West Midlands Regional Observatory

Regional Skills Partnership Cross-Cutting Issues 2006

Innovation: Executive Summary

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PART ONE: THE INNOVATION AGENDA

1 The connection between innovation and skills

Innovation is: “The development and commercial exploitation of a new idea for a product or process that contributes to wealth creation and profitability.” 1 Innovation is important for two reasons: 1) globalisation makes the old adage ‘compete or die’ even more of a universal truth; and 2) the link between innovation and higher performance, productivity and competitiveness makes a better standard of living possible.2

The government’s Innovation Strategy identifies 7 critical success factors for innovation:

1. Sources of new technological knowledge.
2. The capacity to absorb and exploit new knowledge.
3. Access to finance.
4. Competition and entrepreneurship.
5. Customers and suppliers.
6. The regulatory environment, and
7. Networks and collaboration.

The government’s 2005 response to the EU’s Lisbon Strategy for economic growth reaffirms the aim of creating a world class UK knowledge economy with innovation and skills as drivers of growth and productivity. The right skills mix must exist to enable the move into more innovative sectors and businesses - people taking higher value added jobs with the flexibility to retrain and adapt to new technologies.

[1] Tether et al, A Literature Review on Skills and Innovation, September 2005
[2] DTI, Innovation Report, 2003

2 The components of innovation

The European Commission[3] notes various *routes* to innovation:

- The exploitation of an invention.
- Adaptation of a technology or idea from another sector.
- Reconfiguration of existing products and services, or
- A new business approach.

Ideas are essential to innovation. Four stages exist:

- Idea generation.
- Coalition building (where colleagues are persuaded to support ideas).
- The realisation of ideas, and
- Their transfer or dissemination.

The knowledge worker is the lynchpin of an innovative, high performance organisation through the diffusion of tacit knowledge communicated by shared experiences and interaction. Every employee has the potential to be one, since knowledge workers develop and share their ideas and expertise, may operate in teams or work groups, may be multi-skilled, or mentor and coach others. The workplace is a supreme opportunity for continuous learning. ICT provides a means to share information effectively as well as introducing devolved management. Managing human resources effectively is vital to achieving the business strategy.

The components of innovation form three groups:

1. **Human resources factors** - people's qualities, skills and engagement in innovation.
2. **Technological factors** such as research and development, horizon watch and technology transfer, also related activities such as market analysis and collaboration.

[3] CEC, Innovation Policy, Brussels, 2003

3. **Performance factors** including productivity, financial acumen and profitability, investment, and customer service (see Text Box S1).

Text Box S1: The Components of Innovation

a) Human Resources Factors

- Entrepreneurship.
- Management and leadership - championing change; change agents.
- The labour pool and workforce's calibre; skill development, retention; HRM processes and skills.
- Motivating and involving workforces; giving opportunity.
- The ideas culture at all workforce levels, constantly.
- Organisational responsiveness and change; dismantling silos; sharing, not protecting, knowledge.
- Communication, upwards, downwards, horizontally, also two-way externally.

b) Technological Factors

- Market analysis, responsiveness.
- Technology/new horizon watch.
- Research and development.
- Technical expertise.
- Collaboration, partnerships and networks – internal and external.
- Technology and knowledge transfer.
- Process and product development and change.
- Patenting, protecting intellectual property.

c) Performance Factors

- Market development/ product commercialisation.
- Competitor analysis.
- Benchmarking – internally, externally.

- Financial acumen including locating and accessing funding; managing risk.
- Investment.
- Profitability.
- Performance improvement, productivity, cutting waste.
- Customer service and responsiveness.

2.1 Human resources factors

Entrepreneurs are creative, driven individuals, vital to innovation and competitiveness. It is imperative to develop entrepreneurship skills and support infrastructures. However, research indicates that the economic, business and regulatory context in which they operate is a veritable obstacle course.[4]

Leadership is required to create a climate where innovation thrives.[5] The characteristics and behaviour of innovation-promoting leaders should be to:

- Convince rather than order.
- Build teams.
- Hold meetings and disseminate information.
- Seek information from users and collaborators.
- Accept peer reviews.
- Acknowledge other people's efforts.
- Show political sensitivity, and
- Be generous in sharing acknowledgements and rewards with colleagues. [6]

The concept of leadership styles, qualities and behaviours implies the existence of leadership skills which can be instilled by professional and personal development throughout a person's career, and nurtured by external agencies. Leadership occurs at all levels of an organisation – in a manufacturer from the boardroom to the shopfloor

[4] European Commission, Entrepreneurship survey, 2004
[5] Munshi et al (2005)
[6] Kanter (1996)

– and accordingly leadership skills should be developed throughout.[7] But research indicates that training is frequently inadequate or curtailed through cost cutting.[8]

As the workforce is an essential repository of knowledge, expertise and ideas, motivating and engaging their active participation in innovative activity and performance improvement is vital. Crucially important are strong people management, influencing, relationship and communication skills. In high performing firms, it is vital that everyone operates to their optimum. Employers show a concern for developing their workforces and reward them by incentives, formal and informal, financial and social. High employee involvement practices are achieved through job redesign, their inclusion in decision-making, decentralised authority such as self-managed teams, and sharing business strategy and information. But a DTI report found that bureaucratic structures are still prevalent in UK organisations, inhibiting rather than improving individual and organisational performance.

The link is drawn between job rotation and skill development, since people's expertise is broadened and strengthened through multi-skilling as they become adept in a range of operations. [9] This means that workers need to be adaptable to changing circumstances, and open to new ideas.[10] It is not hard to see, too, how job rotation in a company can be an important impetus to and part of the innovation process due to the sharing of ideas and knowledge that occurs when people break out of their functional silos. The workplace is an environment for continuous learning, for learning in the knowledge economy is thought to occur mainly in workplaces (not in classrooms) via: 1) informal learning by doing; 2) learning by interacting, and 3) coaching.[11]

The availability in the labour pool of the right skills, at the right level of competence, is crucial. Deficiencies may be due to skill shortages (not enough people with the requisite skills) as well as skill gaps in individuals' competences.[12] It is important to be able to attract and retain people with the appropriate mix of attributes and qualifications who can be trained and who are motivated to develop themselves. A challenging and interesting job which enables employees to keep at the leading edge in their field can help to attract and retain top people even if salaries are not high.[13]

[7] Such issues were raised in an automotive survey for Skills4Auto (Tilson, 2005)
[8] DTI, Inspired Leadership, c2004/5, using 2003 research by the Chartered Management Institute
[9] Purcell, The HRM-Performance link, 2004
[10] Tether et al, CRIC, 2005, report for the DTI
[11] Hepworth et al, Regional Employment and Skills in the Knowledge Economy, undated (c.2005/6)
[12] Hepworth et al, Innovation in the East Midlands Knowledge Economy, 2005, citing Florida (2002)
[13] Swart and Kinnie (2002)

2.2 Creativity, research and collaboration

"Creativity creates the basis of innovation, which, in its development, raises difficulties that must be solved, once again, by creativity" asserts the EC. [14] Creativity can occur at personal, team, or organisational level. The flow of information ensures that ideas generated can be communicated and developed.[15] Changes in organisational structures help to achieve a working environment more conducive to creativity, such as moving from hierarchical to flatter organisational structures. Generating ideas occurs best when group members act individually before coming together and continuing to generate them as a group. Creativity-supporting techniques[16] include:

- Brainstorming.
- Story Boarding.
- Checklists.
- Mapping processes (a variant of this is innovation value analysis).
- The Excursion Technique, and
- Computer techniques.

