS).
6. DETI Northern Ireland - The Future Role of Manufacturing in Northern Ireland, 2005.
7. Monthly Labour Market Report Feb 2008 (DETI).

FIGURE 2: VALUE OF SALES, EXTERNAL SALES AND EXPORTS, 1996/97 TO 2006/07[8]

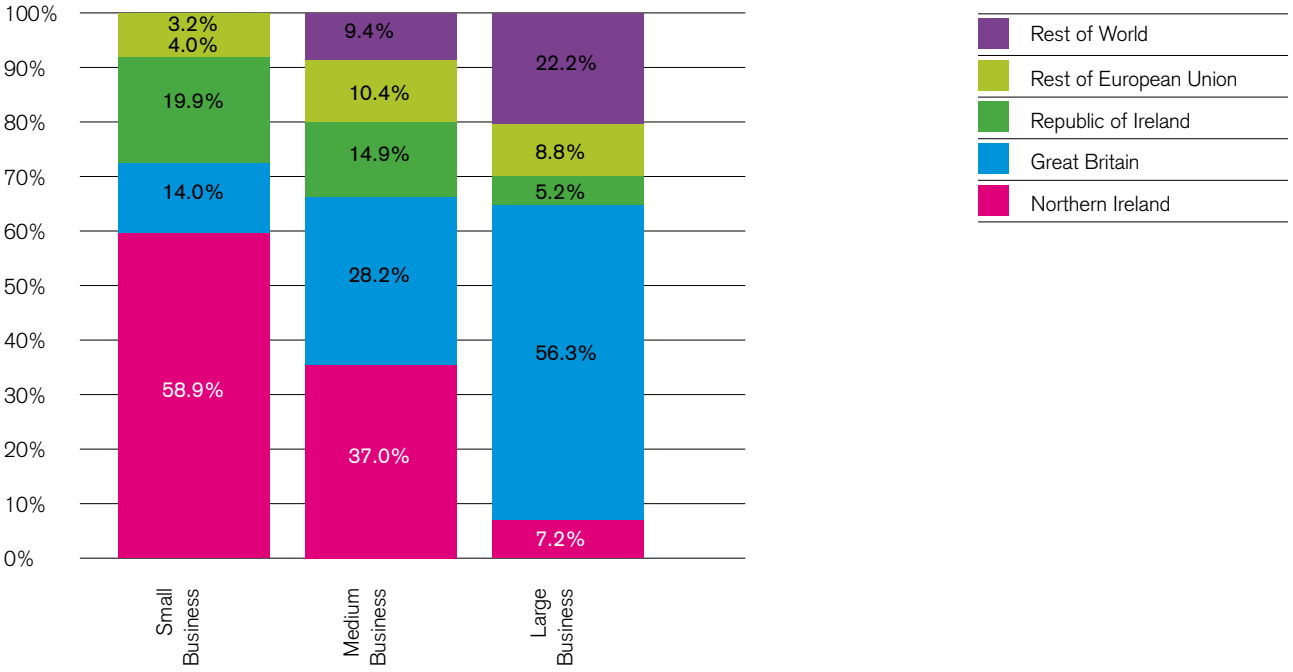


The profile of Northern Ireland companies is heavily SME based and they have a dominant focus for sales within the internal Northern Ireland market, as illustrated in Figure 3. SMEs are inherently less able to absorb the scientific and technology capability in the region through investment in R&D and while the main issue is often funding; the internal (Northern Ireland) market focus compounds this through limiting their international links. It is increasingly recognised that innovation is driven by greater 'connectedness' of companies within the wider economy and in this case by drawing in ideas and capabilities from outside Northern Ireland.

The overall trend in the Northern Ireland context has been one of reduced employment across the sector but a gradual increase in the level of value-add activities and employment growth outside of traditional sectors such as textiles. There is no single manufacturing sector that is showing exceptional potential for growth within Northern Ireland and there is a need to consider where future growth is likely to come from and to create a greater degree of focus within specific areas. These areas should draw on the particular market reach of Northern Ireland companies and further exploit the scientific and technological strengths within the research base.

8. DETI - Northern Ireland Manufacturing Sales & Export Survey (Dec 2007).

FIGURE 3: SALES BY DESTINATION & SIZE OF BUSINESS[9]



9. ibid

2.3 GLOBAL TRENDS

The future of the manufacturing sector in Europe and worldwide has had much attention with many of the general trends being equally relevant in a Northern Ireland context. Major stories constantly focused on trade, European jobs and the perceived loss of the European manufacturing and industrial base due to off shoring or outsourcing of white-collar, back-office, and technology jobs and the future role of manufacturing in the national economies of all European countries have dominated the agenda.

Since mass manufacturing began, many changes have been made in the way products are designed and manufactured. It has always been that a new technology offers both a remedy and a threat to manufacturing, e.g. the introduction of robotics within assembly lines creates a competitive advantage for those that invest and grasp the opportunity and is a competitive threat to those that remain reliant on manual labour.

In the future, a broader definition of the term 'manufacturing' will encompass an integrated system that includes the whole cycle of creation, production, distribution and end-of-life treatment of goods and product/services, and this cycle will be based within a customer/user driven innovation system. This trend is evident within the focus of the Panel and has been an underlying theme across the deliberations of the Panel.

Additionally, the importance of Advanced Materials in the manufacturing sector will continue to be a significant factor in competitiveness. Generally, Advanced Materials can aid improvements in productivity, quality and cost and in many cases these materials create opportunities for new product functionality and characteristics. An example is the use of composite materials within aircraft manufacture, where radically enhanced strength to weight ratios are possible along with the possibility of noise reduction (over traditional materials) during manufacture and assembly operations.

Ironically, the key enabler in this field is not Advanced Materials per se, but rather computational science that underpins their development. Computational science supports the simulations, statistical analysis and testing of the essence of how Advanced Materials will behave in preparation, processing and manufacturing. Through associated theoretical prediction and optimisation, it creates the conditions to reduce prototyping stages in product design and dramatically reduce lead-times in product development cycles, thereby reducing costs. More significantly, these modelling tools should be capable of also ascertaining the lowest cost mechanism of development through theoretical prediction and optimisation. Through these mechanisms, manufacturing can reduce costs and contribute to a sustainable economy.

The nature of the global economy is such that new demands are being placed on manufacturing industries. The timescale of product conception and development is shifting from the long to the shorter term - and ultimately to a near real-time response in some cases. The technologies that will have the biggest influence on manufacturing are based on molecular manufacturing which will use new biomaterials and bio-processing, microelectromechanical systems (MEMS), free form fabrication and newer IT control technologies through improved computers. However, it will be essential to understand that no technology forecast works for manufacturing unless considered in the total picture of other influencing factors - skills, innovation, knowledge management, customer relationships and life-cycle waste reduction.

