Investing in the Future of Jobs and Skills

Scenarios, implications and options in anticipation of future skills and knowledge needs

Executive Summary
Computer, Electronic and Optical Products

This programme is managed by the Directorate-General for Employment, social affairs and equal opportunities of the European Commission. It was established to financially support the implementation of the objectives of the European Union in the employment and social affairs area, as set out in the Social Agenda, and thereby contribute to the achievement of the Lisbon Strategy goals in these fields.

The seven-year Programme targets all stakeholders who can help shape the development of appropriate and effective employment and social legislation and policies, across the EU-27, EFTA-EEA and EU candidate and pre-candidate countries.

PROGRESS mission is to strengthen the EU contribution in support of Member States' commitment. PROGRESS will be instrumental in:
1. providing analysis and policy advice on PROGRESS policy areas;
2. monitoring and reporting on the implementation of EU legislation and policies in PROGRESS policy areas;
3. promoting policy transfer, learning and support among Member States on EU objectives and priorities; and
4. relaying the views of the stakeholders and society at large

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http://ec.europa.eu/employment_social/progress/index_en.html

Overview

This executive summary highlights the main results of the final report *Investing in the Future of Jobs and Skills. Scenarios, implications and options in anticipation of future skills and knowledge needs in the computer, electronic and optical products sector*. Apart from analysing sector trends and developments, the study explores four plausible and distinctly different futures and their implications for jobs, skills and knowledge in the year 2020. The study is scenario-based, and is both forward- and backward-looking. It presents a variety of options and recommendations to address future skills and knowledge needs, aimed at the sector (firms, industry at large, sectoral partners), education and training institutes, policy-makers and other stakeholders.

The study should be placed against the background of the EU's renewed Lisbon Strategy for Growth and Jobs and the recently launched New Skills for New Jobs initiative. Investing in people and modernising labour markets is one of the four priority areas of the Lisbon Strategy. The New Skills for New Jobs initiative (European Commission, 2008; see http://ec.europa.eu/social/) presents a very first assessment of the EU's future skills and jobs requirements up to 2020. The initiative aims to help ensure a better match between the supply of skills and labour market demand and to improve the Member States' capacity to assess and anticipate the skills needs of its citizens and companies.

This study appears in a series of 16 sector studies which are all based on the same common foresight methodology and uniform step-wise approach (see table). The study combines desk research and expert knowledge, and brought together various internal (project team) and external sector experts. The methodological framework that was initially developed by Maria Joao Rodrigues (2007) was further developed, operationalised and applied by a consortium consisting of TNO (lead), SEOR and ZSI.

Methodological framework – the study explained in ten steps

Step 1. Identification of economic activities (sector selection)

Step 2. Main economic and employment trends and structures

Step 3. Main drivers of change

Step 4. Main scenarios

Step 5. Main implications for employment – changes by job function

Step 6. Main implications for skills – emerging needs by job function

Step 7. Main strategic choices to meet future skills and knowledge needs

Step 8. Main implications for education and training

Step 9. Main recommendations

Step 10. Final workshop (validating, complementing, finalising)

The computer, electronic and optical products sector–main characterisation

The computer, electronic and optical products sector covers three main sub-sectors, i.e. office equipment and computers (NACE 30), audio, video and telecom equipment (NACE 32) and medical, optical and precision instruments (NACE 33). The sector is characterised by short product life cycles, strong global competition and a comparatively strong emphasis on R&D. Increasing emphasis on consumer preferences in design and product development, collaboration with customers and increasing miniaturisation of electronic products and components have changed the business, as has international competition. Large global

players set the stage, with off-shoring (relocation) and outsourcing of manufacturing production being a pervasive phenomenon. At the same time, the degree of collaboration and cooperation in the sector is high, organized and orchestrated along global value chains. In recent years these value chains have gradually evolved into global value networks. Medical, optical and precision instruments manufacturing is the only exception to this general trend, with an important share of relatively specialized labour-intensive production being based in Europe in predominantly SMEs, but with a strong export profile, both within the EU and internationally.

Main economic and employment trends

Value added of the sector as a whole amounted to €154 bn in the EU in 2006, of which €147 bn was produced in the EU-15. Value added annual growth was - with 6.1% - almost a factor three faster than the 2.3% growth of the EU economy as a whole during the period 1995-2006. In the new Member States (NMS) the sector grew even more than a factor three compared to the overall economy (10.0% against 3.2%). In absolute terms though value added of the NMS is, however, less than 5 per cent of value added generated by the EU-15. Office equipment and computers accounted for €14.0 bn of total sector value added, audio, video and telecom for €71.8 bn, and medical, optical and precision equipment for €68.5 bn, with annual growth figures of -5.0%, 3.2% and 6.6%, respectively, over the period 2000-2006. Trade amounted to €478.8 bn in exports and €595.8 bn in imports, equivalent to 310% and 386% respectively, of value added. Imports grew faster than exports over the period 1995-2006, with 11.4% against 10.5% annually for the EU as a whole. Trade growth in the new Member States was explosive, with imports growing at a rate of 16.2%, and exports growing at 22.6% annually.