Questions arise about the need for awareness raising about these techniques, and the availability of suitable training provision, facilitation, and access.

2.3 Skills for research, product development and collaboration

Creativity, collaboration, networking and communication skills are vital for both research and product development teams. The need to compete via high-end product strategies involving complex, premium products rather than low price means that a greater diversity of competences and disciplines is needed than a single organisation can possess. This is stimulating firms to open up their knowledge-creation processes. Innovation networks are of growing importance.

The creation of knowledge (expertise) and the management of knowledge (access, transfer, organisation, utilisation) are vital components of the innovation process. Networking and collaboration can stimulate innovation between businesses because:

- Businesses learn from and do business with each other.

[14] European Commission, Innovation Management Techniques in Operation, Luxembourg, 1998
[15] Sefertzi (2000); Hemlin (2002)
[16] These are detailed in some depth in Sefertzi (2000), including various computer-based techniques.

- They are more likely to collaborate on strategic projects.
- This helps to build critical mass to better exploit commercialisation opportunities.[17]

Research confirms that businesses' objectives in networking are primarily to acquire new skills or knowledge.[18] This promotes and enables workforce learning and in that way contributes to their performance improvement. The possession of *relationship skills* is crucial for businesses to make the most of their networking. Smaller firms are less active at networking.[19] External support like R&D is an important substitute where these skills are lacking internally.[20]

Successful technology transfer networks rely on:

- The selection of appropriate members – what they possess or need.
- Working towards targets and keeping members on track.
- The communication, information and expertise of network members.

Clusters create an environment where entrepreneurs can flourish and act as a magnet for qualified people in high-tech and emerging technologies. They are an important source of inter-firm learning through 'knowledge spillovers' in the way that multi-skilling spreads ideas and know-how within organisations. Inter-firm relationships that occur in clustering can be vertical (i.e. involving companies in the same supply chain) or horizontal (in different sectors or competing in the same market).

2.4 Market issues and financial performance

Innovation activity is embedded in the market process. The entrepreneur relies on market signals to indicate the feasibility of their venture. The commercialisation of products and market development go hand in hand. Market information is used to acquire knowledge and outwit competitors.[21] The size and structure of the market, as well as its proximity, have a key effect on the speed of diffusion of an innovation.[22]

Innovative firms are greedy consumers of investment capital for development and growth. They must possess sound financial and business management skills. Challenges include the sourcing and accessing of finance – loans, investments,

[17] HM Treasury, Lisbon Strategy for Jobs and Growth, October 2005, citing RDAs
[18] Turner et al, The impact of networks..., 2006
[19] Turner et al (2006)
[20] Frenz and Oughton (2005), citing Freel (2003)
[21] Metcalfe (2005); Munshi et al (2005)
[22] Frenz and Oughton (2005)

venture capital - and dealings related to intellectual property and the route to commercialisation – licensing, prototyping, testing, joint ventures – as well as maintaining profitability through day-to-day operations, the cost of adopting new technology, and investment in fixed capital.

3 Barriers to innovation

Barriers to innovation relate to *external* or *internal* inhibitors (see Text Box S2):

Text Box S2: Barriers to Innovation

a) External inhibitors

- Legislative and regulatory instruments which impede entrepreneurs.
- Economic conditions which affect businesses' financial viability.
- Lack of demand for innovative products.
- Lack of a culture of innovation in economies, local, regional and national.
- Skill deficiencies in the labour pool and the research infrastructure.
- Lack of opportunity to be innovative.
- Limitations in the training and workforce development infrastructure.

b) Internal inhibitors

- The lack of clear, winnable goals and strategies.
- Lack of vision; lack of ambition.
- Absence of a culture of innovation at individual and organisational level.
- Narrowly defined regimes, programmes and curricula; bureaucratic control.
- Inadequate financial resources.
- Skill deficiencies in managers and workers.
- 'Firefighting' due to time pressure e.g. to meet deadlines.
- Lack of information on the innovation process, or problems in accessing it.
- Technological limitations.

4 Innovation Performance: the UK and Region in the International Context

Though they do not capture all innovation activity, commonly used performance indicators for innovation include R&D expenditure, numbers of research personnel, and patent applications. The measures employed in the UK and Community Innovation Surveys[23] for innovation activity, protection and performance include:

- Engagement in innovation projects and the resources allocated to innovation activity.
- The effects of innovation, including strategic changes, and
- The protection of intellectual property/innovation outputs.

It appears, however, that a comprehensive set of indicators for benchmarking the skills for innovation and the success of organisational change and external interventions awaits further development.

4.1 West Midlands policy context and skill issues

The West Midlands has been hard hit by manufacturing contraction, but also has relatively few jobs in the knowledge-intensive manufacturing sectors which are seen as the route to competitiveness and economic growth. AWM's Innovation Action Plan targets people (e.g. entrepreneurship and innovation leadership), resources, knowledge transfer (e.g. R&D investment and new product development support), and vision and context (e.g. scanning the horizon for new developments). Wide ranging advice and support for innovation by businesses is available. The three High Technology Corridors provide a focus for innovation and industrial diversification. Greater business exploitation of, and linkages with, the Region's knowledge base, is needed, as well as improving the knowledge transfer from higher education. It is also

[23] Robson and Ortmans (2005)

important that technology consultancies are a part of the wider network of business support for innovation and technology transfer.[24]

4.2 Innovation performance

The European Innovation Scoreboard assesses innovation performance using 7 indicators: 1) Tertiary education; 2) Participation in lifelong learning; 3) Employment in medium-/high-tech manufacturing; 4) Employment in high-tech services; 5) Public R&D expenditure; 6) Business R&D expenditure; and 7) High-tech patents. The Scoreboard ranks the West Midlands 29th among the 50 most innovative regions in Europe, below the Eastern region (5th), South East (8th) and South West (14th).[25] In its proportion of knowledge-based businesses the West Midlands improved substantially between 1997 and 2003, though below the UK average (17.6% compared to 21.2%).[26] The proportion of West Midlands jobs in high and medium technology sectors, however, was the greatest among the English regions, at 7% of total employment.[27]

The 2005 UK Innovation Survey revealed little regional variation in the proportion of innovation-active businesses, though the West Midlands and East of England were at the bottom of the field on 55%, compared to 60% in the South East. Local and regional innovation links were most prolific intra-group or with higher education institutions, but most were UK wide. International links were also fairly common. [28]

The previous survey (2001) showed the West Midlands in a fairly strong light for business turnover from new, improved and novel product and (particularly) process innovation. The highest turnover came from electrical and optical products (41%). More could be expected for transport equipment (8%), given its Regional importance.

