ICT practitioner skills and training: automotive industry

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Preface

This study is part of a series of four studies launched by Cedefop in late 2002 under the project ICT platform. A working party, set up to accompany these studies, comprised some 20 eminent experts and expert bodies in the field. This ICT workshop has met three times since its constitution and has the task of advising Cedefop on the approach to, and content of, the surveys and on questions linked to ICT skills supply and curriculum development in general. Links were also established by Cedefop to parallel developments in the European Commission and especially to the e-skills forum and e-Europe action programme launched under the Danish Presidency. The workshop also relates to other important activities of DG Education and Culture on E-Learning. The contractors were invited, on the basis of their former experience and additional surveys, to edit a text of around 50 pages (without annexes) on the subject indicated in the introduction below.

These four studies are now available individually and will be combined in a synthesis report expected to be ready during 2004.

In parallel to the studies, Cedefop cosponsored a workshop in the framework of European standardisation activities (CEN/ISSS). This was intended to validate the outcomes of the work of the Career Space Consortium, published by Cedefop in 2001 and 2002 (www.career-space.com) on ICT profiles and curricula aimed at university level skills and IT practitioner higher education.

Once this validation is concluded (anticipated during 2004) the same procedure will be used to validate the outcomes of these four Cedefop studies (see also the virtual community under http://cedefop.communityzero.com/cen-ict, set up by Cedefop on this issue).

Werner Herrmann, Senior Advisor to the Cedefop Director

Burkart Sellin, Principal Administrator and Project Manager

Introduction

This study analyses important developments in automotive production and in the motor vehicle repair and sales ([1]). The focus is on skill and training needs with a view to developing new curricular concepts for ICT practitioners ([2]), including professionals ([3]) and other skilled employees with a qualification in (vocational) occupations or other ICT business areas at non-university levels. One of the main challenges of this study is to assess the claim by ICT industry representatives that the sector has absolute and independent importance ([4]).

In spite of the recent difficulties of the IT industry, skilled ICT employees are still better off in view of their employment opportunities. There is a coherence between the ICT market situation and the employment opportunities in every sector with a ICT permeation, but this is no linear relation. In addition, ICT offers innovation potential for training and education provision at non-university levels or within short cycle higher education, with sociologists and educationalists interested in studying the skill and training profiles for ICT workers. It seems appropriate to discuss the following issues:

(a) Which role does or will this target group play alongside professionals trained in higher education?

(b) What tasks are emphasised at lower and intermediate level of skill?

(c) Which IT skills and competences will be of highest relevance in the medium term?

(d) What are the new or changed outlines of skill and training or competence profiles?

This study is partly based on the authors' own empirical surveys and partly on analyses in selected fields undertaken to examine trends in the issues mentioned above.

The empirical basis of the study is based on several existing studies of the authors in the field of automotive industries. These studies had no explicit focus on ICT measures only. Therefore all results of these studies were proved by additional surveys to validate the answers to the named questions. In some places it is therefore clear that transfers from other studies with other objectives had to be envisaged. The importance of ICT for skills and competences in the automotive sector should be examined further and deeper in the future – without loosing the focus on the surveyed sector (here the automotive sector).

([1]) The definition and delimitation of the motor vehicle repair and sales sector follows the European Report on *Motor vehicle repair and sales sector* (e.g. Rauner et al., 1994).

([2]) ICT practitioners means all those staff members primarily working in and on core ICT-tasks within this user industry.

([3]) There are many different definitions of the term 'professional'. This problem is discussed in Section 1.1.

([4]) See different publications on the DG enterprise website http://europa.eu.int/comm/enterprise/ict/index.htm

1.   The automotive industry in Europe

1.1.   Delimitation of the sector and scope of the study

Information and communication technologies (ICT) are currently penetrating nearly all fields of occupational activity in the automotive sector, with special importance for automotive production and repair. The proportion of electrical and electronic components in a medium-sized limousine has already reached an average 20 % of value. A 3-Series BMW includes electronic equipment with an equivalent of 30 % of the car's sales value. From 2010 on, the average value share of electronic equipment is forecast to reach 35 %, and even 50 % in luxury vehicles. ICT applications and software will play an increasing role (see Figure 1). More and more functions in a car are determined by software and so are the tools for the workforce in the automotive industry [5].

Figure 1:   *Development of software share of vehicle value*
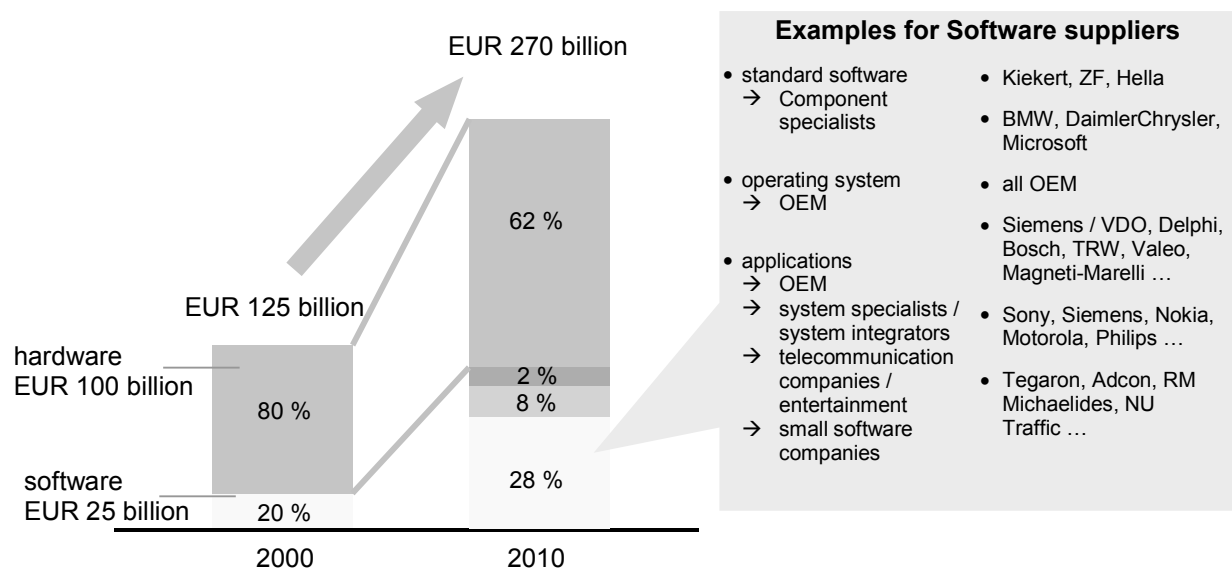
Source: Mercer Management Consulting 2002

The automotive industry is essentially a set of distinct, yet interrelated, activities with a variety of organisational structures and associated skill requirements. Its employees can be allocated to three segments (see Figure 2):

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[5]   These statements are the result of studies revealing such trends. Up to now, the value percentage of electronics increased continuously, however, not at the amount as originally predicted.