Altogether the sector accounted for about 134,000 enterprises, employing 2.06 million people, which equals 5.98% of EU manufacturing employment and 0.94% of overall EU employment. Most jobs – 53% - were in medical, optical and other precision instruments, and another 40% in audio, video and telecom equipment manufacturing. The remaining 17% jobs were in office equipment and computer manufacturing, a sector that also faced the biggest decrease in the number of jobs (-7.3% annually over the period 2000-2006).

Employment, state-of-play 2006 and changes 2000-2006				
Office machinery and computers (NACE 30)	Level 2006 (times 1,000)	Annual growth	Share in EU	Change in share
EU	150	-7.3	100	0
EU15	117	-9.0	78	-10
NMS	33	1.7	22	10
Audio, video and telecom (NACE 32)	Level 2006	Annual growth	Share in EU	Change in share
EU	814	-3.6	100	0
EU15	634	-4.8	78	-6
NMS	180	-1.6	22	6
Medical, optical and precision instruments (NACE 33)	Level 2006	Annual growth	Share in EU	Change in share
EU	1094	1.0	100	0
EU15	934	1.0	85	0
NMS	160	1.6	15	0

Source: Eurostat/TNO.

The majority of firms in the electronic, computer and optical equipment sectors (96.2%) are small firms employing less than 50 employees. 3.8% are medium-sized firms and only 0.8% are large firms with more than 250 employees. Small firms account for 29.5% of all employment and their employment share has, together with that of medium enterprises, sizably increased in the EU-15 (with 4.6 and 2.6 % points, respectively), but decreased in the NMS (with -0.8 and % -0.2 points). Employment in large firms declined substantially in the EU-15 (-6.4% points), but increased in the NMS (+1% point).

Employment trends by job function: shares (2006) and changes in shares (in%), 2000-2006						
	Shares, 2006			Changes in shares, 2000-2006		
	EU15	NMS	EU	EU15	NMS	EU
Managers	10	5	9	1	0	1
Computing professionals	8	6	8	2	3	2
Engineers	21	13	19	3	4	2
Business professionals	5	3	4	0	2	0
Other professionals	11	9	10	3	-5	2
Office clerks and secretaries	9	6	9	-2	-2	-2
Service workers	1	1	1	0	0	0
Metal machinery workers, blacksmiths	4	7	5	-1	0	0
Electric equipment mechanics, fitters	7	10	7	-1	-2	-1
Precision, handicraft, craft printing	6	4	6	0	-1	0
Other craft. trades workers	2	2	2	0	0	0
Assemblers	8	23	11	-5	5	-2
Other plant and machine operators	5	8	5	1	1	1
Labourers	4	3	4	0	-5	-1

Source: Eurostat Labour Force Survey/TNO.

The computer, electronic and optical products sector is a fast-changing, dynamic, R&D-intensive and competitive industry which obviously influences both job volumes and skills mix. Most jobs are in the categories engineers, assemblers, business and other professionals (i.e. accounting & finance, sales & marketing, supply chain management), computer professionals, office clerks and managers. The new Member States have considerably more assemblers, machinery workers and mechanics than the EU-15, whereas the EU-15 has more engineers, professionals and office clerks than the NMS. The share of women in overall employment is with 36% comparable to other sectors in the economy. Employment is dominated by medium educated employees; this is true for the EU-15 (47%), but especially for the new Member States (71%). Low educated workers, with a share of 17% in the EU-15 and only 9% in the new Member States, lost ground; decreases in both the EU-15 and NMS amounted to 5% points over the last 7 years. 53% of all employees is younger than 40 years.

Most volume change during the period 2000-2006 is observed amongst computing professionals, other professionals and engineers (all up by 2 % points) and office clerks and assemblers (down by 2% points). Changes in the NMS show more marked shifts, e.g. in the category other professionals and labourers (both minus (!) 5% points), engineers and assemblers (up 4% and 5% points, respectively) and computing professionals (up by 3% points). The shift in skills structure reflects an apparent shift in specialisation across Europe, with Central and Eastern Europe specialising in production and assembly activities, and Western Europe concentrating on the R&D-intensive, higher value segments. The lower educated ('blue collar' jobs) lost ground overall, gradually being substituted by mid-educated. Likewise, mid-educated computing professionals, managers, however, gradually appeared to be replaced by high-educated colleagues.

Employment by gender, age and education: Computer, electronic and optical products, 2000-06						
	EU		EU 15		NMS	
	Share % 2006	Change % 2000-2006	Share % 2006	Change % 2000-2006	Share % 2006	Change % 2000-2006
Women	36	0	33	-1	50	2
Age < 40	53	-6	51	-7	58	-1
Age 40 – 50	27	2	28	3	23	-3
Age > 50	20	4	20	4	19	5
Low education	16	-6	17	-5	9	-5
Mid education	51	2	47	0	71	4
High education	33	4	36	5	20	1
Entrepreneurs NACE 30	23	n.a.	22	n.a.	27	n.a.
Entrepreneurs NACE 32	15	n.a.	15	n.a.	17	n.a.
Entrepreneurs NACE 33	13	n.a.	12	n.a.	22	n.a.