R&D expenditure on transport equipment (£262 million) was among the highest cross-regionally in 2004, exceeded only by the East of England. Overall, though, R&D expenditure by West Midlands businesses in 2004 was a relatively low £800 million compared to an English regional average of £1,394 million.[29]

The OECD found that, by total entrepreneurial activity, the West Midlands is an average performer in a country which itself is an average performer internationally.

[24] A D Little, Research and Innovation for the West Midlands, 2004
[25] OECD, Local governance and the drivers of growth, 2005
[26] Huggins, UK Competitiveness Index 2005
[27] Lad, Regional competitiveness and state of the regions, April 2005
[28] Robson and Ortmans (2005). Preliminary findings only were available, and did not include novel product and process innovation by region
[29] National Statistics, Research and Development in UK Businesses, 2004, Newport, January 2005

The Region's total entrepreneurial activity dipped markedly in 2003.[30] Attitudes in the Region to entrepreneurship are broadly similar to the UK overall except that fewer in the West Midlands are considering starting a business, and fewer consider that the Region has good start-up opportunities.

4.3 Barriers to innovation in the West Midlands

The problems facing the West Midlands[31] include:

- The low levels of basic, intermediate and management skills.
- A workforce with below the national average of higher level qualifications.
- The problem of retaining graduates.
- Access to higher education in rural areas.
- Below average levels of self-employment, and
- Skill shortages in the public sector and construction industries.

In terms of its development of a knowledge-driven economy enabling 'smart' growth the Region possesses pockets of high human capital underdeveloped because:

- Business drivers of the knowledge economy appear weak. Few business sectors are knowledge-intensive. High skills are concentrated in the public sector.
- The graduate labour pool is limited. Low skill affects nearly 40% of the workforce.[32]

The lack of graduates in the West Midlands (11.9% of the working age population compared to an English regional average of 15.6%) impacts on the nature of innovation in firms and across the Region. This is because graduates tend to drift to London and the South East, where lies the real knowledge intensive presence.[33]

[30] OECD, Local Entrepreneurship Review Series, August 2004, citing Global Entrepreneurship Monitor, 2003; Lad, Regional competitiveness and state of the regions, April 2005
[31] Advantage West Midlands, Regional Economic Strategy; OECD (2004).
[32] Hepworth et al, undated report (c.2005/6) for the DTI
[33] OECD, Local Entrepreneurship Review Series, 2004.

PART TWO: SECTOR ANALYSES

5 Manufacturing

Principal manufacturing industries in the West Midlands by employment size are engineering and motor vehicles and components, materials processing (e.g. metals, polymers and ceramics), food and drink production, and printing and publishing.

5.1 Research and development

Research-intensive industries like pharmaceuticals, aerospace and defence, electronics, and IT hardware receive the greatest levels of UK R&D investment.

UK innovation activity is highest for electrical and optical equipment.

The West Midlands has a particularly high focus of transport equipment R&D expenditure, exceeded only by the Eastern region, but the Region's record of manufacturing R&D is otherwise somewhat undistinguished.

5.2 Skill issues and needs for innovation

Six innovation essentials established for middle market manufacturers comprise:

1. Inspirational and tenacious team leadership.
2. Collaboration on breakthrough products and processes.
3. Hard work, delivering incremental improvements.
4. Enthusiasm for building deep relationships.
5. Empowered and committed people, and
6. Effective use of technology.[34]

Appropriate innovation strategies differ for companies according to their business environment, customer focus, technology, competition and capabilities.[35] SMEs

[34] The Manufacturing Foundation (2003)

encounter particular problems in innovating and adopting new technologies due to issues about accessing funds, markets and skilled labour.[36]

Manufacturing is severely hampered by skill inadequacies in workforces and the labour pool. Globalisation has introduced new skill requirements. Employers need a higher calibre of employee with a better level of basic skills and technical competences. Workers are also now seen as key sources of innovation as well as possessors of technical prowess. Due to greater team working and multi-skilling, soft skills are necessary. Managers are also deficient in the skills to manage effectively.

However, many of the skills needed are in short supply, not only technical and practical skills, but also communication, problem solving, management and customer handling skills. Lack of motivation and the inability to keep up with change are rife.

Intermediate level skills are in short supply. This is especially crucial for manufacturing as these include craft positions like machine operators and technicians. Professional skills are limited, like design/development, and software engineering. Failure to train and develop their staff is an important factor.[37]

5.3 The product development process

Keen interest surrounds what competences and working practices used in product development can give companies that competitive edge. These are thought to include:

- Worldwide patenting.
- Cost-competitiveness through efficiencies and product improvement.
- Close customer relationships.
- Specialist expertise.
- Focus on a niche and/or emerging market, and
- The commitment of extensive resources.[38]

Innovation leaders must be able to motivate team members and themselves to identify ideas for new products and services, and for improvements. Softer skills are needed to facilitate change, and these include wide-ranging competences like networking,

[35] Schumann and Prestwood (undated)
[36] OECD, Science, Technology and Industry Scoreboard, 2005
[37] National Employer Skills Survey (2003); Engineering Employers Federation (2003)
[38] Mason (July 2005)

thinking strategically, creativity, and decision making. [39] Digital technologies used for design, simulation, prototyping and testing exert skill needs and remote working introduces an additional dimension to team working, communication, customer relationship handling and keeping targets on track.

There are questions about suppliers' possession of the range of expertise now needed to participate in customer-supplier product development teams. Issues concern their technical expertise, software compatibility, process innovation and equipment, and their customers' willingness to ensure that they develop the necessary competences.

5.4 Issues about innovating in smart, new and alternative technologies

It is vital that the UK can successfully exploit the next wave of technologies. [40] This requires a focus on advanced materials and resource-efficient manufacturing processes; biotechnology for industrial and healthcare applications; and environmental and clean energy technologies. Organisations undertaking R&D at the technological leading edge must maintain that momentum and diffuse their knowledge and expertise into the industrial base speedily and effectively.