There are eight major trends within Advanced Manufacturing which Northern Ireland must play to and these are:

- Movement away from mass production to semi-customisation. For example, there will be specific treatments for specific diseases as opposed to broad spectrum treatments. This will lead to lower volume, higher margin products with specific lifecycles in R&D, prototyping, use of computational science (see below) and scale up
- Shift away from centralised production location to distributed production sites. This will be enabled by the ability to create Lab on a Chip (LOC) technological solutions and to move away from clean room environments to less costly bases of production
- Shift away from centralised business control of production towards collaboration between production
- Outsourcing will continue to grow, particularly in the medical device sector. In 2006 this stood at 6% compared to 90% in the electronics sector. It was confined to low margin products but China is manufacturing more complex products
- Advanced Manufacturing techniques (lifecycle analysis, green and lean culture) will gain greater adoption levels
- The manufacturing sector will sub-divide into smaller, distributed specialised companies, which will plug into different networks in the global supply chain to find and use particular technologies; then disengage
- To be able to play in the new manufacturing supply chain, companies in high cost economies must be able to create and retain IP whilst manufacturing elsewhere. China will be the major mass manufacturer of mature technologies by 2020
- The new manufacturing environment will demand an extremely adaptive workforce, with fewer operatives and higher skilled people who will be constantly learning through academic / industry switchovers.

These trends are enabled by the shift in manufacturing towards Advanced Engineering and the leveraging of new technologies related to Advanced Materials and ICT.

2.4 CURRENT NORTHERN IRELAND CAPABILITY

In developing the future focus for the Advanced Engineering (Transport) sector, the Panel took into account the current state of capability, in relation to science and technology development and exploitation, as defined in the MATRIX Technology Capability study. The following section presents a summary of that study focusing on the capabilities within Advanced Manufacturing[10] in Northern Ireland.

Advanced Manufacturing in Northern Ireland is highly variable but is considered to have a number of key characteristics such as:

- Generally strong supply chain;
- Strong University links in certain specific areas (e.g. prototyping, advanced materials);
- Strong UK Branding;
- High levels of responsiveness and flexibility;
- High employee turnover; and
- High levels of Government support.

Productivity in manufacturing is among the lowest of any UK region. Latest figures show that Northern Ireland is also the poorest performer in overall terms of all UK regions on productivity and employment rate[11]. Within the manufacturing sector there are particular issues that are creating pressure to change:

- Supply chain is increasingly price sensitive;
- Eroding competitive position due to rising costs;
- Continuing need for increased productivity;

On the skills side, it is recognised that there is a need for stronger linkages between the skills agenda and the innovation agendas. Skills availability and the perception of engineering and technology as a profession, together with graduate retention schemes and appropriate training offerings, are seen as key issues.

10 This was the broad term used within the Technology Capabilities Study for Northern Ireland, MATRIX, 2007
11 DETI, Quarterly Economic Review, Winter 2007

2.5 PRIVATE SECTOR

The Matrix Panel, in its study of technology capability in Advanced Manufacturing, decided to use the following sub-fields in order to understand the sector strengths as set out in Table 1.

TABLE 1: THE SUB-FIELDS THAT ARE USED TO UNDERSTAND CAPABILITY WITHIN NORTHERN IRELAND MANUFACTURING.

ADVANCED MANUFACTURING SUB FIELDS	DESCRIPTION
Traditional Manufacturing	This refers to a traditional manufacturing process and mechanisms whereby traditional products are made using well documented and existing technologies. There is relatively no degree of innovation or focus on improvement.
Lean and Sustainable Manufacturing Processes	This refers to 'lean manufacturing' techniques and processes which demonstrate resource efficient, low cost and sustainable manufacturing processes.
ICT	This refers to new business models introduced by the advent of ICTs and refers to new collaborative manufacturing environments, networked business processes (integrated supply chains) and services 'value added' support for products.
Design, Simulation and Validation	This refers to new design techniques that are used for: • Resilience, reliability and maintainability; • Simulation and modelling of advanced structures and processes including micro and nano level type components; • Design for complete lifecycle including assembly, disassembly and recycling; • Large scale systems validation including testing, inspection, trend analysis etc.
Advanced Manufacturing Technologies and Processes	This refers to a number of recent developments in manufacturing which have advanced it into: • Rapid prototyping / flexible production; • Advanced forming and assembly tools and techniques; • New processes and processing technologies including self-assembly, bioprocesses etc; • New intelligent instrumentation and control techniques.
Computational Science	Computational Science is an interdisciplinary field which addresses biological problems using computational techniques. Computational science supports the simulations, statistical analysis and testing of the essence of how Advanced Materials will behave in preparation, processing and manufacturing.

The capabilities within companies in this area are analysed from this perspective. Key companies investing in R&D and exploiting scientific and technological capabilities for competitive advantage include Thales Air Defence Ltd (formerly Shorts Missile Systems), FG Wilson, Schrader Electronics, Quinn Manufacturing Ltd, Bombardier Aerospace, Wrightbus and Ulster Carpet Mills (Holdings) Ltd.

The analysis of the leading capability companies in Northern Ireland shows that there are demonstrable strengths in a number of distinct areas and these are:

- Fundamental Advanced Materials knowledge and the incorporation of these materials into the product supply chain at relatively low costs, for example there is considerable work on composites as a way to gain greater strength to weight ratios and improve efficiencies;
- Advanced product design and a 'systems' approach to engineering which builds the design concept into the overall supply chain (raw materials, production through to shipment);
- Advanced process control and management in the manufacturing process remains a key strength of all the highly competitive companies in Northern Ireland;
- The ability to rapidly and cost effectively apply new innovations and technologies to scale. For example, there are companies demonstrating capabilities with fuel cells and hybrid technologies. Additionally, some companies are successful through the acquisition of new technology (at a global level) and applying this technology, at scale, to their own operations;
- The leading companies tend to work in multi-disciplinary teams which recognise a distinct functional competence but also see the need to create new approaches to existing problems[12].

12. This reports acknowledges that the culture and environment in companies in never perfect, however these are the key driving issues.

2.6 ACADEMIC SECTOR

Within the academic sector there is also a well developed and diverse set of capabilities with regards to Advanced Manufacturing in both universities, and this is summarised in Table 2. It should be noted that the numeric references in this table refer to the unique numeric reference given to the research institute/group.

There are key capabilities within the Northern Ireland HE sector, which with the equipment to support them, creates a very strong capability in Aerospace, Nanotechnology, Build Environment, Electrical and Electronic manufacturing, Design and Manufacturing and Computational Science. It is also apparent that there are emerging strengths in Energy and Sensors. It is noticeable that the range of skills and capabilities is greater than those utilised in the current sector itself implying that there is some misalignment between them.

With regards to FE, Table 3 lists the HFE courses, the number of students enrolled in them and their locations, that are of relevance to the Advanced Manufacturing sector. It shows that there is quite a level of diversity in both the types of courses available and their locations, which is important as FE students are much less mobile than HE students. It also shows that the total number of students in FE, at this time, undertaking manufacturing related courses exceeds 5,500.

TABLE 2: SUMMARY OF CAPABILITY IN THE HE SECTOR IN THE DOMAIN OF ADVANCED MANUFACTURING.