(a) development, research and engineering,

(b) production (manufacturing and assembly),

(c) repair and sales.

Figure 2:   *Sub-sectors of the automotive sector*
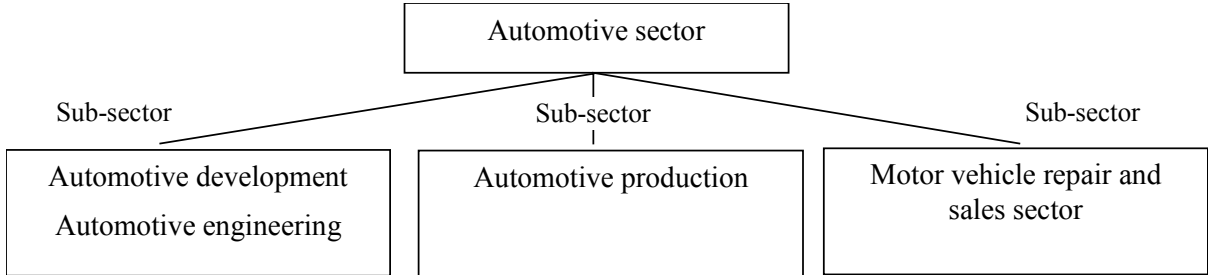
ICT applications (hard and software relevant for the industry) are used extensively in these sub-sectors albeit without any uniformity in the ICT competences required by development, production and repair. The required competences cover a wide range and the process from simple user knowledge via programmer know-how to advanced knowledge of the conception and design of complex ICT structures. These competences are, however, closely interlinked. A differentiation can be made between ICT users or operators and ICT developers or practitioners, though the transitions are smooth and cannot always be clearly delimitated from each other (see Figure 3).

Figure 3:   *Focus on ICT positions*
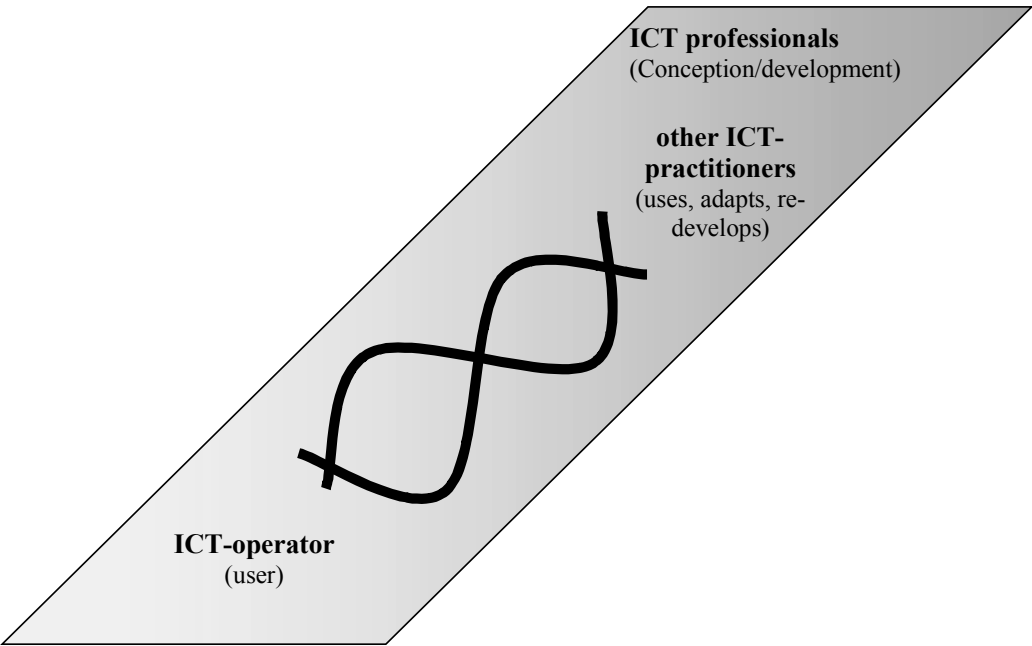
Within the framework of the Leonardo Project EUQuaSIT (⁶), three ICT-groups are distinguished: ICT users, ICT operators, and ICT developers/practitioners (or ICT professionals, other ICT practitioners, see Figure 4). The delimitation between these groups is hampered by the use of varying definitions. In addition there is the question of the classification of those employees with an occupation/profile without initial ICT training but who may be working, e.g. as programmers after a qualification via non-formal pathways in subjects such as engineering or electronics. The creation of a formal difference between users and level four or five professionals seems to be increasingly problematical.

European statistics use a definition based on the NACE codes assigned to companies working in ICT (see Deiss, 2002). This kind of definition leads to some problems in determining the number of ICT relevant employees. The number of persons employed is defined as the total number of persons who work in the observed unit (including working owners, partners working regularly in the unit and unpaid family members), as well as those *who work outside the unit* who belong to it and are paid by it (e.g. sales representatives, delivery personnel). This includes persons absent for a short period and also those on strike, but not those absent for an indefinite period. It also includes part-time workers on the payroll, as well as seasonal workers, apprentices and home workers on the payroll. The number of persons employed excludes manpower supplied to the unit by other enterprises (e.g. Deiss, 2002, p. 7).

This definition does not further differentiate into occupational groups or levels. According to this definition the European ICT-sector had 442 000 companies with 4.5 million persons in 1999 (Deiss, 2002, p. 3). Garland pointed out that the EU's ICT sector in 2000 accounted for approximately 550 000 enterprises, with 6 million persons employed (Garland, 2003, p. 3).

These official statistics do not only include employees working in ICT work areas in a professional way. Also people like the janitor in an ICT company are included here. On the other hand all ICT professionals from other sectors are not included. In addition it is not clarified which employees are dealing with ICT in a practitioner's sense. This obscure situation on defining the term 'professional' stressed that this has to be described more precisely.

When applying further delimitations and definitions for ICT skilled workers it is obvious that a more sustainable work definition has to be determined which is adapted to the professional and skill profiles existing in this ICT sector.

In the proper ICT sector, the EITO (⁷) differentiates between ICT, e-business and call centre professionals (EITO, 2002, p. 38):

(a) ICT professionals: support and develop technology environments in the industries that use ICT (or services vendors selling their ICT professional resources times);

(⁶) See also Cedefop study (Petersen and Wehmeyer, 2003).