Great interest and expectation surrounds the potential for university-industry knowledge and technology transfer as a major element in industrial innovation and the growth of spin-out firms in new and embryonic clusters. There is further potential for industrial-research institution linkages. Concerns exist about the successful transfer to industry from Qinetiq of its vast array of technological know-how. It is also important that SMEs engage with the Advanced Knowledge Alliance which brings together the knowledge providers in the A38 Technology Corridor programme, particularly since firms in embryonic, emerging and fast growing industries like biotechnology, medical devices, ICT and nanotechnology are likely to be small and resource-limited.

Limited exploitation of the development of IT-intensive 'smart' consumer products has occurred. Materials Foresight recommends awareness building, a focused programme of pre-competitive work on the benefits of smart adaptivity, and the development of multi-disciplinary teams. MAS is seen as a key support provider.[41]

The concept of the digital factory is exciting interest in Germany for its potential to heighten manufacturing competitiveness and innovation skills while reducing product

[39] Skills4Business Network, www.ukstandards.org/
[40] DTI, Technology Strategy, Annual Report 2005
[41] Materials Foresight, Smart Materials for the 21st Century, noting Manufacturing Advisory Service

development costs and time-to-market. The Fraunhofer Institute's mapping of digital technologies in manufacturing might be useful to benchmark.[42]

It is important that the Region's emerging research strengths in nano- and micro-technologies are matched by the development of a skill base which responds to its research, prototyping, testing and commercialisation needs, and supports its development with the range of resources and expertise to maximise the potential.

5.5 Solutions to skill limitations

Companies need to draw on the talents of a flourishing creative community (including product designers and software designers) for innovation to flourish. The creative community also has a responsibility to be able to *respond* to the demands of dynamic and ambitious businesses. Smaller firms are particularly inhibited about innovating due to limited knowledge and skills about how to access and exploit creativity, what it entails, and how it could help them grow their business. Solutions include:

- Raising awareness and changing behaviour.
- Providing support and incentives.
- Preparing future generations of creative specialists and business leaders.
- Using the power of public procurement, and
- Creating greater visibility for the UK's creative capabilities.[43]

Smaller companies respond poorly to general awareness-raising programmes or business support, so it is proposed to reach them on a local basis via the Manufacturing Advisory Service. It is also proposed to encourage medium-sized firms to get a greater diversity of skills and backgrounds into the Boardroom, and for a requirement for 'managing creativity' to be included in the Chartered Director syllabus. The Design for Business programme is advocated for encouraging and enabling SMEs to take up design services. Its skills-raising component is via:

- A design-matching service for clients and designers.
- Professional development for business advisors and designers, and
- Accreditation and training for design mentors and others who deliver the programme.

[42] Fraunhofer Institut, Integrated training opportunities in knowledge transfer and skill creation in Advanced Industrial Engineering, undated.
[43] The Cox Review of Creativity in Business, 2005

Businesses may need to change their organisations and their working practices and cultures if they are to achieve successful innovation outcomes, and must make the necessary investment. The West Midlands public and private sector organisations have established mechanisms and funding to give support, advice, information, ideas, collaboration, and training.[44] Further investigation of innovation skills will indicate where additional delivery could be placed.

[44] See, for example, Advantage West Midlands, Making Innovation Real, undated (2005)

6 Automotive

The West Midlands had a 33% share of the UK's vehicle output in 2004. Prior to the collapse of MG Rover there were at least 1,500 automotive suppliers in the Region, including 17 first tiers. It is estimated that productivity will increase by 31% and employment will fall by 23% for the transport technologies cluster as a whole.[45]

The principal drivers for innovation and change in the automotive industry are:

- The global market: both as an opportunity and the source of fierce competition.
- Legislation and regulations, e.g.on passenger safety, emissions, recycling.
- Lifestyle changes; end-customer expectations of certain user features and choice.
- Improved profitability, performance, efficiency and cost reduction.
- Procurement changes, notably online auctions (e-procurement).
- ICT – change along the whole value chain from design to delivery and end-of-life.
- Materials and technology changes, including for light-weighting.
- The development of new fuels.
- Policies, programmes and initiatives giving strategic direction and business support.

Automotive suppliers need to have excellent Quality, Cost and Delivery performance, as well as innovation capability, if they are to take advantage of the development of new models by UK-based vehicle manufacturers like Bentley and the Ford brands – Jaguar, Land Rover and Aston Martin.[46]

[45] This estimate was prior to the Peugeot closure announcement of April 2006
[46] Malpass, Fighting back, Accelerator magazine, 9, Autumn 2005

6.1 New materials and technologies

The Foresight Vehicle Programme[47] identifies 5 themes for future technologies:

1. Engine Powertrain.
2. Hybrid, electric, and alternatively fuelled vehicles.
3. Software, sensors, electronics and telematics.
4. Advanced structures and materials, and
5. The design and manufacturing process.

The End of Life Vehicles directive and the sustainability agenda have introduced considerable emphasis on design for recycling and the necessity to consider the whole value chain from conception to disposal.

The fuel cell and hydrogen are among the most promising technologies. Their development must be accompanied by advances in software, sensors and electronics. Hybrid technologies offer development potential in conjunction with the Japanese. Microwave, radar and broadband technologies are transforming motoring through intelligent transport solutions (telematics) and low-cost vehicle-to-vehicle communications like satellite navigation, electronic parking aids and voice recognition.[48] Opportunities exist in rapid prototyping, safety systems, lightweight and advanced materials. Midlands research and technology organisations' expertise includes electronics, braking systems and control systems.[49]

By the end of this decade, many changes will be under way which could exert supplier obsolescence if their technological adaptation and innovation is inadequate.

6.2 Skill issues and needs for innovation

The automotive industry is considered to be ahead of other manufacturing sectors on the implementation of lean manufacturing approaches to embed continuous performance improvement.[50] Nevertheless, despite success in implementing continuous improvement techniques, the automotive supply chain's performance in no way reaches world class standards. In strategic capability it is considered particularly poor, but performs best in terms of product quality and technical innovation.[51] SMEs

[47] DTI programme, now administered by SMMT. Foresight Vehicle website, accessed March 2006
[48] DoT, ITS in the United Kingdom Today, 2004
[49] Ricardo (2005)
[50] SEMTA, Automotive Sector Skills Agreement: Stage 1, September 2004
[51] Ricardo (2005)

understand that they need to compete better, be more inventive and invest in new technology and product development. They also need to offer a higher level of customer service, develop their internal information systems, and upskill their workforces.[52]

There is a perceived risk to West Midlands automotive firms of missing out on involvement in developing leading edge technologies. [53] Ricardo (2005) note the need for technical skills relating to emerging technologies, products and processes. Concerns have been raised that the UK should retain a strong skill base in more standard technologies related to fabrication, like welding (particularly programming robot welders) and machining; also in toolmaking.[54] Both Ricardo and A D Little see further potential for the engineering industry to take a co-ordinated approach to tackle technical issues.