Source: Alphametrics/TNO based on Eurostat Labour Force Survey.

SWOT Analysis and Identification of Main Drivers

SWOT analysis Computer, electronic and optical products sector	
Strengths	**Weaknesses**
• Strong science base across sub-sectors • High performing groups (Eindhoven-Leuven; several groups in Germany, etc) • Strong 'surrounding 'ICT services • Strong base for open innovation • High purchasing power in home market → potential for lead market and market for high end products • Single EU market scale attractive for firms to locate • High management capacity to manage large orchestrator firms in sector • Strong brands creating value added	• Low skilled European labour uncompetitive (high wages and labour costs) • Development part of R&D moving with production to Asia • Resources, particularly R&D, accumulated in few large firms • Weak IPR in third countries • Short development / product cycles increase competitive pressures • Lack of standardisation / competition between countries (regulation) • Fragmented research in national EU markets • Barriers to EU job mobility
Opportunities	**Threats**
• High value added products require strong design / creativity / product development competences at which European firms are good at • Megatrends of energy/environment and security as future growth markets (co-driven by regulation!) • Digitalisation of production and consumption (digital media, e-health, e-democracy) • Health and medical equipment and digital media as growth markets • High-end market segments as growth markets – white goods / audio / etc. • Short product life cycles expand markets	• Asia moving from production to R&D, design & manufacturing location • R&D potentially relocating with production to Asia • Decrease of high volume / low profit segments undermining industry – impact on high end segments • Concentration of large firms – globally mobile

Source: TNO/SEOR.

The Strengths-Weaknesses-Opportunities-Threats (SWOT) analysis and the expert-based search for main drivers of change (see Tables) both yield important building bricks for the design and construction of the scenarios. A further differentiation was made been exogenous drivers (drivers that form a "given" at sector level)[1] and endogenous drivers (drivers that can be influenced at the sector level, for instance by national or European policy-making, or by collective effort from within the sector.

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[1] With the exception here of Technology, parts of which can be influenced at firm level. For reasons of internal consistency of the scenarios, this driver is nevertheless categorised as exogenous.

Category	Driver	Is this driver relevant for the sector? Y / N	How relevant is this driver for the sector? Scale 0-10	How uncertain is this driver for the sector? Scale 0-10	Are substantial impacts expected on the levels of employment? Y/N	Are substantial impact expected on employment composition? Y/N	Are substantial impacts expected on new skills? Y/N	Short, medium or long run impact?** S	M	L	Are substantial differences expected between (groups of) countries? Y / N	Are substantial differences expected between sub-sectors? Y / N
D*	Ageing - Adapt to the market demands of an ageing and more diversified society	Y	8	1	N	N	N		x	x	N	Y
E*	Income per capita and household	Y	9	2	N	Y	Y		x	x	Y	Y
Globalisation	Outsourcing & offshoring	Y	9	1	Y	Y	Y	x	x	x	Y	N
Globalisation	Increasing global competition	Y	9	1	-	-	-	x	x	x	N	N
Globalisation	Emerging economies driving global growth (new market demand, especially BRICs)	Y	8	3	N	N	N	x	x	x	N	N
Globalisation	Global / regional production networks (dispersed production locations, transport)	Y	8	2	N	N	N	x	x	x	N	N
Globalisation	Counter-trend regionalism / protectionism	Y	6	6	Y	Y	N	x	x	x	Y	Y
Cultural values	Increasing market segmentation (tailor made production, mass customization)	Y	9	2	N	Y	Y	x	x	x	Y	Y
Cultural values	Lifestyle changes	Y	8	2	N	Y	Y	X	X	X	Y	Y
Technology and innovation	Advances in IT impacting on organizational structures & new business models	Y	8	1	Y	-	-	x	x	x	N	N
Technology and innovation	Internet changing production and consumption patterns (e-business; etc.)	Y	8	3	N	Y	Y		x	x	Y	Y
Technology and innovation	Environmental regulation including energy efficiency	Y	6	4	N	N	N	x	x	x	N	N

Notes: * D: Demographic. E: Economic. ** Short = 0-3 years; medium = 3-7 years; long = > 7 years. All three categories may apply

Scenarios and implications for employment

Four future scenarios have been constructed and explored: 1) *High-end Customer Hi-Wi-Fi,* 2) *Hi-Wi-Fi for Everyone,* 3) *Footloose and Offshored,* and 4) *Fading Away* (see also Figure). The scenarios depict plausible and credible futures for the electronic, computer and optical equipment sector in Europe by 2020. Rather than wishful pictures of the future, scenarios are founded on drivers and trends observed and are derived in a logical and deductive way, hence making inferences about plausible future developments. Rather than predictions or forecasts based on a model, the scenarios outcomes in this study are based on expert opinion. The bandwidth between the most extreme scenarios can be interpreted as indicative for the degree of uncertainty indicating possible paths for flexible anticipation.