(⁷) EITO: European Information Technology Observatory

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(b) e-business professionals focus on supporting business strategies related to the Internet;

(c) call centre professionals provide sales and support activities in the emerging phone channel.

Figure 4:   Classification of ICT-skilled workers into users, operators and professionals
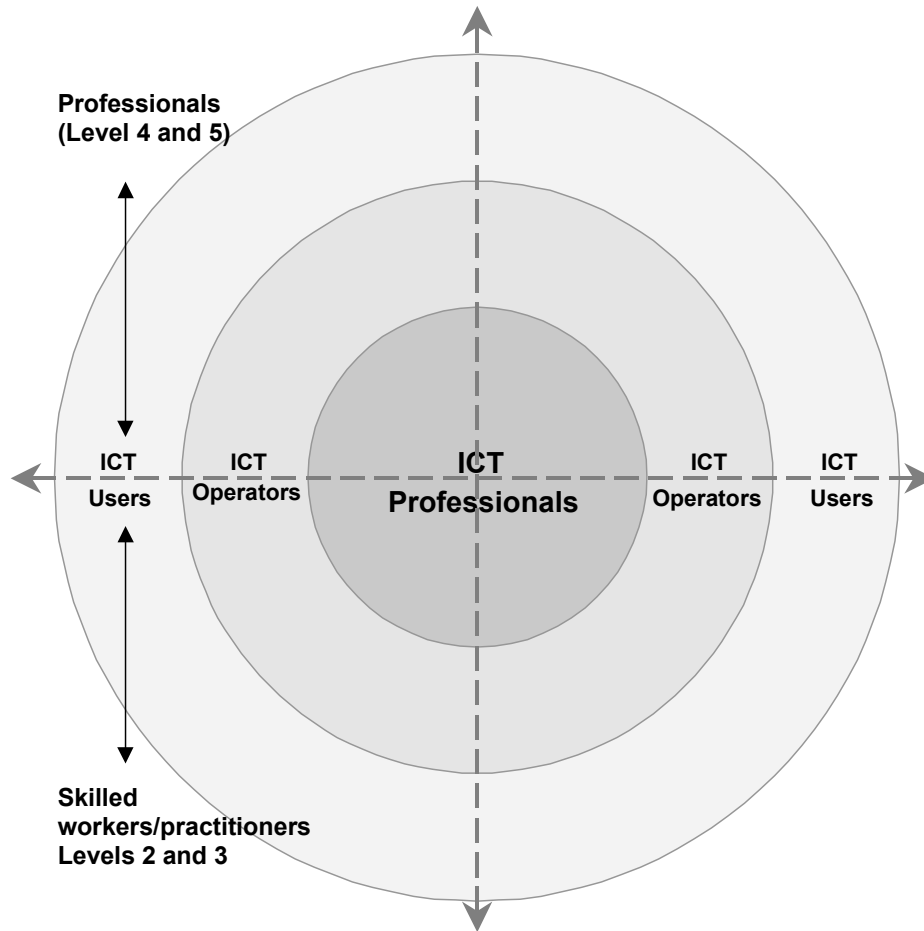
Source: Petersen and Wehmeyer, 2002, p. 20

These definitions already point at a rather wide perception of ICT, including ICT professionals as well as ICT practitioners.

In their efforts to provide a uniform description of ICT professionals, the International Federation for Information Processing (IFIP) in 1998 developed a draft for an ISO standard defining a professional as follows:

'Professional identifies the particular responsibility of a person with high levels of knowledge and related practical skills in a given discipline with respect to members of the public who do not have that knowledge or skill-set. It is particularly relevant to the information technology profession because it has significant impact on society at large. The power of the knowledge must be balanced by a sense of responsibility towards others.

This definition is focused on *practitioners*, persons who actually develop, maintain and operate software systems for commercial or governmental purposes' (IFIP, 1998).

Similar to the other definitions the preceding ones are based on a universal comprehension. This makes it more difficult to delimit professionals, practitioners and operators or users. The relationship between professionals and practitioners can only be understood by taking into consideration that the term denominates developers and operators in a practical sense, e.g. not in fundamental research.

According to a BIBB-IAB survey in Germany (Dostal, 2002), around three million employees or 8 % of all working persons describe themselves as professional users of ICT. The term professional users is, however, used as a general term. More precise definitions do not play any role here.

ICT operations include programme development, system analysis, professional operation of ICT appliances, plants and systems, advisory tasks and training for ICT tasks. They are, however, not part of IT core occupations (*Kernberufe*) ([8]).

The ICT-skills monitoring group describes professional skills as 'the ability to use advanced ICT tools and/or to develop, repair and create them' (e-Europe, p. 8).

The large number of surveys on the needs for ICT skilled workers are based on different definitions and differing methodological approaches; this emphasises that there is no generally acknowledged definition of ICT professionals or practitioners. The definition of ICT staff can in no way be confined to the core ICT sector nor to respective occupational titles.

For the sake of clarity in this study we have selected a definition which is appropriate for the automotive sector in the context of ICT practitioners:

(a) ICT practitioners develop, maintain and operate software systems and ICT solutions in the automotive industry;

(b) ICT practitioners plus have an explicit orientation towards ICT as well as sound knowledge of and skills in the automotive sector (Focus: ICT context);

(c) automotive experts plus ICT have a clear orientation towards the tasks of the automotive sector and sound ICT knowledge and skills (Focus: Automotive context);

(d) ICT professionals are ICT practitioners with a university degree.

This definition allows for a more precise differentiation between ICT work profiles, with development and user tasks allocated their respective roles.

The following fields will be considered separately:

([8]) A 'core occupation' defines the emphases and competences deemed absolutely necessary by all those involved in occupational training (industry, institutions) and which therefore are formally accepted.

(a) ICT in the vehicle;

(b) ICT in the production of the vehicle;

(c) ICT for automotive services;

(d) ICT in the automotive industry (production, service);

    (i) ICT for the support of business processes in automotive production;

    (ii) ICT for the support of business processes in automotive service.

This is necessary as the fields of application of ICT exert a considerable influence on the ICT oriented competences of the employees. The technological importance of ICT during the production of vehicles and in the vehicle itself does not yet allow for drawing conclusions on the skill needs or the curricular importance for employees in the automotive industry. The first group (ICT in the vehicle) is no indicator for competences of employees and the second group (ICT in the production of the vehicle) has to be analysed with regard to the necessary competences to use, operate, install, configure and to develop this technology. Thus there is no direct interrelationship between the diffusion of ICT and the required competences. Each ICT field is to be surveyed individually with regard to the consequences and the required competences.