NO	INSTITUTION/GROUP	LOCATION
1	Northern Ireland Technology Centre	QUB
2	Polymer Processing Research Centre	QUB
3	Knowledge Transfer Centre	QUB
6	The Institute of Electronics, Communications and Information Technology (ECIT) - System on Chip	QUB
17	Electrical Power and Energy Systems	QUB
19	Intelligent Systems and Control	QUB
20	Knowledge and Data Engineering	QUB
23	Atomistic Simulation	QUB
29	Design and Manufacturing	QUB
30	Centre of Excellence for Integrated Aircraft Technologies (CEIAT)	QUB
31	Internal Combustion Engines and Gas Turbines (ICERG)	QUB
41	Build Environment	QUB
56	Information Engineering Research Group	UU
58	Intelligent Systems Engineering Laboratory	UU
64	Centre for Sustainable Technologies	UU
65	Northern Ireland Centre for Energy Research and Technology	UU
68	Electrodes and Sensors Group	UU
71	Engineering Composites Research Centre (ECRC)	UU
72	Advanced Metal Forming Research Group	UU
73	Nanotec Northern Ireland	QUB/UU

TABLE 3: SUMMARY OF CAPABILITY IN THE FE SECTOR IN THE DOMAIN OF ADVANCED MANUFACTURING

SUBJECT CODE OF COURSE	TOTAL	LOCATION
General Engineering	654	Armagh, Castlereagh, Causeway, East Antrim, East Tyrone, Limavady, Lisburn, Newry & Kilkeel, North East, North West, Omagh, Upper Bann
Integrated Engineering	621	BIFHE, Castlereagh, Causeway, East Tyrone, Fermanagh, Newry & Kilkeel, North East, North West, Upper Bann
Refrigeration	128	Castlereagh, East Antrim, Fermanagh, Limavady, Lisburn
Computer Aided Engineering	122	Fermanagh, North East, North West
Others in General Engineering	54	East Antrim, North West
Civil Engineering	223	BIFHE, North West, Omagh, Upper Bann
Mechanical Engineering	545	Armagh, BIFHE, Causeway, East Antrim, East Down, Fermanagh, Limavady, Lisburn, North East, North West, Omagh, Upper Bann
Mechanisms & Machines	8	Upper Bann
Agricultural Mechanics	83	Omagh, Upper Bann
Engineering: Automobile/Motor Vehicle	1,306	Armagh, BIFHE, Causeway, East Antrim, East Down, Fermanagh, Limavady, Lisburn, Newry & Kilkeel, North Down & Ards, North East, North West, Omagh, Upper Bann
Automobile Assessment	8	BIFHE
Motor Cycle Engineering	20	Castlereagh
Vehicle Bodywork	122	Fermanagh, North East, North West
Road Transport Engineering	54	East Antrim, North West
Motor Vehicle Electronics	50	BIFHE, East Antrim, Fermanagh, North East, North West
Mechanical/Electromechanical Engineering	128	Castlereagh, East Antrim, Fermanagh, Limavady, Lisburn
Mechanical/Production Engineering	21	East Antrim
Others in Mechanical Engineering	108	Castlereagh, North West, Omagh
Aeronautical Engineering	58	BIFHE
Aerospace Studies	52	BIFHE
Engineering Design & Manufacture	300	BIFHE, North Down & Ards, North West
Manufacturing Engineering	215	BIFHE, Lisburn
Fabrication Engineering Craft Practice	115	BIFHE, East Antrim, North West,Upper Bann
Mechanical Engineering & Maintenance	183	BIFHE, Lisburn
Sheet Metal Work	9	Upper Bann
Welding	198	BIFHE, East Antrim, East Tyrone, Limavady, Omagh, Upper Bann
Others in Production Engineering	21	BIFHE, Newry & Kilkeel
Plant/Process Engineering	10	BIFHE
Other Engineering	197	BIFHE, Castelreagh, Causeway, East Tyrone, Limavady, Lisburn, North East, North West, Omagh, Upper Bann
Sum	**5,613**	

2.7 SUMMARY

Manufacturing is a key element of the Northern Ireland economy and across the UK[13] and improving the sustainability and growth of the sector remains an important challenge to be addressed here. The sector itself is becoming increasingly sophisticated and knowledge-based, resulting in a trend towards higher overall contribution to GVA despite reducing employment levels.

The nature of the industry base in Northern Ireland, composed primarily of SMEs, presents particular challenges to increasing levels of innovation and R&D and gaining greater connectedness internationally. While many SMEs are grasping the challenges of the new higher value demands, others remain more reliant on local markets and traditional business models. However, there are several larger companies that are successfully engaged in R&D and moving up the value chain within their individual business areas. These represent important focus points for the industry more generally and often create a bridge between global markets and the local base.

The academic sector provides a rich source of capability across Advanced Engineering disciplines both from a research and teaching perspective. The continued development of this capability, with improved focus on the particular needs of industry in Northern Ireland and balancing this with the more global perspective of sector based research, is critical to future success of Northern Ireland.

13. Manufacturing is responsible for over half of UK exports and makes up approximately a sixth of GDP

ISSUES DRIVING THE SECTOR

THE ADVANCED ENGINEERING SECTOR IN NORTHERN IRELAND FACES A RANGE OF CHALLENGES TO ITS POSITION. THE IMPLICATIONS OF THESE CHALLENGES CAN BE CONSIDERED AS THREATS TO THE EXISTING MARKET POSITION OF THOSE BASED IN THE SECTOR, OR OPPORTUNITIES TO BE GRASPED THROUGH DEVELOPMENT OF NEW AND IMPROVED PRODUCTS AND SERVICES.

THIS SECTION CATALOGUES THE KEY CHALLENGES FOR THE SECTOR AS IDENTIFIED BY THE PANEL. IT IS NOT INTENDED TO BE COMPREHENSIVE BUT FOCUSES ON THOSE CONSIDERED OF GREATEST IMPORTANCE IN THE CURRENT MARKET.

3

3.1 ENVIRONMENTAL

3.1.1 THE ISSUE

Issues of an environmental nature increasingly pervade all aspects of business and in this area are key to future competitiveness. The environmental challenge relates primarily to reducing the energy and material costs of design, production, distribution, use and disposal. The Panel highlighted three specific environmental challenges, namely:

- Reducing emissions - in terms of the transport sector these primarily relate to reducing emissions of the transport mode, which makes a significant contribution to overall emissions. For example, in the UK, road transport accounts for around 22% of all CO2 emissions, while air transport accounts for a further 3%. The Panel also recognised that there is pressure to reduce emissions around the production process itself. Some emissions targets are regulatory, for example the EURO 5 Emission Limits for passenger cars and light duty vehicles. Others are self-imposed, for example the European aviation industry has set their own environmental goals for new aircraft emissions by 2020 (compared to a 2000 benchmark) of:
- Reducing CO2 emissions by 50% per passenger kilometre
- Reducing NOx emissions by 80%
- Reducing perceived aircraft noise by 50%
- In terms of cars, manufacturers are required (under various EU Directives) to provide information on CO2 emissions (as well as fuel efficiency) as part of the EU energy labelling scheme. This increases visibility of information on emissions to consumers and raises the profile of environmental issues with customers.