Construction, hypotheses and use of the scenarios

In constructing the scenarios, a clear distinction has been made between exogenous and endogenous drivers, the main difference being the scope and ability for direct influence. Exogenous drivers are drivers that form a "given" at sector level. Endogenous drivers are drivers that can be influenced at the sector level, for instance by national or European policy-making, or collective effort from within the sector. In constructing the scenarios, those drivers have been selected that scored high on the criteria relevance, impact and uncertainty. The relevance criterion was used to focus and tailor the scenarios to the aim at hand, i.e. drawing inferences on the future of jobs and skills and knowledge needs by 2020. Impact and uncertainty were used to define distinct directions in the four scenarios which have been depicted in the figure below, with the exogenous drivers on the horizontal axis and the endogenous drivers on the vertical axis.

The scenarios apply to the manufacturing of electronic components, computers, communication equipment and consumer electronics on the one hand, and of medical and optical equipment on the other. This does neither imply that future developments in each sub-sector are to be taken as one and the same, nor that development paths between Member States need to be similar. The sectors will face different dynamics in terms of market structure and developments, while driven by similar but differently impacting drivers. The way the scenarios have been constructed enables such differentiation. Note that the demographics – ageing (less young, more retirees) – and its effects on labour supply have not explicitly been identified in selecting the drivers, as demographics in the time frame of 2009-2020 are relatively certain (i.e. predictable) and play a role across all scenarios. Education and training, which stricto sensu could be perceived as endogenous factors, have been excluded. They form - together with a number of other strategies and/or policies - the solutions and hence a possible response to the impact of the scenario on skills, knowledge and jobs. The key features of the four scenarios can be described as follows:

Scenario I: *High-end Customer Hi-Wi-Fi*

High-End Customer Hi-Wi-Fi depicts a world characterised by openness, willingness to experiment and look for creative solutions for everyday problems (work, leisure, quality of life). Industry creates sustainable high-end niches and is able to market its products both domestically and abroad in a context of continuing and strong international competition. With a focused EU innovation policy and ditto national policies, a viable environment is created for regaining ground in innovation and market leadership for EU-based firms. Different life-styles and a strong demand for individualised products are met by mass customisation and individualisation. There is strong progress in recycling of materials and increasing energy-efficiency. European firms are leading in organising and orchestrating flexible international value networks. Most standardised production is offshored, but European companies

increasingly move parts of production back to Europe (NMS!) to serve high-end niche segments of their market, closer to customers, with better quality assurance and creating logistics savings.

Four future scenarios for the non-metallic materials sector and main underlying drivers

Endogenous, sector-specific drivers:
- Trade and market regulation
- Societal and cultural environment
- Innovation policy

- Open and multilateral trade
- Open society and economy
- New and innovative spirit
- Leading-edge EU innovation policy

Exogenous drivers:
- Outsourcing & offshoring
- Globalisation and global competition
- Market segmentation
- Demand (lifestyle, e-sales)
- Technology: IT automation and Internet
- Income

Continuing

Strong global competition and globalisation

Mass consumption

Mixture of traditional and modern lifestyles and households

Modest roll-out and adoption

Low growth

Hi-Wi-Fi for Everyone (Scenario II)	**High-end Customer Hi-Wi-Fi (Scenario I)**
Fading Away (Scenario IV)	**Footloose and Offshored (Scenario III)**

Continuing, Europe orchestrating

Strong global competition and globalisation

Mass customisation

Individualisation, convenience, tailor-made

Strong roll-out and adoption

High growth

- Selective border protection and bilateral trade agreements
- Closed society and economy
- Conservative spirit
- Fragmented 'follower' –type national innovation policy

Source:
TNO-SEOR-ZSI

Scenario II: *Hi-Wi-Fi for Everyone*

Hi-Wi-Fi for Everyone depicts a world characterised a social and cultural climate that is conducive to change, with apt innovation policies stimulating further high tech innovations. However, European income growth is low, and European consumer demand is less individualized than elsewhere (US, Asia). The most important high-value niche opportunities for firms in the sector lie outside Europe. Product developments for specific groups, e.g. the elderly, halt in Europe because of fragmented markets and the dominance of national regulation; the single European market for services does not materialise. Europe only specialises in a few niche markets, like medical equipment for hospitals. Offshoring continues and assembling presently located in the new Member States will move out of Europe, with only a few niche products for the export market remaining, Differentiation allows European firms to compete, being the leading coordinators of international value and production networks.

Scenario III: *Footloose and Offshored*
Footloose and Offshored depicts a world characterised by strong income growth and a demand for more customised and personalised products. Yet European society becomes more inward-looking; fragmented (national!) innovation policies do not generate sufficient mass to matter much for innovation. European firms are outcompeted in meeting demand for individualized products (including age-specific ones), which will come increasingly from outside Europe. Consumers pick and choose from whatever is available, world-wide, facilitated by the Internet. Assembling will move almost completely out of Europe; this also holds for specialised and tailor-made assembling. European firms will remain leading in global value networks, but with hardly any production locations in Europe anymore. Following the Benetton model, headquarters, PR and marketing functions are still in Europe but most of the other vital company functions are performed elsewhere. R&D is gradually moving out off Europe.