1.2. Facts and figures

1.2.1. Production

In the year 2001, around 20 million vehicles were produced in Europe. Germany and France had the highest production, 47 % of the European total (see Figure 5).

Figure 5:   Motor vehicle production in European countries

Bar chart showing motor vehicle production values:
- Germany: 5.691.677
- France: 3.620.155
- Spain: 2.849.888
- United Kingdom: 1.685.238
- Italy: 1.579.656
- Belgium: 680.764
- Sweden: 529.208
- Netherlands: 220.587
- Portugal: 194.883
- Austria: 114.565
- Finland: 23.810
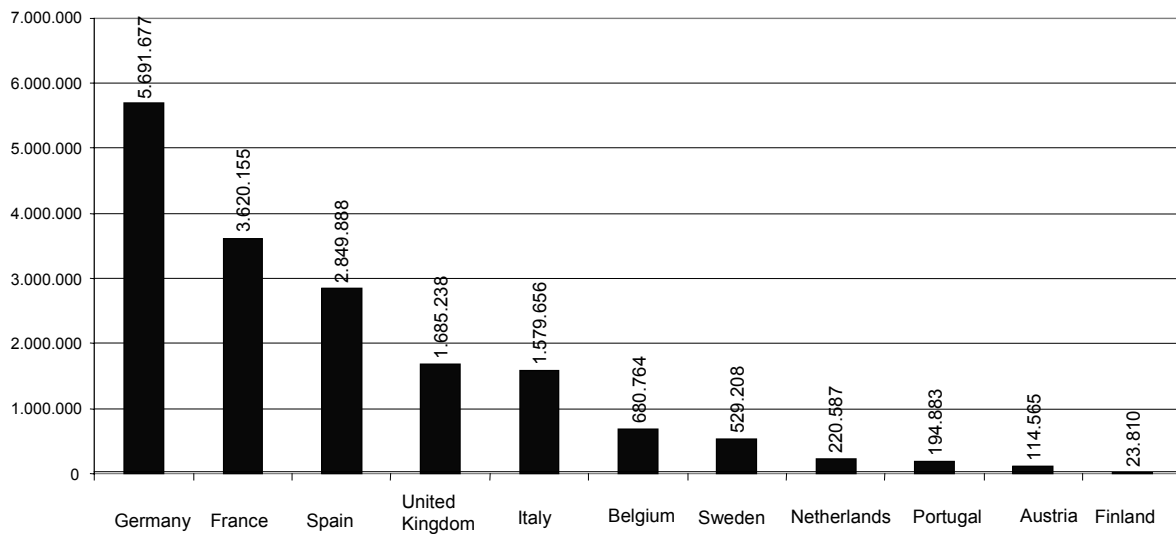
Source: Eurostat

1.2.2.   Employees in production

In Europe around two million employees work in automotive production, subdivided as follows:

(a)   59.4 % in vehicle and motorcycle production,

(b)   33.8 % in supplier companies,

(c)   6.8 % in body and trailer manufacturing (Eurostat 2001).

More than half the employees in the industry work in Germany and France (see Figure 6). Some 10 % of all industrial employees in France are in the automotive industry (CCFA, 2002); the figure for Germany is approximately 12 % (VDA, 2002, p. 240).

Figure 6: *Employees in European automotive production*

persons employed; manufacture of motor vehicle and of motor vehicle
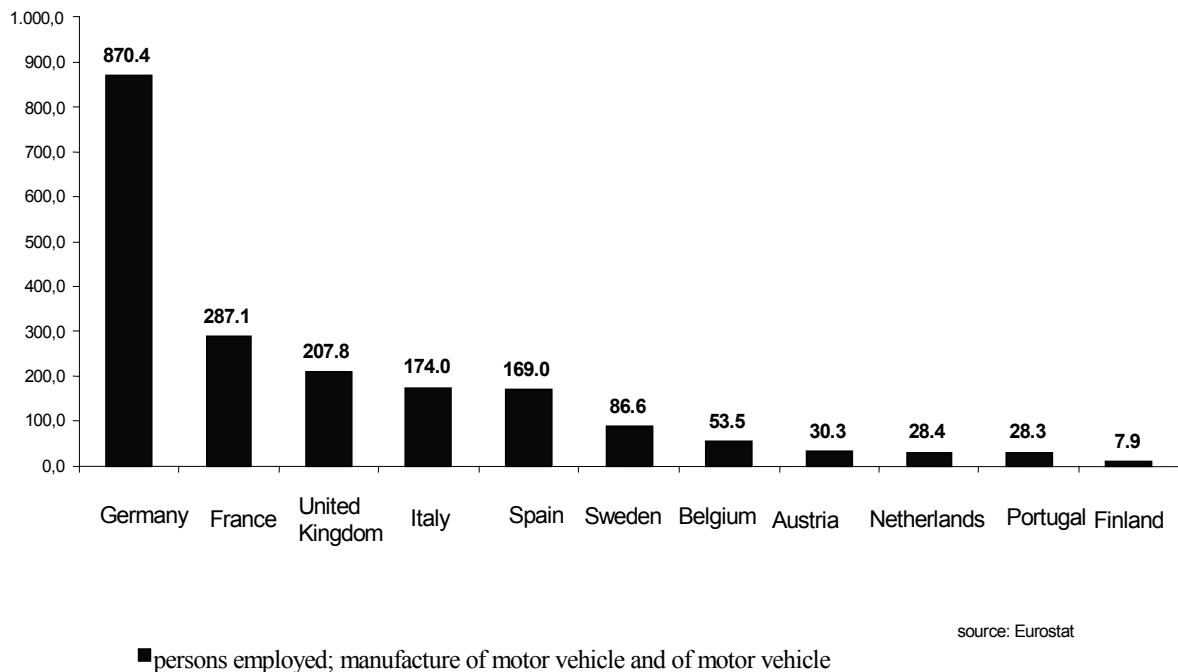
source: Eurostat

Source: Eurostat

1.2.3. Employees in motor vehicle repair and sales

It is more difficult to assess the importance of the automotive repair sector for the labour market than the importance of production. One possible indicator is the number of vehicles in operation (see Figure 7) since these vehicles have to be repaired and maintained in workshops. In 2002, about 44 200 automotive companies were in existence in Germany (ZDK, 2002) compared with around 30 000 in France (CNPA, 2002).