The sector recognises that such multi-faceted emissions targets represent a significant engineering challenge that will not be easily overcome. For example reducing CO2, NOx and noise in aeroplanes introduces a further step-change in complexity - conventional engineering design indicates that decreasing CO2 for an engine is likely to increase NOx, whilst decreasing noise increases CO2. There is expectation that to deliver these will therefore requiring novel engineering solutions outside conventional design thinking

Energy efficiency - this relates to a number of elements, including:

- The desire to reduce weight in the mode of transport. This is particularly relevant in the aerospace industry where there are significant gains to be had, e.g. for long distance passenger routes the weight of fuel exceeds the weight of the empty plane. By increasing the efficiency of engines the deadweight of fuel can be reduced, thereby increasing the overall fuel economy
- The increasing cost of oil-based fuels, for example the above inflation increase in crude oil price from under $20 a barrel in 2002 to around $100 a barrel in early 2008. This reflects both a growing demand for oil and the increasing cost of extracting more marginal reserves. The Panel's expectation is that the price of oil will be one of the main drivers of innovation in the sector
- A desire to exploit (both for cost and environmental reasons) alternative fuel sources (including bio-fuels and hydrogen) and electric-based/hybrid engines. These will be increasingly viable as the price of oil continues to rise

Waste reduction/recycling - this relates to:

- Minimising waste, surplus and bi-product materials from the manufacturing process. This is particularly the case for advanced materials, which tend to be more expensive than traditional materials and, in some cases, are less easy to store and re-use
- Where waste materials are produced that they are in a form that is manageable (i.e. they are stable, non-toxic and can be safely disposed of). This is becoming increasingly challenging and costly as the regulations around waste disposal become more stringent.
- Designing in capacity for future upgrade/ modification/refit such that a product may have several life cycles. This is particularly relevant as customers adopt new business models. For example, many bus operators

3.1.2 THE SECTOR RESPONSE

are required by local authorities to have buses no older than seven years old. Operators must therefore replace their fleet once it reaches seven years old, regardless of condition. Given this, there is a supply of second hand buses (most of which have a useful lifetime of 12-15 years) that are seven years old. To resell these buses may require them to be modified and all of this must be taken into consideration during design to provide competitive products/solutions.

- Designing in disposal/recyclability after end-of-product life. This reflects changing consumer requirements (in particular more environmentally conscious), value of scrap and the need to meet regulations (for example the End-of-Life Vehicles Regulations 2003).

The Panel highlighted the environmental challenge as the largest single issue for the sector in Northern Ireland (and indeed to the transport sector worldwide) and the potential for greatest opportunity in terms of leadership. This does not mean that it should be the only focus of the sector; rather that it provides the greatest stimulus for change.

The Panel members highlighted that these environmental challenges are likely to see a greater emphasis on 'design for environment' (i.e. manufacturability, reuse, efficient disposal, etc.), in particular:

Greater focus on reducing emissions and increasing efficiencies.

Greater use of alternative materials and fuels, both in the production process and in the end products.

More emphasis of modular design for reuse.

Greater account taken of end of life disassembly.

Total life cycle management to be considered during design to optimise solutions with respect to the relevant life phases.

3.2 SAFETY AND SECURITY

3.2.1 THE ISSUE

In terms of safety, the risk of injury on any form of transport is low. For example, in the UK, even the most dangerous types of transport (cars) have less than 120 fatalities for every billion kilometres travelled. The relative risk varies depending on how people choose to travel; figures show that public transport is safer than personal motorised forms of transport such as cars, and motorbikes have the highest risk of fatalities. In general, transport safety can be enhanced through:

- Education of transport users (for example driver training and testing). This is a role that historically government have undertaken, however, with increasing in-vehicle telematics there will be opportunities for providing feedback to drivers on driving styles. In this role, accurate vehicle sensing devices will be key
- Enforcement by authorities of regulations (for example, in terms of car regulations around speeding and drink-driving). Again this is a role that government have undertaken, although there are opportunities for soft enforcement (for example with the introduction of alcolocks and intelligent speed adaptation devices)
- Engineering, which includes both reactive safety measures (providing infrastructure to make collisions more survivable, e.g. airbags in cars, crash barriers on roads) and, increasingly, proactive safety measures (such as vehicle proximity sensing devices).

While safety of individuals has increased significantly over the last 20 years, there is greater emphasis on safety from consumers, consumer groups and transport providers. This has been supported with greater visibility on safety, for example through organisations such as Euro NCAP providing consumers with standard information on the safety rating of vehicles (relating to occupant, child and pedestrian protection).

The attacks in the USA in September 2001 (aeroplane), Madrid in March 2004 (rail) and London in July 2005 (bus and underground) have changed the context for transport security around the world. Security, and in particular responding to the threat of terrorism, has become, and is likely to remain, a major factor in the development of transport infrastructure and systems for the foreseeable future. In addition to this, there is an ongoing demand from the public for public transport providers to create safer, more secure and more comfortable environments on transport.

The consequence is that transport operators/ users are requiring:

- Tamper-proof infrastructure
- Vandal-proof materials which are still comfortable and aesthetically pleasing (for example seat covers on buses)
- Intelligent surveillance of both the infrastructure and public transport users
- Survivability in the event of an incident.

3.2.2
THE SECTOR RESPONSE

The Panel members highlighted that in spite of increasing transport safety and the relatively low security risk, these factors were becoming more important for consumers and hence for those in the Advanced Engineering (Transport) sector. The response needed from the sector is to develop safety and security systems that make incidents both more survivable and less likely, in a way that does not place unreasonable costs on operators and the travelling public.

In practical terms the Panel highlighted that 'design for safety and security' would mean greater emphasis on:

The use of new materials and better design to increase survivability

Use of vehicle telematics/intelligent transport systems to reduce the chance of collision

Use of monitoring systems to collect more information on passengers in transit.

3.3 ECONOMICS

3.3.1 THE ISSUE

The Panel highlighted a range of economic factors which are continuing to impact on the Advanced Engineering (Transport) sector, including:

- Globalisation, brought about by the more rapid and easier movement of goods, services, technologies, capital and knowledge between countries, with particular emphasis on the growth of India and China as competing nations. This presents both opportunities and threats for the Northern Ireland Advanced Engineering (Transport) sector. In terms of opportunities, globalisation increases the potential market for Northern Irish goods and services significantly. Threats from globalisation include:
  - Lower labour costs, including both skilled and unskilled labour, which provides a cheaper cost base particularly in relation to manufacture and assembly focused operations.
  - Increased demand for limited raw materials forcing up raw material prices. In these circumstances larger operations tend to have better negotiating position than smaller ones. Given that the Northern Ireland Advanced Engineering (Transport) sector has a large number of SMEs, this is a potential threat to the success of the sector.
  - Inequalities in the application of regulation, in particular that some countries do not have infrastructure and mechanisms in place to ensure that appropriate regulations are complied with and copyright/patents are followed. Operators in these countries may be able to leverage competitive advantage simply through not following required regulations and laws and not incurring the costs to do so.
  - Larger customer base, which makes it more expensive to engage with and understand the requirements of a wider range of potential customers. Not only are there more potential customers, they are more geographically dispersed.
  - Commoditisation. Competing against a wider range of organisations means that it is more difficult for the Northern Ireland Advanced Engineering (Transport) sector to differentiate itself from other providers. There is a risk of being viewed as commodity engineers with no specific insight or experience.
- Continued pressure on margins across the economy with better communications and transparency of information allowing buyers to compare supplier prices more easily, and hence drive margins down.
- Consolidation. The Panel identified that in a global economy it can be more difficult for small and medium-sized enterprises (SMEs) to compete on the international stage simply because they are small.

3.3.2 THE SECTOR RESPONSE

The Panel highlighted that the economic challenge was not a new one for the sector - globalisation, pressure on margins and consolidation are not new phenomena. However, these challenges are combining with others (environment, safety and security and changing customer demands) to create a critical situation for the Advanced Engineering (Transport) sector in Northern Ireland.

One of the implications of combined environmental, safety and economic pressures is that customers of the Advanced Engineering sector are seeking more from the materials used, specifically they are demanding, lighter, stronger and more affordable materials. The use of traditional materials (steel, aluminium and plastics) is being challenged by the need for:

Lighter materials, specifically to reduce weight whilst maintaining strength, thereby contributing to improved fuel efficiency

Better surface properties, in particular increased resistance to wear and contact damage

Materials that can operate at much higher temperatures and pressures.