Scenario IV: *Fading Away*
Fading Away depicts a world dominated by low income growth, and although Europe is still a sizeable market, demand for renewing innovative and individualized high value products and services lags behind. User industries tend to go where the(ir) markets are, with Europe losing ground. European society is inward-looking with protectionist tendencies lurking. Innovation policy is mainly national policy and fragmented. European firms show a striking lack of initiative and capability to develop new high tech products for the export market. Most production will be offshored outside Europe. Only the development and production of very specialised niche products will remain. Europe faces the risk of a brain drain of people working in the sector to other sectors, as well as the industry outside Europe.

Implications of scenarios for jobs, skills and knowledge by job function

In determining job volume changes, a distinction has been be drawn between electronic components, computers, communication equipment and consumer electronics on the one hand, and optical, medical and precision equipment on the other. *High-End Customer Hi-Wi-Fi* delivers most positive results in overall employment volume by 2020. Europe will be leading and orchestrating the global innovation, production and sourcing networks and this will result in a demand for more managers, IT professionals and business professionals, especially those positions that require system integration capabilities. A sizeable assembly platform will gradually develop in the NMS with tailored production and assembly platforms, focusing on highly specialised niche markets, increasing employment in assembling. Europe will further extend its comparative advantage in the highly specialised and tailored medical and optical equipment segment, resulting in an increase in specialised metal and machinery workers as well as precision workers and repairers.

Hi-Wi-Fi for Everyone will result in a relatively stable employment level. The opportunities will lie outside Europe and in very high-tech niche markets, for example in medical and precision equipment (X-ray, but also radar, navigation, and process control equipment). Europe remains an important orchestrator of global networks, which requires managers and business professionals capable of organising these networks. Europe will continue developing specialised high-tech products, but it will be less extensive than in the first scenario, with increases in employment mainly to be expected in the optical and medical products sector.

The net overall employment implications of *Footloose and Offshored* show a stable development for management and business professionals, but a decline in design and production functions. All production and R&D move outside Europe and high-tech products

and services are developed in other parts of the world, jobs moving with them. European firms are still important actors in organising the global value networks, but the only function they will keep in Europe are functions close to the market: marketing, PR and main headquarters functions. The impact of *Footloose and Offshored* will not differ much between electronic components, computers, communication equipment and consumer electronics on the one hand and optical, medical and precision equipment on the other. European consumer demand for these products is booming, but their supply will come from elsewhere.

Implications of scenarios: job volume changes by function, 2009-2020. Sub-sectors: Electronic components, computers, communication equipment and consumer electronics

	High-end Customer Hi-Wi-Fi	Hi-Wi-Fi for Everyone	Footloose and Offshored	Fading Away
Managers	+	0	0/+	0/-
IT system developers	+	0/+	0	-
IT system appliers and supporters	0	0	0	-
Production engineers	0	0	-	-
R&D engineers	+	0/+	-	-
Accounting & Finance	0/+	0	0	-
Sales & marketing	+	0	0/+	-
Supply chain managers	+	0/+	0/+	0/-
Support staff	-	-	-	-
Metal and machinery workers	0	-	-	-
Electric/electronic equipment mechanics and fitters	-	-	-	-
Precision workers and repairers	0	0	-	-
Assemblers	0/+	-	-	-
Labourers and operators	-	-	-	-
Overall job change	*+*	*0*	*0/-*	*-*

Source: TNO-SEOR-ZSI. Note: - = decrease, + = increase, 0 = maintain.

Implications of scenarios: job volume changes by function, 2009-2020. Sub-sector: Medical, optical, & measurement devices

	High-end Customer Hi-Wi-Fi	Hi-Wi-Fi Exported	Footloose and Offshored	Fading Away
Managers	+	0/+	0/+	0/-
IT system developers	+	+	0	-
IT system appliers and supporters	0	0	0	-
Production engineers	+	0	-	-
R&D engineers	+	+	-	-
Accounting & Finance	0/+	0	0	-
Sales & marketing	+	0	0/+	-
Supply chain managers	+	0/+	0/+	0/-
Support staff	-	-	-	-
Metal and machinery workers	0/+	0/+	-	-
Electric/electronic equipment mechanics and fitters	-	-	-	-
Precision workers and repairers	+	+	-	-
Assemblers	+	0	-	-
Labourers and operators	-	-	-	-
Overall job change	*+*	*0/+*	*0/-*	*-*

Source: TNO-SEOR-ZSI. Note: - = decrease, + = increase, 0 = maintain.

Fading Away is most negative in terms of employment volume. Due to negative market developments in Europe in combination with a conservative spirit, European firms will loose ground. European firms will move their activities completely outside Europe, although some firms will continue their function of organising and leading global value networks.