E-business is growing for purchasing, marketing and selling, billing, and despatch, as well as materials resource planning, and documentation for the traceability of products and materials. It also has an expanding design and development facet. It is crucial for vehicle manufacturers to be able to transfer designs and other development materials to their first tiers, and that the first tiers mirror them in the technical, ICT and skill investments they make. This also poses a question for the lower tiers SMEs in paralleling these abilities. The lack of experience of SMEs in product development, as distinct from development assistance in manufacturability, limits their competence for collaboration.[55]

The UK automotive industry has a priority need for skills in design engineering, project engineering, specialist computer solutions for manufacturing and, increasingly, in simulation software. Modularisation introduces fresh challenges in relation to production processes. Keeping in step with advances in electronics and information technology is a constant battle.[56] AWM note that the West Midlands has a weakness in electronics.[57]

The capability of the West Midlands to attract and retain talent is a concern. [58] There is also confusion over qualifications, course accreditations, training provision and funding. Key issues concern the suitability and quality of existing training, the ability of suppliers to access it, whether by e-learning or traditional methods, and the means for trainers to keep at the edge of development themselves. Studies have also

[52] Tilson (2005), report for Skills4Auto
[53] Ricardo (2005); Tilson (2002); A D Little (2004)
[54] Tilson (2004); ibid (2005)
[55] Tilson (2005)
[56] Tilson (2002); Deloitte & Touche and BCT Research Associates, The West Midlands Automotive Supply Chain Study, report for the Accelerate Partnership, 2001
[57] AWM, Automotive Cluster Business Plan diagram, 2006
[58] AWM, Automotive Cluster Plan diagram, undated sheet, 2006; A D Little, Research and Innovation for the West Midlands, 2004

highlighted weaknesses in leadership and management competences in the supply chain, including project management. It is crucial that people at all company levels develop leadership skills, including team leaders. Innovative thinking and strategic management must also involve the shopfloor's input. Better team working is needed, and this emphasises soft skills like negotiation, relationship building and communication, internally and externally.[59]

6.3 Solutions to skill limitations

The various routes for in-company or external skills raising include via:

- Universities and colleges.
- Collaboration or networking with industry customers and partners.
- The developers and suppliers of products and equipment.
- Commercial training providers.
- Public or private sector support agencies such as Skills4Auto, Accelerate, the LSC, Industry Forum or the Chamber of Commerce.
- Specialist trade associations or agencies within or *outside* the automotive industry such as Motorsport Development UK, the Engineering Employers Federation or the Society of British Aerospace Companies (for technology transfer).
- Research institutions such as Ceram, RAPRA, Warwick Manufacturing Group, or the Technology Innovation Council, or
- Research programmes and initiatives led by the DTI, EC, or regional bodies.

AWM confirms the Automotive Academy as the focus for industry upskilling.[60] The workforce development and training spoke of the Academy is Skills4Auto. AWM has also funded Warwick Manufacturing Group's Premium Automotive Research and Development Programme involving new technologies, improved production processes and more craftsmanship. [61] The DTI is urging collaborative R&D programmes, [62] and the Learning Grid (motorsport) has a programme linking students, teachers and industry to science, technology, engineering, design and mathematics. [63]

[59] Tilson (2005); Ricardo (2005)
[60] AWM, Automotive Cluster Business Plan 2005 - 2008
[61] DTI, Innovation Report, 2003
[62] Foresight Vehicle website, accessed March 2006
[63] The Learning Grid, Introduction to the Learning Grid, website accessed February 2006

7 Medical and Healthcare Technologies

An estimated 400 – 500 West Midlands companies have some or all of their turnover derived from medical technologies, and frequently operate in one or more other sectors such as automotive, engineering and plastics processing. Another 500 – 600 could consider diversifying into medical technologies, either fully or in part. [64]

The medical and healthcare technologies sector includes firms engaged in:

- Orthotics and prosthetics.
- Rehabilitation and mobility.
- Pharmaceuticals and biotechnology.
- Opthalmic goods.
- Dental and orthodontic devices.
- Electromedical equipment.
- Surgical and medical instruments, and
- Medical disposables.[65]

Medical and healthcare technologies have cross-sectoral links to disciplines such as plant science and agriculture, environmental, the retail food sector and sports science.

7.1 Research and development

The West Midlands has a substantial medical technology, healthcare and biotechnology research focus in higher education institutions (with the University of Birmingham medical school at the forefront) and Warwick and Keele science parks.

[64] Lewis (2005)
[65] Burfitt and Gibney (2003)

Pharmaceuticals and biotechnology are highly R&D-intensive sectors and need to remain strong if they are to continue to attract research resources from international players. Biopharmaceutical drugs are the fastest growing part of the pharmaceuticals market. Bioscience is a high value added, knowledge-based industry, related to the quality and quantity of the intellectual property it generates and the input from highly educated and skilled employees during research and product development.

Pharmaceutical and biotechnology companies have to conduct substantially more R&D investment than firms in other sectors so as to ensure that patented compounds are effective and safe. This means that skills like research, analysis, testing, and general laboratory work and administration are required, as well as continuing support and investment over a longer timescale.

Pioneering surgeons, clinicians and other medical practitioners, notably surgeons, have a pivotal role in medical and healthcare innovation and may invent and oversee the development of new product ideas placed with manufacturers. It is important for firms to form close relationships with key individuals like these to gain market intelligence and to form collaborative production arrangements.[66]

7.2 New materials and technologies

Engineering and materials research are major strands of existing and potential research and application, including polymers, metals, advanced ceramics, composites, and nanotechnology. The Materials Foresight report highlights the potential of smart materials and technologies in the medical and healthcare sector. [67] The National Institute for Health's interventional procedures programme is raising the prospect of the greater use of innovative and rare technologies in the NHS. Opportunities include:

- Biomaterials and advanced woundcare.
- Tissue engineering.
- Structures for devices, including their control systems and software.
- Diagnostics, orthopaedics and assistive technologies.
- Telemedicine, especially monitoring and wellness and care in the community.
- ICT/e-technology, and

[66] A D Little (2005)
[67] For a full discussion see Materials Foresight, Smart Materials for the 21st century

- Infection control. [68]

Potential exists for closer synergies with existing West Midlands clusters of ICT, textiles and plastics. Marine biotechnology may also provide opportunities.