A customer care approach has gained momentum in the automotive service sector, employing customer relationship management through an increasing use of the Internet and database-oriented tools to promote customer loyalty and satisfaction. Although this is currently only relevant in countries with a high car density (Italy with 570.6; Germany with 539.2; France with 484.9 vehicles per 1 000 inhabitants), this development is one of the great challenges for Europe. The service infrastructure is primarily provided by the use of ICT applications, with logistics (parts, vehicles) and e-business activities playing an increasingly important role. The exponentially increasing information needed for the repair of complex automobiles has led to ICT-guided workshop information systems (knowledge management) and diagnostic tools. These exert a considerable influence on the skill profiles of employees.

Figure 7:   *Automobiles in use in European countries*

passenger cars and commercial vehicles /2002
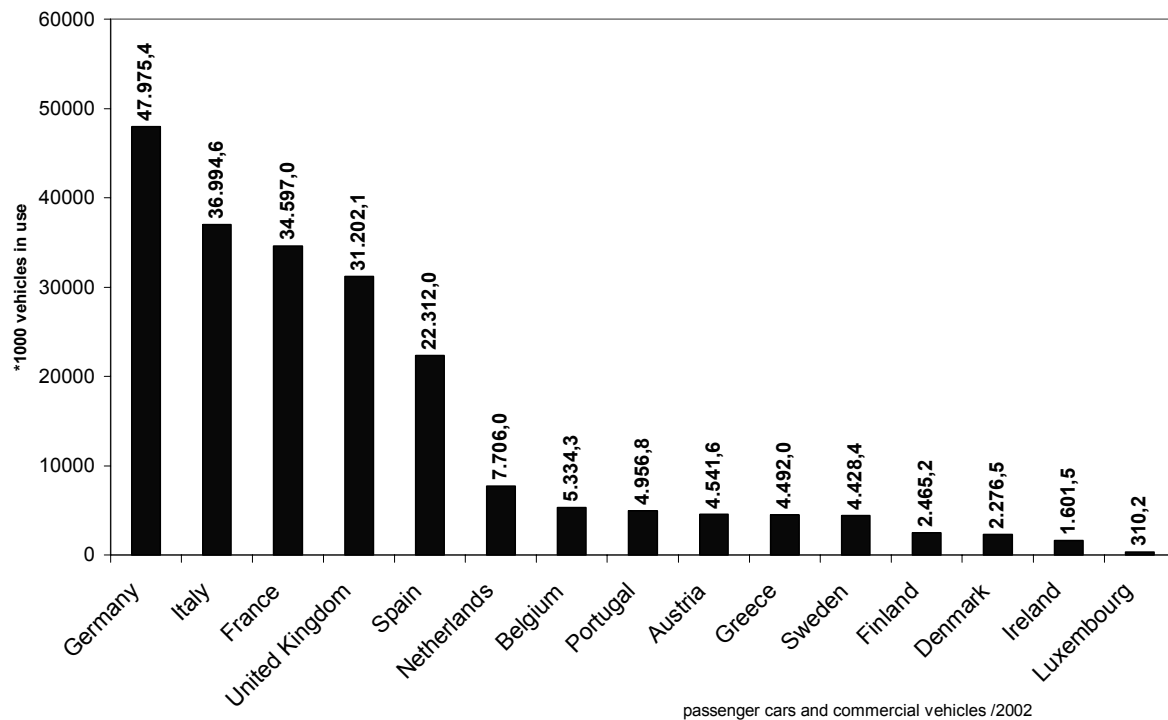
Source: Eurostat

Surveys in eight European member states suggest that the number of employees in repair workshops can be estimated at about 2.5 million. Some 1.3 million employees work in enterprises not affiliated to a manufacturer (independent workshops) and about 1.2 million employees work with authorised dealers linked to manufacturers. In Germany about 514 000 persons are engaged in the motor vehicle repair and sales sector (ZDK, 2002), in France about 388 000 (CCFA, 2002, p. 40). Employees working independent of workshops in an automotive trade sector (second hand vehicles, vehicle parts and accessories) should be added to these figures. No valid figures are available for this group. As ICT skills in this area are only user skills, this only plays a subordinate role.

1.3.   Characteristics of the sector

Despite rationalisation in recent years, the automotive sector still significantly contributes to economic growth and employment endeavours. The importance of the sector is underlined by a glimpse to the two most important 'automotive countries' in Europe: Germany and France. In Germany, the automotive industry has created an additional 111 000 jobs during the last five years (VDA, 2002, p. 243, largely the result of the strength of exports to countries outside the EU.

The sector associations estimate that an increased application of e-business and Internet purchase (⁹) will lead to cost saving arising from:

(a) a reduction in input costs due to stronger competition between suppliers (according to Ford between 3 and 14 %);

(b) reduction in costs of business processes (by 90 % according to DaimlerChrysler);

(c) faster communication, swifter deliveries and reduction of storage costs.

Important reductions of costs are expected due to the implementation of the Internet compared to previous 'just-in-time' systems. Some projects in the automotive sector are implementing Internet-based engineering, procurement, manufacturing, quality, supply, sales, marketing, services and parts delivery processes (e.g. FastCar by DaimlerChrysler). Altogether cost savings amounting to EUR 3 500 per vehicle are anticipated (Com 2001/711). These considerations are primarily based on the use of e-business with the aim to improve the networking of automotive manufacturers, suppliers, sales agents, and customers (see Figure 8). This activity is already increasing significantly.

The consequence is a growing need for networking skills within the workforce and in the use of ICT technologies.

There will be a shortage of such skills for the next few years. The shortfall in networking skills with the use of ICT technologies is estimated to an average of 33 % for Germany and 28 % for France to for the period 1999 to 2004 (see IDC, 2001). A growing number of companies are using networking technology to interlink with their suppliers and partners, leading to the establishment by some manufacturers of Covisint (¹⁰), an e-Marketplace for cost-effective procurement of supplies (e.g. IDC, 2001, p. 2).

In recent years, many companies have addressed the skills shortage by using less labour-intensive computing technology. The so-called 'low-cost-automatisation' and the software support of the organisation of production was increasingly applied. However, the process of replacing work by the use of ICT seems to be no longer valid. It has become commonplace that an increase in information technologies entails a parallel improvement of the competences of the employees. However, to reduce the requirement for skills by the use of well selected technology seems to come to an end on a not ultimately defined level and labour has to be deeply qualified.

(⁹) Not yet very successful.

(¹⁰) Covisint (collaboration, vision and integration) alone as the biggest e-business platform is predicted to reach more than USD 500 million in sales.