From the manufacturing side, there is also a need for cheaper materials that are easier to manage during the manufacturing process.

3.4 CHANGING CUSTOMER DEMANDS

3.4.1 THE ISSUE

New business models and evolving customer requirements are placing a number of significant challenges on the transport supply chain, including:

- Customers are increasingly seeking more sophisticated and innovative ways of buying, primarily moving away from buying products to leasing or buying managed services. For example:
  - Some tyre manufacturers are providing 'tyre solutions' to fleets whereby they charge on the basis of per mile rather than per tyre
  - Rolls Royce provides a fixed engine maintenance cost ('power by the hour') over an extended period of time. Operators are assured of an accurate cost projection and avoid the costs associated with unscheduled maintenance actions
- Customers want to be supplied faster, with much shorter times from design to delivery
- Customers do not want generic products, rather they want customised products to meet a range of frequently changing needs
- Customers are seeking greater flexibility from the production process, often from multiple organisations
- There is significant ongoing industry restructuring, which is resulting in geographic dispersion away from 'traditional' core centres of production to a more global engineering solution. At the same time, there is a requirement to produce more complex and innovative engineering solutions, the consequence being that producers are required to be more flexible across wider geographies to deliver more complex solutions (often to a shorter timescale).

3.4.2
THE SECTOR RESPONSE

The move to new business models, with faster turnaround times, greater customisation and a more flexible approach to production represents a significant challenge to the Northern Ireland Advanced Engineering (Transport) sector, in particular the SMEs operating within the sector. To meet these challenges will require:

Excellent access to and relationships with a range of parties across the production process, in particular Primes and Tier 1 organisations

Organisations to have a better understanding of the value of their products/services to businesses and how this value relates to other elements of the supply chain within the overall business model

A more flexible approach to the supply chain process, both in terms of who organisations work with and what organisations do. This flexibility must respond to (and indeed pre-empt) developments in customer requirements

3.5 FRAMEWORK ISSUES

3.5.1 THE ISSUE

The Advanced Engineering (Transport) sector is a truly global sector and as such Northern Ireland is in direct competition with other countries to be the regional and indeed global base for operations of individual companies. Northern Ireland therefore needs to have the right 'ecosystem' to create and support successful Advanced Engineering companies. This should build on current strengths, reduce bureaucratic obstacles, provide an attractive fiscal environment, have appropriate logistical infrastructure and provide good standards of education and lifelong learning opportunities for potential employees.

These issues are not unique to Advanced Engineering (Transport) sector and many could be applied to any sector in any country. These generic issues are referred to as 'framework issues'. During the assessment of challenges to the sector, the Panel highlighted a number of framework issues, namely:

- Skills base, in particular the lack of suitably skilled and qualified staff in Northern Ireland. The Panel highlighted that this was in part due to the poor image of engineering as a career and (consequently) the lack of students entering tertiary education for engineering-related degrees.
- The level of research and development expenditure (both government and private sector) in Northern Ireland is low and insufficient to drive the industry.
- There is a general lack of local collaboration and knowledge sharing across the sector, in particular between SMEs.
- Local congestion, in particular the increasing congestion in Northern Ireland. While this was not highlighted as a major issue for movement of goods, it was highlighted as a factor that is increasing travel times for staff and hence potentially reducing the catchment area for companies to recruit from.
- Fiscal system, unlike any other part of the UK, Northern Ireland is the only region of the UK with a land border and this is to a low-tax economy. The Republic of Ireland enjoys a more advantageous business taxation and rating systems. The issues around this have been covered elsewhere.[14]

14. www.hm-treasury.gov.uk/media/1/3/varney171207.pdf

3.5.2
THE SECTOR RESPONSE

The Panel recognised that the sector needs to:

- Support and develop the local skills base.
- Encourage greater levels of research and development expenditure.
- Stimulate greater links across the sector, both between private sector organisations (in particular SMEs) and between private sector organisations and academia.
- Develop fiscal arrangements that support investment and put Northern Ireland on a par with the Republic.

CONCLUSIONS & RECOMMENDATIONS

SECTION 2 SET OUT A CLEAR STATEMENT AS TO THE CAPABILITIES OF THE ADVANCED ENGINEERING (TRANSPORT) SECTOR, WHILE SECTION 3 IDENTIFIED A NUMBER OF KEY CHALLENGES. THE PANEL CONSIDERED THESE AND, ON THIS BASIS, DREW A NUMBER OF CONCLUSIONS AND DEVELOPED A SET OF RECOMMENDATIONS ON THE WAY FORWARD FOR THE SECTOR. THESE ARE DISCUSSED IN THIS SECTION

4

4.1 CONCLUSIONS

On the basis on the work carried out during the Panel sessions and the parallel activity within the Technology Capabilities Study the Panel agreed that the Advanced Engineering (Transport) sector remained an important contributor to the overall Northern Ireland economy. Further, they found that:

- The focus of the sector should be on building upon existing capabilities and relationships (with customers, academia and other suppliers) to further develop the sector generally and create a specific focus on the existing strengths in aerospace and automotive industries
- The existing research base, both within academia and a small percentage of the business base, provided an important platform on which to build the future of the industry and finding an effective means of bringing these together in productive partnerships was key
- The environmental challenge is the largest single challenge to/opportunity for the sector in Northern Ireland (and indeed to the transport sector worldwide). This does not mean that it should be the only focus of the sector; rather that it provides the greatest stimulus for change
- The sector faces a number of other challenges and opportunities, namely:
  - Safety, while safety of individuals has increased significantly over the last 20 years, there is greater emphasis on safety from consumers, consumer groups and transport providers
  - Greater transport security, including tamper-proof infrastructure, vandal-proof materials, which are still comfortable and aesthetically pleasing, intelligent surveillance of both the infrastructure and public transport users and greater survivability in the event of an incident
  - Economic factors, including continued globalisation, pressure on margins, and consolidation
  - Changing customer demands, with customers increasingly seeking more sophisticated and innovative ways of buying, in a faster more flexible manner
- The skills and capabilities within the sector are relevant to other sectors, for example the Energy Sector and the Advanced Materials sector. There is thus potential for diversification, where necessary and appropriate
- There are a number of framework issues that need to be addressed to ensure the future success of the sector in Northern Ireland. These include a poor skills base, low levels of investment in R&D, the lack of local collaboration and knowledge sharing across the sector and fiscal challenges.

4.2 VISION

The status quo is unacceptable - the sector needs to change its value proposition if it is to continue to remain viable. This was illustrated in Figure 4 how the Panel members saw their business developing in the short term against a set of axes as set out below. The general consensus of the Panel demonstrated a shift towards greater focus on innovation and exploring new markets, while retaining all that is valued within existing activity. That is, while it is possible, and indeed likely, for the companies to exist within different quadrants, the direction of travel illustrated by the arrows provides an overview of where the future investment and opportunity lies.

On this basis, the Panel developed the following vision for the Advanced Engineering (Transport) sector:

'We will build upon existing capabilities and relationships focusing on the aerospace and automotive industries to transform the Northern Ireland Advanced Engineering (Transport) sector into one that is focused on higher value-add activities.

The sector will respond to the key challenges and in particular focus on the market opportunity created by the need for environmentally optimal products and services within Automotive and Aerospace sectors.