7.3 Skill issues and needs for innovation

A 2005 study of the West Midlands medical technologies cluster identifies a need for companies to improve their human resource capability in general and specifically in business development, marketing and regulatory affairs. Access to domestic and international markets, and the creation and protection of intellectual property, are also prominent requirements. Issues are raised about the possibilities of e-procurement and the need to work with the NHS procurement system. Increasing interest is shown in working with design and development companies, universities, and the NHS amongst other collaborators, as well as forming joint ventures, pursuing acquisitions and mergers, and undertaking trade fairs and missions.[69]

A study of the workforce development needs of medical technology manufacturers in Coventry and Warwickshire[70] indicates that their skill needs include:

- More advanced quality planning, including statistical process control.
- The ability to use more sophisticated electronic equipment, including CNC.
- Knowledge of new laser products, and the acquisition of skills to make laser-powered surgical products.
- Greater expertise on the shopfloor of polymer processing.
- Multi-skilling on the shopfloor, to achieve a more flexible workforce.
- Medical knowledge by engineers.
- Design skills to enable collaboration with the customer on product development and adaptation.
- IT skills including software systems development.
- Legal knowledge, e.g. of patenting.
- Knowledge of medical compliance/regulations.

[68] Lewis (2005); A D Little (2005)
[69] Lewis (2005)
[70] Tilson, The Medical Technologies Research Project, 2002

- Management, teamworking and other people skills including motivational, customer liaison.
- Distribution and logistics skills.
- Knowledge of exporting.

Many issues exist about sourcing appropriate skills and labour. The shortage of specialists creates problems, including scientific, product design, pharmaceutical and vocational. The lack of appropriate training features strongly, as well as training costs. Indeed, these problems beset a medical implants start-up in Staffordshire and their solution was to teach themselves. Skills they developed included foresighting, collaboration, the management of outsourcing, how to differentiate themselves in the market, manufacturing, and locating funding. They advise that firms diversifying into medical technologies should keep their eye on their core business while diversifying, as this takes years to accomplish. Having the right people on board and getting insiders' buy-in to the diversification programme is seen as essential.[71]

Analysis of biotechnology firms in Warwickshire[72] shows that bringing research to successful commercialisation introduces a tranche of additional requirements. Scientists need to be multi-disciplinary, possess business skills, manage production competently, understand health and safety, deal effectively with supply chains, meet quality standards, and understand overseas medical regulations.

7.4 Solutions to skill limitations

Priority support areas for West Midlands medical technology companies are:

- Skill enhancement in marketing, regulatory affairs and business development.
- Investing in higher value added processes, as well as the use of low cost economy sourcing, where appropriate, but with intellectual property protection.
- The development of quality systems from ISO 9001 to ISO 13485: 2003.

The NHS is looking abroad to identify best practice.[73]

The scarcity of larger firms and the relatively small size of the cluster also exerts other disadvantages for the medical and healthcare technologies sector:

[71] Bratt (2006)
[72] Tilson (2002)
[73] Lewis (2005)

- Fewer people receive training outside of the formal education sector.
- The leakage of expertise into the labour pool is less.
- There is less demand for skills, so training provision is more limited.
- Support services are less well developed.
- The potential Regional linkages which firms can form for innovation are fewer.
- The formation of R&D links elsewhere in the UK and overseas makes it more likely that firms will manufacture elsewhere, and that they will move away.
- The cross-fertilisation of ideas and know-how between sectors is more limited.

Enormous scope is seen in developing the linkages across the industrial base throughout the West Midlands within and outside medical and healthcare, and in further developing the linkages for this sector into and out of the university research institutions, the medical science parks and hospitals.[74]

[74] Shields (2005)

8 Construction and the Built Environment

The construction sector includes building, infrastructural and structural engineering, architectural consultancy, building services such as electrical, plumbing, heating and air conditioning, and gas services. It also encompasses the production and manufacture of materials for the building industry, including polymers and timber.[75]

Drivers for innovation and change in the sector include:

- Globalisation.
- Major building programmes.
- Building regulations and environmental legislation.
- Rising costs of materials, fuels. Also the rising cost of house prices.
- The multi-facetted sustainability agenda which includes recycling, energy efficiency, modern construction methods and affordable housing.
- The development of new materials, technologies and processes.
- Performance improvement, and
- The use of ICT across the value chain.[76]

8.1 Research and development

There is a mixed picture of research and development, since construction R&D investment is much lower than among manufacturing sectors, though the West Midlands is one of the more significant regional players (£4m compared to £40m across the UK). However, in relation to turnover from the introduction of new, improved or novel products West Midlands construction scores a low 1% compared to

[75] Much of this chapter is based on Tilson, RSP Construction Sector Profile, WMRO, 2005; Tilson, Innovation and change in construction and the built environment: the skill implications, WMRO presentation, 2006. See wmro.org

11% UK-wide. International comparisons show that the adoption of new technologies is also tardier in the UK than elsewhere. For example, the share of housing sales for pre-fabricated construction was 1% in Britain in 2005 compared to 15% in Germany.

The DTI report, A Strategy for New Materials (2006), emphasises the need to optimise the research base for construction-related activity and materials research in general. There is also a need for multi-disciplinary research.

8.2 New materials and technologies

Modern methods of construction and new and alternative materials are inherent in the concept of sustainability to speed up construction, and reduce resource consumption, costs and defects. Prefabrication has a central role in this concept through the off-site manufacture of pre-cast and assembled structures. New materials and technologies include composites and joining methods, smart technologies, sensors and advanced steels and light alloys. Fuel cells offer prospects as power sources. Nanotechnology has potential, already foreseen in cement and coatings. Green concepts are highly significant for ensuring environmentally sound materials and construction methods, the use of alternative (including harvested) materials, and recycling.

8.3 Skill issues and needs for innovation

Performance improvement among West Midlands construction businesses is severely curtailed by skill deficiencies across the spectrum of competences from technical and managerial to inter-personal among the range of occupations from managers to skilled trades. This also restricts the innovation potential of firms and creates problems for introducing new working practices. The use of more sophisticated ICT across all functions exerts many skill needs and for suitable training and qualifications. The availability of appropriate training and support is also important to give contractors familiarity in innovative building techniques and materials. Prefabrication promises to revolutionise construction and building services engineering as much work will be done in factories – the question is where? Although prefabrication may not reach significant levels until about 2020 it is imperative to initiate the necessary adaptive mechanisms and structures including related to the supply and delivery of training.