Figure 8: E-business in the automotive industry
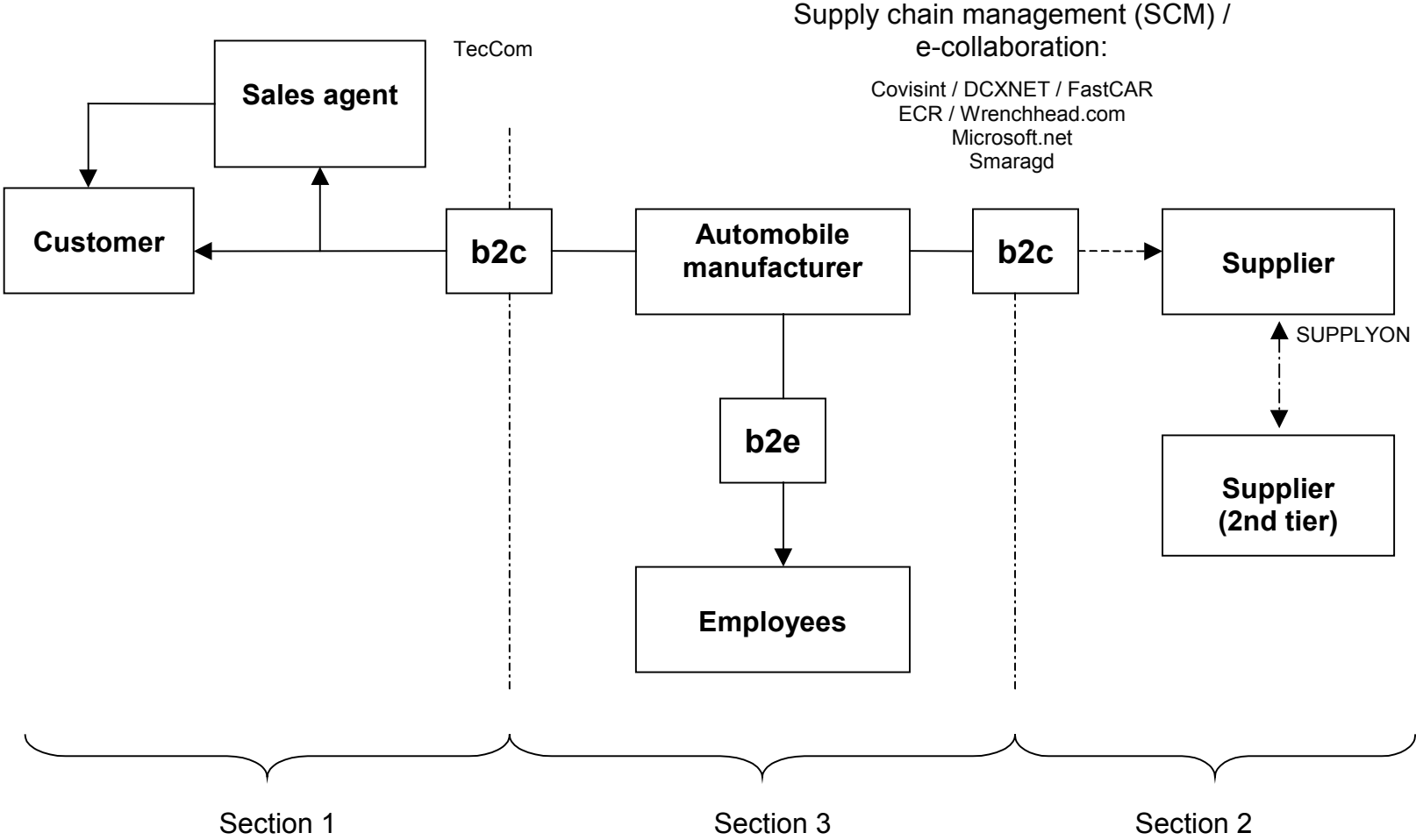
Source: CSC, 2001 ; biat, 2003

1.4. ICT fields of work in the automotive industry

ICT-relevant work areas can be shown in the form of a value-added chain (see Figure 9). ICT practitioners can be employed wherever work processes are developed, mastered, supported or optimised by ICT. The working fields themselves are, however, not necessarily ICT dominated. They are generally oriented to the core business of automotive production and services, employing skilled workers with different occupational profiles. They have some ICT competences and make use of them as ICT practitioners. Only a small proportion, for instance within research and development at supplier companies and automotive manufacturers (OEM [11]), can be described as ICT dominant. Such units normally work independently, as in software development for automotive control units. These departments use only employees with an academic degree (see Bosch-Zünder, 2003, p. 6). There are no skilled workers and only a restricted number of associate professionals (technicians) employed in these areas.

Figure 9:   Value-added chain in the automotive industry
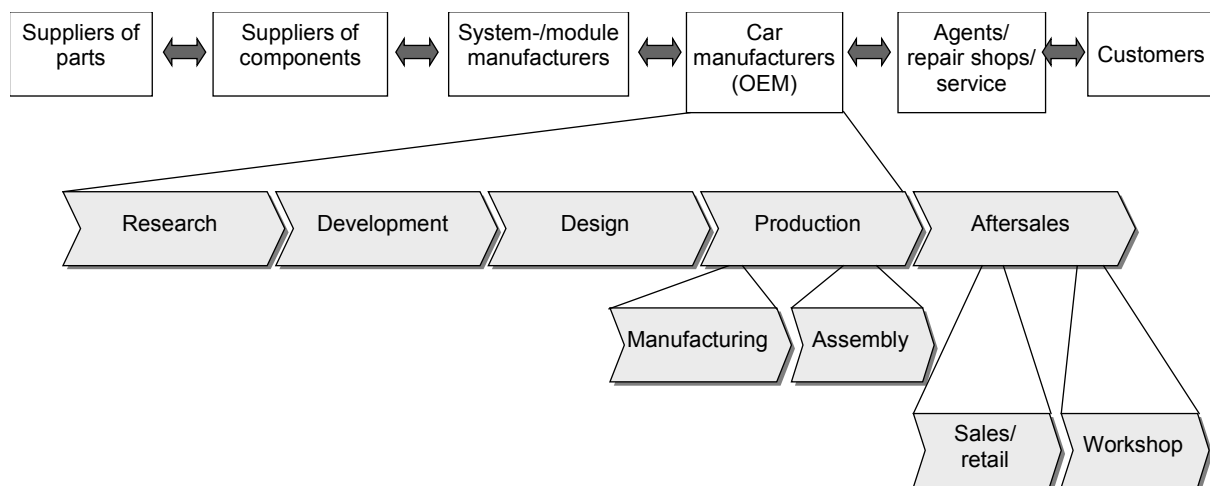
Source: biat

1.4.1.   ICT fields of work in production

The automotive industry underwent considerable restructuring in the 1990s, resulting in crucial changes in company structures with considerable consequences for skill requirements and training profiles.