Identification of emerging competences, skills and knowledge needs
By taking the scenarios and drivers as a starting point, logical inferences ('guestimates') of skills and knowledge needs were made for each of the identified job functions. *Skills* refer to the ability to apply knowledge and use know-how to complete tasks and solve problems. In the context of the European Qualification Framework (EQF), skills are described as cognitive (involving the use of logical, intuitive and creative thinking) or practical (involving manual dexterity and the use of methods, materials, tools and instruments). *Knowledge* refers to the outcome of the accumulation of information through learning. It is the body of facts, principles, theories and practices that is related to a field of work or study. In EQF context, knowledge is described as theoretical and/or factual. *Competences* refer to the proven ability to use knowledge, skills and personal, social and/ or methodological abilities, in work or study situations and in professional and personal development. Competences thus defined come actually close to what is generally understood nowadays as 'soft skills'. In EQF context, competences are described in terms of responsibility and autonomy. In the practical elaboration of future skills and knowledge needs for the purpose of this study, both have been further 'disentangled' to result into six clusters of similar and related skills and knowledge needs (see Box).

Overview of skills and knowledge needs identified for each job function and scenario
Knowledge ('hard skills')
• Legislative / regulatory knowledge (environmental / safety / labour / contracting); Language*; e-skills; Marketing skills; Technical knowledge; Product knowledge; Product development
Social Skills
• Team working skills; Social perceptiveness (listening / understanding); Communication; Networking; Language*; Intercultural
Problem-solving Skills
• Analytical skills; Interdisciplinary; Initiative, Multi-skilling; Creativity
Self-management Skills
• Planning; Stress and time management; Flexibility; Multi-tasking
Management skills
• Strategic & visionary; Coaching and team building; Change management; Project management; Process optimizing; Quality management; People skills crucial for collegial management style
Entrepreneurial skills
• Supplier and customer relationship / understanding; Business understanding / development; Trend setting / trend spotting
Source: TNO-SEOR-ZSI

Future skills and knowledge needs by job function
Across all job functions soft skills will become increasingly important, especially so for high skilled professional job functions. The general trend of up-skilling across job functions is bound to continue in the coming years. Due to the changing nature of jobs, predefined

technical knowledge capabilities will become somewhat less important while skills to adapt and learn new competences and life-long learning will be put at a premium. Certain knowledge – notably e-skills – will become more important. Emerging competences of higher skilled jobs mostly refer to *how* to learn, communicate, interact and adapt to changing environments in addition to a high quality education. Emerging competences in medium-educated job functions that mostly execute defined tasks and processes refer mostly to specific knowledge sets that can be taught through learning.

We illustrate the key emerging skills and knowledge needs for three of the eleven distinguished job functions, including are engineers (production and R&D), and precision workers and repairers.

Engineers - by far the largest occupational function in the sector, comprising of production and R&D engineers. In scenarios characterised by fast change and dynamic markets, the move towards sustainable market niches and market segmentation is a key differentiator for the skills and knowledge requirements of engineers. R&D engineers are vital, as R&D forms the basis for growth in the sector in Europe and elsewhere. Production engineers are key in the highly complicated production of high-tech products ('the Fab is the Lab') and in the optical, medical and precision products sector. Both require not only technical but also organisational and social skills. Social skills (esp. team working, communication and networking), problem solving skills (analytical, interdisciplinary, initiative, multiskilling, creativity) and self management (planning, flexibility, stress and time management) skills are important for both production and R&D engineers. R&D engineers need to focus on the design of new products and services, should be able to have a broad perspective on potential market needs and should be able to integrate different solutions into one product. While keeping up-to-date with technical knowledge, product (development) and system architecture knowledge is key for R&D engineers, business understanding and customer understanding is crucial as well. Innovation is organised around interdisciplinary expert teams, project based and collaborative, also incorporating external experts either from universities or other firms. This requires increased project management skills from especially R&D engineers. As surveyors of the production process, process optimising and quality management skills will be important for production engineers.

Precision workers and repairers – comprising precision workers in metal and other materials, precision-instrument makers, and precision repairers mainly active in maintenance and repair. For both the most important competence is technical knowledge. Keeping this knowledge up-to-date, and acquiring new knowledge is prime. Product knowledge is crucial, as are quality control skills and product(ion) relevant regulation. Problem-solving skills including analytical and interdisciplinary skills, initiative and multiskilling, as well as self-management (flexibility) will be key in the future. However, also for precision workers and repairers the changes in work organisation require increasingly social skills related to team working and communication skills.

Main strategic choices to meet skill and knowledge needs

In order to meet future skills and knowledge needs, apt and timely solutions – referred to here as strategic choices - are required (see Table below). Strategic choices refer and relate to the medium- and longer term, even though emerging skills and knowledge needs in practice may also apply to the now and tomorrow. Essential in seeking appropriate solutions is to keep this longer time perspective in mind. Rather than focusing on one single solution, a set of linked strategic choices will in most cases be the best strategy to follow. Prioritising both in time

(what first, where to follow up) and in allocation of resources (including budgetary focus) followed by further fine-tuning is a clear necessity to guarantee that skills needs are targeted and solved. Skill needs can be identified at various levels, ranging from assessments at the national or even European sector level to more precise assessments at the regional and company level. Increasingly the identification of skills and knowledge needs but also the search for adequate solutions will have to become an integral part of an overall longer-term business strategy, also for SMEs. Some solutions will be found within the company itself, e.g. through reorganising functions within or between plants, by offering (re)training trajectories or by active global sourcing of personnel. For SMEs and especially for micro-enterprises such longer-term, more strategic human resource management often will be more difficult to organise and operationalise.