[76] Tilson, RSP Construction Sector Profile, WMRO, 2005. wmro.org

8.4 Solutions to skill limitations

It is important to motivate and enable firms in all facets of construction and the built environment, both large and small, to learn about and utilise new materials and techniques, and to increase their ICT use. Managers need to understand and drive change, and manage their supply chains better. Only by taking a proactive approach to self-improvement can firms make the efficiencies that the Deputy Prime Minister has called for. The automotive and engineering sector provides a benchmark for the adoption of performance improvement and lean manufacturing techniques.

Engaging employers in training initiatives is vital - encouraging them to train their staff, and devising solutions to issues which hinder training by being innovative in the way that training is delivered. It is important that trainers themselves keep at the forefront of technological advances. Bringing on the next generation of mechanical and electrical engineers, and solving these skill shortages, are high priorities. It is also crucial to increase the numbers of graduates and research students in disciplines like materials science and civil engineering. The lack of a sufficient level of demand from employers needs to be resolved. It is also important to increase the numbers and calibre of young people in further education, and to improve the participation rates among women and minority ethnic groups. An image-raising exercise will help.

Issues are many. Will the UK – and the Region – grasp the opportunities that the growth of prefabrication offers for developing and producing innovative building solutions? Will the knowledge and expertise, as well as the networks and information exchange mechanisms to engage in R&D programmes and to see these into commercialisation, evolve more fully in the Region, not only for prefabrication but for advanced and new technologies and systems more generally? There is also potential for greater involvement in UK and international collaborative research programmes on materials, structural innovation and new horizon technologies.

9 Information and Communication Technologies

ICT is a basic skill of modern business - indeed, a business enabler - ranking highly alongside literacy and numeracy. ICT software, systems and hardware expertise possesses cross-sectoral importance, underpins organisational and supply chain management, and enables firms to unite globally for innovation through internet communications; to design, develop and manufacture products and systems; to document electronically, and to exploit internet-based information for market, competitor and supplier analysis, as well as for marketing, selling, and procurement.

The correlation between ICT use and increased business productivity is confirmed:

For every additional 10% of employees ICT enabled in manufacturing industries, productivity is increased by 2.2%. For younger firms it is 4.4%.

For every additional 10% of employees internet enabled, productivity is increased by 2.9%. For younger firms it is 3.4%.[77]

The West Midlands has a developing strength in software, interactive leisure software (screen, games and new media) and hardware consultancy.[78] The Region ranks 5th among the English regions for the size of its ICT workforce, totalling 87,777 people. Over half of these (53%) work in the ICT industries, the remainder as ICT professionals working in other industries, mainly as computer software consultants.

9.1 Research and development

The UK is a strong base for ICT innovation, with a growing number of research intensive SMEs.[79] English regions which are highly innovative and R&D intensive have a better ratio of ICT professionals to employees. The East, for instance, has one ICT professional for every 25 workers, the West Midlands ratio is 1 to 33.[80]

[77] Clayton (2005); Farooqui (2005)
[78] Advantage West Midlands, Digital West Midlands – The Regional ICT Strategy, 2005/6
[79] HM Treasury, Lisbon Strategy for jobs and growth, October 2005, citing EU and OECD research
[80] E-skills UK, IT insights: regional skills in the West Midlands, 2005

Firms in the vanguard of R&D often have little choice but to develop what they need themselves both in terms of hardware and expertise. Mature innovative firms can find it a challenge to keep at the forefront of a developing market, particularly when their product portfolio is more complex and their operations are sizeable.

There is no perfect product development process. Issues raised by the Silicon Valley Product Group include:

- The question of what constitutes 'best practice'; issues also of quality assurance.
- The problem of achieving user-ready products which work well.
- Collaboration must occur between businesses, customers and product developers.
- Real user feedback is vital to ensure the software will be robust in user settings.
- Effective teams are crucial to share ideas and review each others' work.
- The importance of product/project management expertise.

9.2 Skill issues and needs for innovation

The West Midlands has high levels of skill gaps among ICT users.[81] Keeping up with ICT-driven change is a challenge, particularly for smaller firms. Firms need constant financial and professional support. Concern is aired about the quality of graduates in the Region's labour pool, and the suitability of course content to local industry.[82] Internet-based ICT is increasingly used for managers and sales people to record, organise, source and supply information, services and products. [83] Mobiles and personal digital organisers with network functions enable the business community to analyse every aspect of its customer interface. They must invest in technology and skills to exploit the opportunities. However, the National Employer Skills Survey 2003 shows that skill gaps affect 46% of administrative staff, and one in 3 professional and associate professional staff.

Specialist software is utilised by businesses for applications such as:

- Design and engineering.

[81] E-skills, IT insights: drivers of demand for skills, 2004
[82] A D Little (2004)
[83] E-skills UK, IT User Digest, 2, October 2005

- Project portfolio management.
- Supply chain management.
- Enterprise resource planning.
- Customer relationship management.
- Financial systems.
- Web/multimedia.

Not surprisingly, due to its concentration of manufacturing, the use of software for design and engineering is highest in the West Midlands (20%) than nationally (9%), and the use of computer aided design (CAD) is also particularly high in the Region.

Significantly, the 2004 e-Skills UK survey found that West Midlands firms are more severely affected than most regions by skill gaps, and ICT professional skill gaps are more prevalent in West Midlands firms than nationally.

Operations technicians are in relatively short supply in the West Midlands, and the professional skill base could also be improved. The role of ICT professionals will change from technology support to business application. They will be part of the business and improvement team with a much broader remit for processes and procedures.[84] Expertise in systems architecture and integration, networking, web design, and security will be in continued demand, particularly those with systems expertise who can work in [international] teams to design business-relevant systems and services. The geographical clustering of high-tech industries will exert added demand for ICT expertise, not least through business growth in the Technology Corridors, R&D undertaken at public and private sector research institutes, the commercialisation of R&D and knowledge and technology transfer.

Some 58,840 managers needed improved ICT professional skills in 2005, 40% to level 2 and 60% to level 3+.[85] ICT skills will be increasingly important for managing change. There is also a major issue about providing managers of small businesses with ICT skills if they lack in-house professional staff because there is little skill development in place to address this. There is also a lack of accessible diagnostic and support tools for SMEs to make strategic use of ICT.[86] The 2005 Review of Education and Training within the Birmingham and Solihull ICT Sector found that nearly all employers feel that current training provision lacks relevance to what is happening in the ICT sector. Further points cover the need for collaboration skills to

[84] E-Skills UK, It insights: drivers of demand for skills, 2004
[85] Birmingham and Solihull LSC, Review of education and training within the ICT Sector, 2005
[86] Sector Skills Development Agency, Exploitation of IT, ssda.org.uk/, accessed February 2006

work with other disciplines; adaptability to change; the ability to transfer skills to others; and the need for 'soft' skills, including among recruits.