Four different – idealised – factory structures can be identified (see Figure 10):

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[11] OEM: Original Equipment Manufacturer

Figure 10: Development of factory structures

Axis labels (top-left, vertical): **Assigned to employees (skilled workers)** — **Responsibility for success** — **Assigned to management**

Industrial company structure
companies with single orders and a high skilled competence

(High diffusion of ICT-Networks)

Ⅱ

Open factory structure
Value-adding employees as entrepreneurs in companies

(High diffusion of ICT-Networks)

Ⅰ

Closed factory structure
Company with function-related departments

(Work with clearly defined products)

Ⅲ

Heterogeneous factory structures
Companies with partly autonomous group work
- groups arranged in master workshops

(High diffusion of ICT-Networks)

Ⅳ

Horizontal axis labels: traditionally narrow | Hierarchy | De-hierarchisation
vertically | Division of work | horizontally

Source: biat

(a) Quadrant I: open factory structure,

(b) Quadrant II: industrial company structure,

(c) Quadrant III: closed factory structure,

(d) Quadrant IV: heterogeneous factory structure.

Our surveys showed that companies with a so-called open factory structure (Quadrant I) actually exist. They reveal a high degree of development dynamic and have basically abandoned a vertical hierarchy organisation and respective levels. The employees work in close cooperation with their colleagues as a team or as a group. They are largely autonomous during their work, receive no further orders on tasks to be performed and take over responsibility for deadlines and best quality. Individual tasks in open structured enterprises are coordinated in a way which guarantees that any flawed processes will be further optimised.

Industrial quality structures (Quadrant II) can also be encountered in the automotive industry, though mainly in small enterprises. We could only sporadically identify faint industrial structures in medium sized enterprises. It is characteristic for such cases that specialised skills play an important role, with employees working autonomously and independent of superiors.

The high importance of special competence and of industrial skills demands specific work division. In most small enterprises with a strong division of work the business know-how is concentrated in the management. As a consequence the companies are marked by a 'top-down' approach underpinning traditional hierarchies.

Quadrant III marks company structures with a strong function or product oriented division of work. A large number of companies surveyed indicated the establishment of function oriented departments that were clearly pursuing the principle of product flow. In these cases, each department takes over responsibility for clearly defined tasks within the manufacture of products. In this strict departmental structure overall coordination is of minor importance. This exerts a considerable influence on product quality and demands much reworking or a considerable loss of time during assembly.

Heterogeneous industrial structures (Quadrant IV) were the most common ones in our study. As a rule these were enterprises in the process of open-end restructuring ([12]).

Assembly companies in the automotive industry stood out by the fact that they had been reorganised to group work. However, the introduction of so-called master departments (where several groups are organised) mean that not all of the responsibility had been delegated to lower levels. Important decisions such as the wages and salaries of individual employees, the planning of working times and holidays, the division of tasks within the groups, etc., can only be made in coordination with the master departments. This sub-autonomy ([13]) can also be explained by the fact that the companies are continuously experimenting in order to determine the number and the nature of the individual assembly cycles per employee or per group. The management thinks that joint control by senior employees is required. Production includes master craftsmen and senior coordinators such as team leaders and heads of departments. It is assumed that these structures will not change significantly in the near future.

Another important result of the survey is the predominance of engineers in research and development departments of the automotive industry. They take over software and product development so that ICT practitioners concentrate on production, assembly, service and maintenance, quality control and partly on design (see Figure 11).

([12]) Open-end restructuring processes are organisational processes with no definite determination of all details. Final clarifications and determinations are left to persons such as the skilled workers at shop-floor level.

([13]) Sub-autonomy means that groups or departments autonomously make decisions on issues such as work organisation or work planning. The management only deals with the general transactions of the company and the safeguarding of the infrastructure.

Figure 11:   Current and future fields of work of ICT practitioners

Process visualisation

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┌─────────────┐   ┌─────────────┐   ┌──────────────────┐   ┌──────────────────┐
│   Design    │───│ Production  │───│    Assembly      │───│  Repair/service  │
│             │   │             │   │(internal/external)│   │(internal/external)│
└─────────────┘   └─────────────┘   └──────────────────┘   └──────────────────┘
                         \                                 /
                          \    ┌──────────────────────┐  /
                           \───│ Check and quality control│──
                               └──────────────────────┘
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Automation
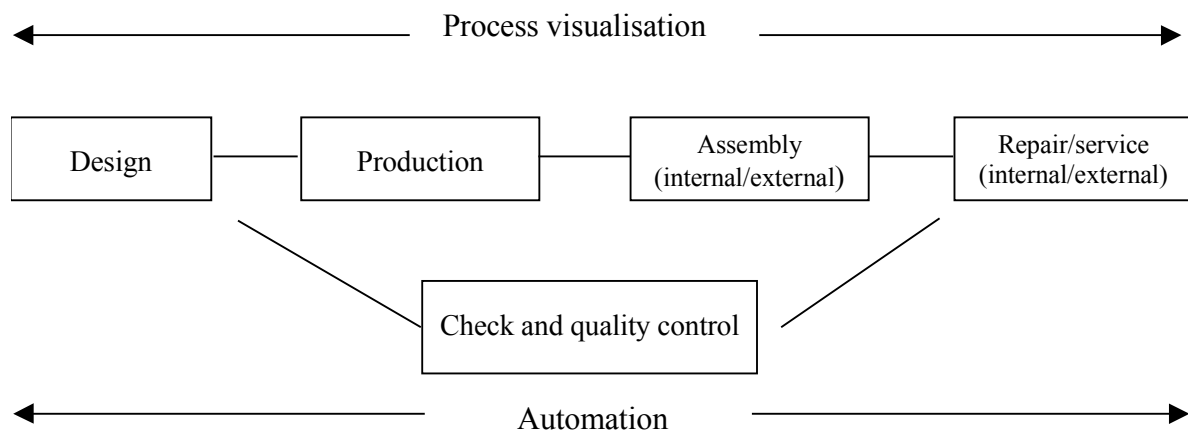
As the company structure, the quality management systems, the forms of work organisation and the application of technology differ considerably in the various enterprises, an ideal-typical case, an ideal-typical field of work and the respective qualification spectrum will be characterised. The appropriate skill spectrum and respective profiles will also be indicated. The observations are based on a medium sized company and a department in a large enterprise with 180 employees. The employees are considerably encouraged to shape both work and work organisation. The extent of a typical order/task performance process is shown in Figure 12.