In order to address the identified future skills and knowledge needs in an encompassing and timely manner, appropriate joint action is needed by all stakeholders, including the industry (firms, sector organisations and social partners), training and education institutes, intermediary organisations and, last but not least, government at all levels (EU, national, regional and local). Collaboration is needed in order to agree on and implement a package of feasible solutions. Timely, targeted and reliable information to make decisions – i.e. adequate monitoring and analysis - is an essential prerequisite.

Conclusions

Implications, conclusions and recommendations refer to two distinct levels: the individual job function (micro) level focusing on available options by job function and the more aggregate generic 'meso-level' level. They are aimed at sectoral stakeholders (firms, social partner, education and training institutes and others) and policy-makers. The preceding table summarises the micro-level options and highlights the main findings by category. At the meso-level a further distinction has been made between education and training on the one hand and 'other' main conclusions and recommendations on the other.

Conclusions and recommendations on education and training

1) Adapt and modernise vocational education and training (VET) and general education systems, but do this nationally rather than at the EU level;
2) Enhance the flexibility in education and training by promoting modularization;
3) Stimulate targeted facilitation of Life-Long Learning (LLL);
4) Strengthen collaboration between vocational training institutes and industry;
5) Strengthen knowledge networks in higher education;
6) Build on existing know-how transfer and establish learning networks alongside the value chain;
7) Enhance flexibility in learning forms – e-learning and blended learning;
8) Foster a culture of learning, innovation, openness and tolerance;
9) Strengthen basic skills early on and improve the quality of primary education;
10) Promote the natural sciences and mathematics in schools and improve the image and visibility of technical and scientific job careers;
11) Supply special courses dedicated to sector characteristics: supply change management, design engineering, nano-electronics and nano-optics;
12) Supply special courses for older workers;
13) Pay more attention to interdisciplinary and multidisciplinary studies;
14) Foster multi-skilling.

Main other conclusions and recommendations

1) Foster collaboration between all stakeholders and between different political-geographical levels and stimulate Partnerships for Innovation and Job creation and Social Dialogue;
2) Develop and cherish successful regional clusters;
3) Diversify the personnel base and recruitment scope;
4) Increase flexibility in work organization;
5) Increase intra- and intersectoral as well as transnational mobility and promote international and intersectoral acknowledgement of certificates;
6) Promote the intra-sectoral, intersectoral and transnational acknowledgement of IT skills by introducing an IT driver's licence;
7) Provide better career guidance for those in search of a job, supported by skills assessment schemes;
8) Increase co-operation to improve the information systems on skills and knowledge needs and job opportunities.

		Hi-Wi-Fi for Everyone	Hi-Wi-Fi Exported	Hi-Wi-Fi for Everyone	Hi-Wi-Fi Exported	
Summary of changes in job volumes, skills changes, main strategic choices and main players in anticipatory action by scenario						
Managers	1. Employment volume change	+, +*	0, 0/+	+, +	0/+, +	**R&D engineers**
	2. Skills changes counted 1); 2)	18		20		
	3. Emerging skills needs	Entrepreneurship, Strategic& visionary skills, Change management, Self management, Social skills (communication, networking, language, intercultural skills), Knowledge (e-skills, supply chain management, Intellectual Property Management)		Knowledge (technical, product development, system integration), Problem solving skills, Self management (planning, stress & time management, flexibility), Social skills (team working, communication, networking), Entrepreneurship (especially understanding customers and suppliers), Project management, Process optimising, Trendsetting and spotting skills, Strategic and visionary skills		
	4. Most important solutions	Recruiting, Training and re-training, Designing & offering new courses, Providing information, Stronger cooperation between stakeholders		Recruiting from other sectors, other Member States, non Member States and unemployed, Training and retraining, Changing work organisation, Outsourcing and offshoring, Changing vocational education, Designing and offering new courses, Providing information, Improving image, Stronger cooperation between stakeholders		
	5. Most important actors	C, G, E, U		C, E, G, I S, U		
IT system developers	1. Employment volume change	+, +	0/+, +	0/+	0, 0	**Accounting and Finance**
	2. Skills changes counted	15		10		
	3. Emerging skills needs	Knowledge (Imaging, System integration, Modelling & simulation, Programmes Languages), Problem solving skills (analytical skills, multi-skilling)		Knowledge (legislative and regulatory, e-skills), Analytical skills, Self Management (stress & time management, flexibility, multi-tasking), Social skills (team working, language, intercultural skills), Process optimising		
	4. Most important solutions	Recruiting from other Member States, from non Member States and young people, Training and retraining, Changing vocational education, Designing and offering new courses, Providing information, Improving image, Stronger cooperation between stakeholders		Recruiting, Training and retraining, Outsourcing & offshoring		
	5. Most important actors	C, G, E, I, S U		C, E, G, I		
IT system appliers and supporters	1. Employment volume change	0, 0	0, 0	+, +	0, 0	**Sales and Marketing**
	2. Skills changes counted	13		20		
	3. Emerging skills needs	Problem solving skills (especially analytical skills and multi-skilling), Self management (especially stress & time management), Knowledge (especially B2B IT platforms), Social skills (team working, communication)		Entrepreneurship, Client relationship management, Social skills (especially intercultural), Self management, Knowledge (product), Problem solving skills (interdisciplinary, creativity), Project management		
	4. Most important solutions	Recruiting from other sectors, other Member States, non Member States, young people and unemployed, Training and retraining, Outsourcing and offshoring, Changing vocational education, Designing and offering new courses, Providing information, Improving image, Stronger cooperation		Recruiting, Training and retraining, Changing work organisation, Outsourcing and offshoring, Designing and offering new courses, Providing information, Stronger cooperation between stakeholders		
	5. Most important actors	C, G, E, I, S, U		C, E, G, I, U, S		