9.3 Solutions to skill limitations

It is imperative to determine and address employers' needs for continuous professional development (CPD) in managers, professionals and other occupations, to monitor technological and business change and additional ICT needs. It is also vital to identify and address the particular CPD needs of the ICT professionals themselves operating in, and supporting, the key business sectors of the West Midlands economy, and those with growth potential. This requires an understanding of ICT technological and occupational change, and how industries it serves are transforming. The trick will be to marry the competency needs of ICT specialist expertise, industry expertise (e.g. automotive, aerospace, medical technology, construction), and business acumen.

Strategic objectives by Advantage West Midlands and its partners include:

- The encouragement of personal creativity in order to stimulate skill needs relevant to future knowledge-based industries. This is of particular interest given that ICT acts as a disruptive technology and also has a knowledge-enhancing role. Collaborative knowledge working is considered key to achieving efficiencies.
- Achieving a step change in the adoption of e-business by industry. Exploiting ICT is linked to the growth of entrepreneurship and commercial advantage.
- Increasing the generation, development, dissemination and take-up of e-learning. Innovation action includes potential growth areas and market applications; also addressing the teaching and mentoring of ICT.[87]

[87] AWM, Digital West Midlands, Digital West Midlands – the regional ICT strategy, 2005/6

PART THREE: CROSS CUTTING ISSUES AND RECOMMENDATIONS

10 Skill and workforce development issues and opportunities

Innovation is not solely concerned with R&D and product development, for the ability to innovate requires a large bundle of competences. Skill deficiencies can therefore limit the potential for individuals and businesses to innovate and perform highly. According to SEMTA (2004), the priority cross-sectoral skills include entry level skills, management and leadership, and ICT skills. Service functions are increasingly important in manufacturing, emphasising softer skills like problem solving, project and operational management, communication and team working. The relationship between entrepreneurship and innovation requires the nurturing of an enterprising approach. But a 2006 West Midlands Regional Skills workshop revealed a wide gap between employers' needs and what is available. Issues concern the skills for achieving higher value added products and services; the skills and training of young people; training delivery and qualifications; and the need to communicate to pupils, teachers, advisors, brokers and parents about the changing needs of the market. Skills foresighting can be used to communicate with employers about skills and training.[88]

10.1 Skill needs and solutions for innovating businesses

Many employers are national and international and identify with their sectors and their supply chains (rather than the locality in which they are based) particularly in keeping up with leading edge techniques, product or service innovation, and knowledge transfer from new research.[89] This has implications for understanding where each sector is going, and regional *and* sectoral action. SEMTA (2004), noting pan-industrial skill needs, warns against a one-size-fits-all approach and advises that manufacturing industries should emulate automotive's lean manufacturing approach and the fast new product development methods pioneered by the electronics sector.

[88] West Midlands Regional Skills Partnership, Skills Summit, 3 February 2006
[89] DfES, 21st Century Skills: realising our potential, Cm 5810, July 2003

Business support for innovation must be relevant, accessible, and appropriate.[90] It is crucial to address speedily and continually where the system works well, or not, and to adapt it where necessary, as well as providing the right level of resources, and to work on the demand and supply sides of the labour market. To achieve its aim of becoming a knowledge economy, the West Midlands must stem the brain drain to London and the South East and provide more high-quality jobs.

Other issues which must be addressed include:

- Improving management training and development at all workforce levels.
- Achieving working cultures where innovation can flourish, through organisational change as well as skills enhancement.
- Entrepreneurship training, learning, networks and strategic partnerships.
- Consideration of the impacts on innovation of the growth of offshoring, and
- Language and other skills for international trade.

10.2 Addressing research and technical skill needs

Five themes must be addressed in order to enhance the prospects for the successful development and exploitation of materials and their product applications:

1. Knowledge transfer.
2. Raising awareness.
3. Accelerating innovation.
4. Improving skills and knowledge.
5. A better business environment.

These themes are significant across the innovation and technological spectrum.[91] Businesses need to be more aware of design and how it can be used, and to understand sustainable development and consumption. Greater interaction should occur between engineers and scientists, production engineering and the design community to enable information exchanges which could lead to innovations. The demands on the technical community are changing. The skill and training implications

[90] DTI, Innovation report, 2003
[91] DTI, A materials strategy, 2006

cover the production, processing, safe use, re-use, recycling and assessment of the whole product life cycle. Identifying and benchmarking best practice is advocated.

The Lambert Review's (2004) discussion of R&D incentives raises the issue of the right type and level of incentives and support, particularly for small innovators, especially at the mid and final stages towards commercialisation.

Business support for innovation is particularly difficult to manage in relation to the research institutes, universities and commercial R&D organisations that must be more easily accessed by businesses. It is crucial that these organisations have the skill mix, resources and systems necessary to maximise their support of business innovation. An expansion of student work placements is warranted, initiatives focusing on SMEs.

The impacts need to be addressed of an expansion of research by British companies overseas at the expense of their British research since this affects their demand for specialist and advanced skills, and other skills including at technician standard. It means less innovation occurs, less interaction with research institutions, lower levels of research activity at those, fewer partnerships between UK companies, and less diffusion of research knowledge and expertise into the economy and labour pool.

A D Little (2004) assert that the continued growth of high technology sectors in the West Midlands stresses the significance of solving any skills issues as that growth will exert a greater need for specialist services, engineering skills, and patent agents. The Science City initiative could drive the knowledge economy through the innovative application of the science and technology base in support of the Region's target sectors. A primary role is identified for the Regional Skills Partnership in the demand-led evidence-based approach relevant to this initiative. However, although some companies can benefit from leading edge technological development, most need to apply *established* technology more effectively to improve their competitiveness.[92]

The government's 10-year Science and Innovation Investment Framework (2004) asserts that a vibrant innovation system relies on a strong supply of specialists in science, technology, engineering and mathematics, and identifies shortages of specialist science and maths specialists nationwide. The perceptions of young people must be changed to attract them into these fields. Enhancing the learning and teaching of these STEM subjects at all educational levels is crucial, and improving the incentives to recruit and retain science teachers and professional researchers.

Developing and utilising the entire cross-section of potential skills is vital, including those under-represented in science, engineering and technology like women and minority ethnic groups, and to consider the contribution that the mature workforce could make, also any group's particular training and development needs. Furthermore,

[92] Shields (2005)

giving graduates and others a quality of life that will help to retain their talents in the Region is seen as key to achieving a successful knowledge economy [93]

[93] Shields (2005)

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