This vision will be achieved through:

- **Greater exploitation of industry-led applied innovation**
- **Better collaboration across the private sector, academia and government, and**
- **An increased focus on specialist markets to deliver world leading solutions and services from Northern Ireland.'**

Key elements are as follows:

Build upon existing capabilities and relationships
The Panel recognised that it is neither practical nor desirable to develop new areas and/or relationships. Rather they identified that Northern Ireland's existing engineering capabilities (in particular in aerospace and automotive) provide a strong base upon which to develop.

Transform
The pace of change globally in the sector is such that the Advanced Engineering (Transport) sector in Northern Ireland cannot afford to develop slowly. The Panel stressed the need for urgency - any advantage that Northern Ireland possess in this sector needs to be developed rapidly before competitor regions catch up.

Focus
The Advanced Engineering (Transport) sector in Northern Ireland has historically pursued and delivered a range of diverse elements. In a market that is becoming more complex (more flexible, greater degree of customisation) and has an increasing number of suppliers (making it more difficult to differentiate against others), the sector in Northern Ireland needs to move away from a generalist approach to focus on specific areas (which may be defined by value rather than sub-sector [e.g. aviation] or activity [e.g. design]).

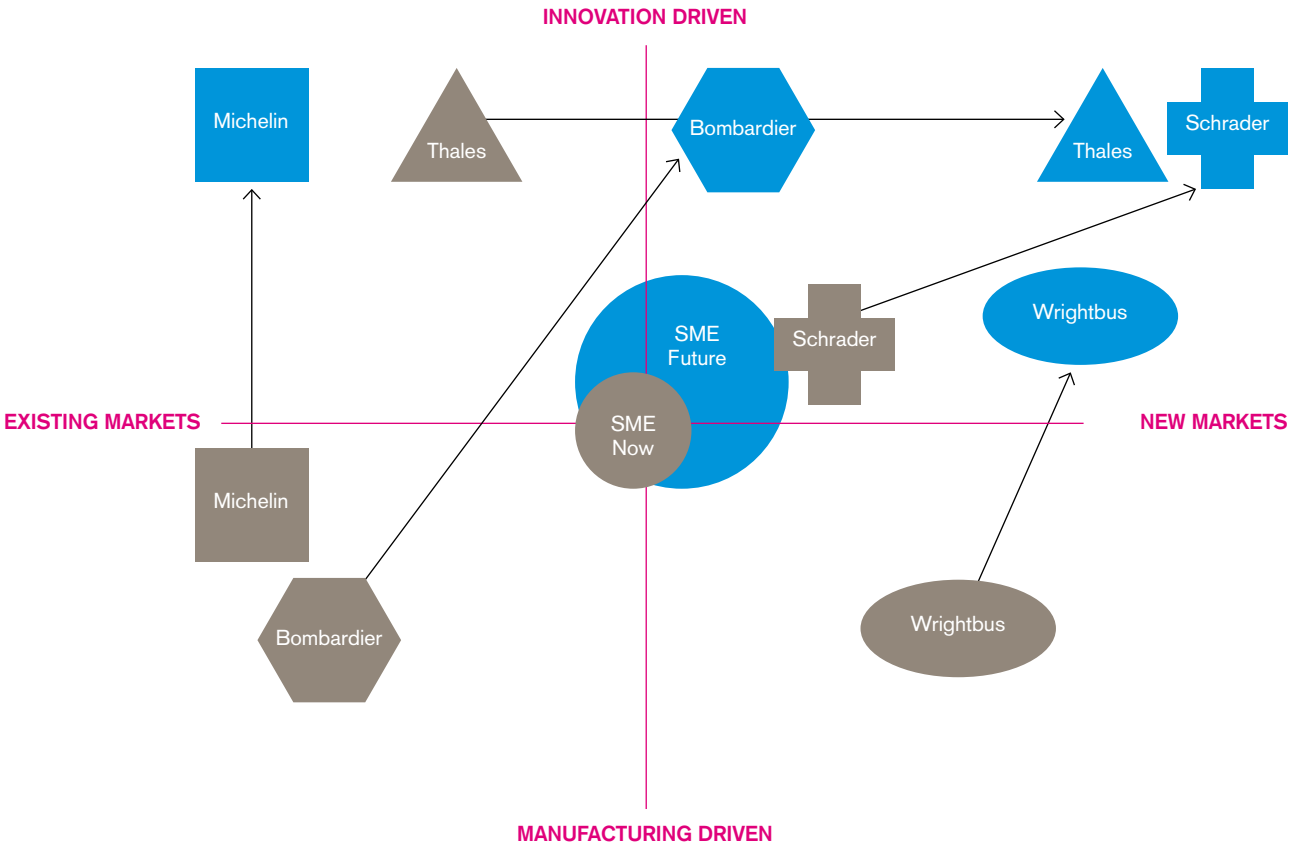
Develop higher value-add activities
The Panel recognised that in a global economy Northern Ireland cannot afford to compete against others on the bases of low-cost, low-value, commoditised activities - Northern Ireland will only lose out to economies with much lower wage levels. The sector must therefore focus on those areas, where there are opportunities to apply expertise to build upon sector expertise and experience, to create higher value-add.

Create more industry-led R&D
The Panel highlighted the need for greater collaboration (covered below) to provide value-add, but this can only be really effective where it is driven from a commercial perspective rather than an academic basis.

Collaborate
To deliver innovation and to meet evolving customer demands (in particular the challenge of new business models) the Panel identified the need to adopt more collaborative approaches across the sector. This will involve close working both within the sector (private company to private company) and between the sector and academia.