		Hi-Wi-Fi for Everyone	Hi-Wi-Fi Exported	Hi-Wi-Fi for Everyone	Hi-Wi-Fi Exported	
Production engineers	1. Employment volume change	0/+	0, 0	+, +	0/+, 0/+	**Supply chain managers**
	2. Skills changes counted	14		10		
	3. Emerging skills needs	Problem solving skills, Self management (planning, stress & time management, flexibility), Knowledge (technical and e-skills), Process optimising, Quality management, Social skills (team working and communication)		Social skills (networking, language, intercultural), Knowledge, Analytical skills, Self management (stress and time management, flexibility)		
	4. Most important solutions	Recruiting from other sectors, other Member States, non Member States, unemployed, Training and retraining, Changing work organisation, Outsourcing and offshoring, Changing vocational education, Designing and offering new courses, Providing information, Improving image, Stronger cooperation between stakeholders		Recruiting, Training and retraining, Changing work organisation, Outsourcing and offshoring, Changing vocational education, Designing and offering new courses, Providing information, Stronger cooperation between stakeholders		
	5. Most important actors	C, E, G, I S, U		C, E, G, I, S, U		
Support staff	1. Employment volume change	-, -	-, -	-, -	-, -	**Electric/Electronic equipment mechanics and fitters**
	2. Skills changes counted	9		10		
	3. Emerging skills needs	Self management (especially flexibility and multi-tasking), Initiative, Social skills (team working, communication, language, intercultural), Knowledge (e-skills)		Knowledge (especially technical), Social skills (team working and communication), Problem solving skills (initiative, multi-skilling), Flexibility		
	4. Most important solutions	Recruiting, Training and retraining, Outsourcing and offshoring, Designing and offering new courses		Recruiting, Training and retraining, Outsourcing and offshoring, Designing and offering new courses, Providing information, Improving image, Stronger cooperation between stakeholders		
	5. Most important actors	C, E, I, G		C, E, I, G, S, U		
Metal and machinery workers	1. Employment volume change	0, 0/+	-, 0/+	0, +	0, +	**Precision workers and repairers**
	2. Skills changes counted	10		11 (precision makers), 13 (precision repairers)		
	3. Emerging skills needs	Knowledge (especially technical and quality control), Social skills (team working and communication), Problem solving skills (initiative, multi-skilling), Flexibility		Knowledge (technical , product, quality control), Problem solving skills (especially analytical), Social skills (team working, communication, language, intercultural), Flexibility)		
	4. Most important solutions	Recruiting, Training and retraining, Outsourcing and offshoring, Designing and offering new courses, Providing information, Improving image, Stronger cooperation between stakeholders		Recruiting, Training and retraining, Outsourcing and offshoring, Changing vocational education, Designing and offering new courses, Providing information, Improving image, Stronger cooperation between stakeholders		
	5. Most important actors	C, E, I, G, U, S		C, E, I, G, S, U		

Assemblers		Hi-Wi-Fi for Everyone	Hi-Wi-Fi Exported	Hi-Wi-Fi for Everyone	Hi-Wi-Fi Exported	Labourers and operators
	1. Employment volume change	0/+, +	-, 0	-, -	-, -	
	2. Skills changes counted	11		5		
	3. Emerging skills needs	Knowledge (technical, product, e-skills), Social skills (team working, communication, language), Problem solving skills (initiative, multi-skilling), Self management (stress & time management, flexibility)		Knowledge (e-skills, technical knowledge, quality control), self management (stress & time management, flexibility		
	4. Most important solutions	Recruiting, Training and retraining, Changing work organisation, Outsourcing and offshoring, Designing and offering new courses, Providing information, Improving image, Stronger cooperation between stakeholders		Recruiting young people from the education system (replacement demand); Training and retraining (up-skillling)		
	5. Most important actors	C, E, I, G, S, U		C, E, I		

C=Companies; S=Sectoral organisations, U=trade Unions; E=Education and training institutes; G=Government (EU, Member State, regional, local). Notes: 1) The term 'skills' includes knowledge (needs). 2) The 2nd row 'skills changes counted' refers to the number of skills categories in the most extreme scenario. *) Assessment of volume changes for electronic components, computers, communication equipment and consumer electronics on the one hand and for the optical and medical products on the other hand