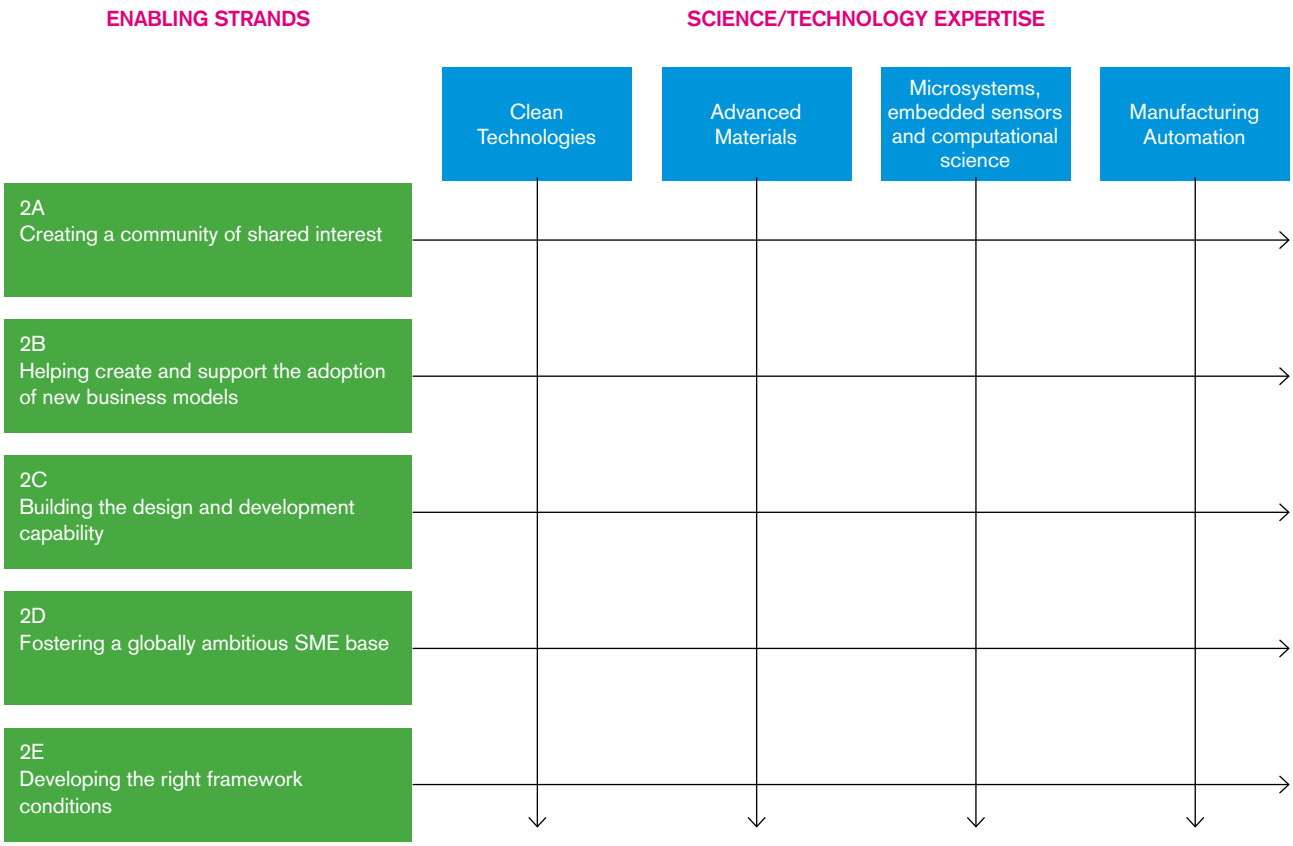
Exploit need for specialist solutions
The Panel highlighted that it was unlikely Northern Ireland companies will be able to lead across mass market areas in terms of scale but that there will be continued opportunity within these markets for specialist solutions and customised goods and Northern Ireland must have the capability and flexibility to respond.

FIGURE 4: THE DIRECTION OF CHANGE FOR KEY NORTHERN IRELAND ADVANCED ENGINEERING COMPANIES



4.3 RECOMMENDATIONS

FIGURE 5: AREAS OF EXPERTISE AND ENABLING STRANDS OF ACTIVITY



To realise this vision, as shown in Figure 5 above, the Panel identified two broad themes that need to be addressed:

- The development of specific science and technology expertise
- The delivery of supporting activities which act as 'enabling strands' to help the Advanced Engineering (Transport) sector in Northern Ireland exploit this science & technology expertise. The delivery of supporting activities is fundamental to the realisation of the vision, as shown above.

The Panel members highlighted the need to build upon and exploit the momentum and interest developed through MATRIX. Thus, while no timescales are attached to the recommendations below, the Panel stressed the need to move quickly and action these recommendations. Failure to do this will further erode Northern Ireland's competitive advantage.

4.3.1 THE DEVELOPMENT OF SPECIFIC SCIENCE & TECHNOLOGY EXPERTISE

Key to delivering high value-add activities will be the continued development of genuine science and technology expertise in Northern Ireland. Given the diversity of the sector, the Panel did not focus on a single 'big bet' technology; rather a number of core science/technology areas were highlighted, which can form the basis of the future for world class Advanced Engineering in Northern Ireland.

These include:

- Technologies to support a cleaner, safer environment
- Advanced Materials, including biomaterials, nano-structured materials & composites
- Microsystems, embedded sensors and computational science
- Use of robotics/automation in the manufacturing process
- Further detail on aspects for development in science and technology would be highlighted via the development of sectoral route maps and in collaboration with other MATRIX Panels. These would need to be reviewed on an ongoing basis to test their relevance for the sector.

4.3.2 THE DELIVERY OF SUPPORTING ACTIVITIES

The Panel recognised that development of genuine science and technology expertise in Northern Ireland would not be enough. To address this, a number of recommendations were made around:

- Creating a community of shared interest
- Helping create and support the adoption of new business models
- Building the design and development capability
- Fostering a globally ambitious SME base
- Developing the right framework conditions

A key theme that cuts across many of the recommendations is that to develop and exploit high-value products and services the sector will need to move from a single-organisation, manufacturing-based approach to a collaborative, solution-based perspective.

Creating a community of shared interest

Key to collaboration is having a community of interest - combining the private sector, academia and government - to allow thoughts, ideas, insights and opportunities to be shared in a way that is mutually beneficial. This, as either a formal or informal group, does not currently exist in Northern Ireland. The Panel, therefore, recommends establishing a community of interest with a particular focus on science and technology. This community will seek to support the Advanced Engineering (Transport) sector in Northern Ireland, though will have relevance to other sectors. Their objective would be to facilitate better exchange of information and intelligence either to provide better understanding of likely trends for the sector or to pursue specific business opportunities. Specifically this community would:

- Provide a directory of:
  - Organisations active in the sector and contacts within these organisations
  - Activities undertaken by these organisations and
  - Marketing opportunities, for example trade events, conferences or business opportunities
- Share understanding of draft/emerging regulations (in particular European regulations) before they are enacted. This would allow a wider group of organisations in Northern Ireland to start planning in a proactive manner for emerging regulations, thereby improving their competitive advantage
- Develop and share 'road maps' of likely technology developments for the sector, presenting a sectoral view as to the likely technology developments (some of which will be in response to draft/emerging regulations). These road maps could be used in a number of ways, for example ensuring that HFE courses/research better reflects emerging themes, helping ensure that research proposals are closely aligned with likely sectoral development and providing a heads-up to SMEs as to the emerging technologies
- Provide a technology and business opportunity brokerage service. With the adoption of innovative business models, there will be a need to provide organisations with a means to 'exchange' technology and business opportunities without compromising intellectual property rights
- Provide a brokerage for any 'surplus' materials. Panel members recognised that some organisations regularly generated surplus materials from the manufacturing process. These may traditionally have been treated as waste but could be of use to other organisations, for example for prototyping/product development. This is particularly the case for Advanced Materials
- Provide brokerage for Advanced Materials for SMEs. Taking the above step a stage further, the Panel recognised the need to help organisations, in particular SMEs, in sourcing Advanced Materials
- Provide a rapid means of sourcing student/researcher placements. The Panel recognised that there was an overhead associated with sourcing student/researcher placements and that if this was managed centrally this overhead could be reduced. A community of shared interest could provide a means for rapidly and simply gaining access to a list of student/researcher placements who could help, in particular SMEs, with product development and innovation

- Provide an efficient means of showcasing ideas to venture capitalists. Similar to the above recommendation, the Panel acknowledged that such a community of interest could provide a means to showcase ideas to venture capitalists/ funders.

One of the key challenges for the community of interest is to encourage and incentivise sharing and collaboration in a way that:

- Is win-win for all organisations involved - the value of the community will only be realised if all relevant companies, academic organisations and public sector have trust in the mechanisms and encourages the right behaviours
- Does not compromise intellectual property rights
- Works for the benefit of the sector in Northern Ireland but recognises that companies and research bases outside Northern Ireland may contribute.

Helping create and support the adoption of new business models

As identified above, new and innovative business models for the sector require a significant shift in focus from products to overall customer solutions (which combines products and services). To deliver this requires mechanisms to be set in place to help integrate business and engineering thinking across the private sector, academia and government. In the Northern Ireland context, the Panel recognised that there were a number of aspects to this, specifically:

- Funding research on business model development (including IPR and legal issues)
- Sharing exemplars of new business models across the community of interest

Building the design and development capability

The Panel recognised the need to move up the value chain from primarily manufacturing to designing and delivering 'knowledge-based engineering solutions'. To do this will require collaboration on the design and development of fully integrated engineering solutions, including:

- Delivering effective knowledge management to support inter-company work across the supply chain in areas such as market and customer requirements, roadmaps, standards, regulatory requirements and forthcoming legislation/ regulations. The community of interest aspect identified this above
- Establishing a centre (or focus for industry led research activity) to develop and deploy a set of tools, methods and approaches for optimising 'design for X' (where X reflects a range of desire outcomes, such as assembly, reuse and sustainability)
- Prioritising support on high value-added engineering activities that increases intellectual property creation in Northern Ireland and capability and capacity in the supply chain
- Developing a programme to enhance business modelling and technology planning capability.

Panel members identified that to deliver these may require a specialist organisation - something akin to Draper Laboratories in the USA - to be set up to act as the focus for thinking and development.

DRAPER LABORATORY WAS ORIGINALLY SET UP WITHIN MASSACHUSETTS INSTITUTE OF TECHNOLOGY (MIT). IT IS NOW AN INDEPENDENT, NOT-FOR-PROFIT RESEARCH AND DEVELOPMENT CORPORATION. IT CURRENTLY EMPLOYS MORE THAN 750 ENGINEERS, SCIENTISTS, AND TECHNICIANS IN A BROAD ARRAY OF PROGRAMMES FOR GOVERNMENT AND COMMERCIAL SPONSORS. FURTHERMORE, THROUGH THEIR COMMITMENT TO ADVANCED TECHNICAL EDUCATION, THEY EMPLOY 55 TO 60 GRADUATE STUDENTS, LARGELY FROM MIT.

Draper Laboratory's mission is to serve the national interest in applied research, engineering development, education, and technology transfer by

- Helping sponsors clarify their requirements and conceptualise innovative solutions to their problems
- Demonstrating those solutions through the design and development of fieldable engineering prototypes
- Transitioning products and processes to industry for production, and providing follow-on support
- Promoting and supporting advanced technical education

As a not-for-profit, R&D Laboratory, Draper has freedom to work on problems that are considered too risky or too early to attract commercial industry funding. They develop prototype systems and technologies, demonstrate that they are feasible, and transition the technology to industry for volume production.

Draper Laboratory has an Independent Research & Development (IR&D) and Corporate Sponsored Research Programs to enable them to continuously refresh core competencies and apply those capabilities to current sponsored work as well as to new programs.

Fostering a globally ambitious SME base
The Panel highlighted that Northern Ireland has some excellent Advanced Engineering capability which provides a sound basis for growth. Much of this capability however, is within SMEs and based on a manufacturing capability that Northern Ireland no longer has a lead or competitive advantage on. Further, where SMEs have the desire to innovate, it is a relatively costly process and typically they lack the available resources to explore opportunities away from their traditional customer base.

The Panel recognised that to exploit and develop the Advanced Engineering capability of SMEs will require mechanisms to ensure that they are appropriately engaged within the wider recommendations of the Panel. The Panel therefore made very specific recommendations targeted at developing the SME capability in Northern Ireland including:

- Communicating to SMEs operating in the Advanced Engineering sector both the threats (for example any draft regulations) and opportunities (for example the technology road map) - the status quo is not viable in the medium term
- Deploying similar support services to those that are seen as successful elsewhere within the UK, for example Manufacturing Advisory Service (MAS)
- Developing innovative approaches to supporting R&D, e.g. research bonds, in particular for SMEs

Developing the right framework conditions
Framework conditions are the elements that make up the broad 'ecosystem' for Northern Ireland and must be developed and tuned to ensure it is conducive for the research, development and uptake of technologies. They are not specifically technology-based but refer to general issues such as incentives, funding, skills etc. A series of recommendations have been developed to improve the Northern Ireland ecosystem.

- Research, development and innovation. Research, development and innovation are important inputs to value creation. While there are some good examples, more needs to be done to encourage higher levels of R&D and innovation, in particular to clearly separate the Northern Ireland sector as a high value-add sector, rather than a manufacturing sector. The Panel identified a number of areas that need addressed, specifically:
  - Advanced Engineering transition must be a core part of the Regional Innovation Strategy
  - Northern Ireland's proximity to Ireland on R&D funding and programmes must be better exploited, e.g. through greater collaboration in FP7
  - Specific funding must be provided with appropriate mechanisms for collaboration that places greater emphasis on the commercialisation and exploitation of research outcomes
  - Innovative approaches must be developed to encouraging private sector R&D investment
  - The sector must develop grand challenges for the sector/individuals to deliver (and be enabled by government) which are consistent with and complementary to the route maps
- Skills - quantity and quality. There is a recognised shortage of appropriate skills within Northern Ireland to progress the vision of the Advanced Engineering sector. This reflects both an issue attracting people to this sector (with a view that there are limited career opportunities) and a quality issue (with both a need for stronger engineering skills and a need to extend the skills base to have a more entrepreneurial, innovative and business aware workforce). To achieve this will require:
  - Academia to deliver engineering graduates who are entrepreneurial, innovative & business aware
  - Industry, business, universities to be involved in supporting STEM in schools to foster engineering and business acumen from primary school age
  - All interested parties actively promoting engineering as a credible career
- Competition regime and entrepreneurship. Historically, companies in Northern Ireland were under less pressure to use new technologies and apply significant

pressure on finding ways to improve their performance through cost reduction alone. This is clearly sufficient for some period of time but eventually must give way to higher value-added activities, which include the use of new materials. OCED reports that entrepreneurship rates in the UK (and Northern Ireland performs poorly in the UK context) are at best moderate despite some important advantages in the business and regulatory environment.

- Access to finance. Although the UK capital markets are well developed and sophisticated, it would appear that weaknesses in innovation performance are probably more due to a lack of incentives and capacity to innovate rather than a lack of funding. Weaknesses in skills have probably affected the demand for, and success in obtaining, finance for innovation.
- The role of Government - Business and academia (as evidenced at the Joint Panel meeting on the 7th February) are committed to delivery against the Panel's recommendations. Government has a key enabling role to play in helping the sector move forward, specifically it can:
  - Help set up and contribute to the community of interest
  - Re-examine the metrics used to measure investment success and that subsequently drive behaviours within the public sector. For example (and in support of the recommendations above), the Panel felt that it might be appropriate to introduce Key Performance Indicators to measure performance of companies in terms of them sharing knowledge, encouraging STEM etc, and investing in levels of R&D
  - Provide sufficient focus on support to SMEs
  - Have a less risk averse and agile approach to company support. Rather than considering individual company support, the risk profile of the sectoral support should be considered
  - Seek to reduce red tape for business and provide insight, tailored within an Northern Ireland context, as to emerging regulations
  - Develop the school curriculum with a greater emphasis on STEM.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SCIENCE INDUSTRY PANEL

INNOVATION POLICY UNIT
DEPARTMENT OF ENTERPRISE,
TRADE AND INVESTMENT
NETHERLEIGH
MASSEY AVENUE
BELFAST BT4 2JP

PROFITING FROM SCIENCE
WWW.MATRIX-NI.ORG

Department of
Enterprise, Trade
and Investment
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