A customer query (e.g. issued by an internal customer) leads to an offer and afterwards possibly to an order. Normally the configuration of offers and orders is assigned to the design and offer departments. Consulting qualified skilled workers and master craftsmen/technicians is, however, common practice. As soon as the order is placed, the project is passed on to the project management for coordination of the departments involved. As soon as the design department has worked out all construction related details of the order, the production department takes over. Project and production management ensures the availability of the necessary material and parts as well as the fixing of deadlines for order processing. The respective production managers (mostly master craftsmen or technicians, or engineers in larger enterprises) and the skilled workers in charge are responsible for all production-related issues. As soon as the product (plant, vehicle) is finished and as soon as the production department has performed a function check, the customer accepts the order and the product is delivered. These tasks include project, production and assembly management. In this ideal-typical case the persons involved are skilled workers, master craftsmen or technicians; all of them are part of a production-specific vocational educational tradition. The plant manager, the engineering manager and the commercial manager are among those with academic degrees. Most of the other employees qualified as skilled workers or technicians within a formal vocational educational training or apprenticeship.

Figure 12:   From order via processing to delivery

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                        ┌─────────────────────┐
                        │   Customer query    │
                        └──────────┬──────────┘
                                   ▼
                        ┌─────────────────────┐
                        │  Offer set up by PLV│
                        └──────────┬──────────┘
                                   ▼
                        ┌─────────────────────┐
                        │   Customer order    │
                        └──────────┬──────────┘
                                   ▼
           ┌──────────────────────────────────────────┐
           │  Enter order and creation of SAP by ATD   │────────────┐
           └──────────────────┬───────────────────────┘            ▼
                              │                          ┌──────────────────┐
                              │                          │ Deadline of order │
                              │                          │     in  SAP       │
                              ▼                          └──────────────────┘
       ┌────────────────────────────────────────────┐
       │ Passing on the project from PLV to          │──────────────┐
       │ PLA/AKM/AKE/ATD                             │              ▼
       └──────────────────┬─────────────────────────┘   ┌──────────────────────────────┐
                          │                              │ Separate critical parts      │
                          │         Mechanical and       │   (previously)               │
                          ▼         electrical dpt.       └──────────────────────────────┘
       ┌──────────────────────────┐─────────────────────────┐
       │   Construction AKM/AKE    │                         ▼
       └──────┬───────────┬───────┘          ┌──────────────────────────┐
              │           │                  │  Set up of construction  │
              ▼           │                  │         plans            │
    ┌──────────────┐      │                  │  enter parts list in SAP │
    │  Set up of   │      │                  └──────┬─────────────┬─────┘
    │documentation │      ▼                         ▼             ▼
    └──────┬───────┘  ┌────────────────────────┐ ┌────────────┐ ┌────────────┐
           │          │ Passing on project     │ │ AV sets up │ │Acquisition │
           │          │ from PLA to production  │ │ production │ │    ATD     │
           │          └───────────┬────────────┘ │   plans    │ └────────────┘
           │                      │               └─────┬──────┘
           │                      ▼
           │          ┌────────────────────────────┐
           │          │ Start of assembly automotive│
           │          │ Team                        │
           │          │ Control by FL in coordination│
           │          │ with PLA                    │
           │          └───────────┬────────────────┘
           │                      ◄──── Determination of components
           │                      ◄──── Part purchase
           │                      ▼
           │          ┌────────────────────────────┐
           │          │   Function check ML/MKE     │
           │          └───────────┬────────────────┘
           │                      ▼
           └───────►  ┌────────────────────────────┐
                      │ Customer acceptance         │
                      │   PLV/PLA/FL/ML             │
                      └───────────┬────────────────┘
                                  ▼
                      ┌────────────────────────────┐
                      │      Delivery ATD           │
                      └───────────┬────────────────┘
                                  ▼
          ┌──────────────────────────────────────────────┐
          │ Assembly and putting into operation (training, │
          │ accompanying of production) ML with service    │
          │ team                                           │
          └────────────────────────────────────────────────┘
```

Key:

PLV: Project manager sales
PLA: Project manager order processing
ATD: Process technology, technical services
AKM: Process technology mechanical construction
AKE: Process technology electrical construction
AV: Work preparation
FL: Production manager
ML: Assembly manager
SAP: Software programme

Source: Case Spöttl et al., 2003

Skilled workers, master craftsmen and technicians play an important role from order acceptance via processing to delivery and the final use of the product. The overview and the mastering of business and work processes by skilled workers ensure a valuable, competent contribution to the entire order process. The tasks are not only confined to specific skilled operations but also include order processing and tasks linked to customer relations. The specialised aspect of order processing is outlined in a considerably broad range compared to the mere execution of selected tasks. Table 1 gives an overview of the work process, the work tasks, tools, methods and qualification/competence requirements. Employee tasks are seen to be diversified as soon as decentralisation takes place. Apart from narrowly defined traditional tasks, the use of personal computers and appropriate software is an automatic part of the process. This is also true for the use of modern measuring tools and the execution of quality control, function control and others with the assistance of ICT.

Employees have to be qualified for such a multitude of tasks. It is important to include the tools – ICT and others – and the methods relevant for skilled work into the qualification processes. The process beginning with plant design and ending with the start-up of the plant should be in the centre of interest rather than the tools themselves without their links to the comprehensive context.

It is already evident that every employee must have ICT competences, however, not necessarily as an ICT practitioner or professional. Aspects of the competences that characterise an ICT practitioner are nevertheless necessary.

Table 1: *Fields of work of persons employed in production*

Work process	Work tasks	Tools/methods	Competence/qualification requirements
Design department AKM, AKE	Discuss customer orders with designers/engineering	If possible take over existing documentation and adapt to the specific needs of customer orders	• Estimation of technical specifications, • Coordination with regard to installation and functioning of the plant • Include customer wishes
Passing on the project from PLA to FL and team construction finalised 90 %	Discuss design documents, plants and the layout of plant components.	Team discussions, discussions with PLA and AKM	• Coordination within the team, • Overview of plants and process technology, • Service-friendly layout, • User-friendliness
Start of assembly in the automotive team	Control by FL with PLA, safeguarding of deadlines, capacity planning, safeguarding of material and production documents	PC hardware and software Telephone and fax	SAP: • View date of delivery of plant, plan assembly time, set starting date. MS-Excel: • Monitoring of data. Lotus Notes: • Communication between PLA, PLV and customer. • Communication with customers and suppliers
Function check by ML and MKE	Function tests of the entire plant (hardware and software); set up check protocols, survey on machinability (MFU), coordination of measuring and control technology/components	Measuring devices of process technology PLC-programming device, Print forms and PC PC-software and measuring tools	Handling of: • Software, PC • measuring devices, • programming devices • Reading of circuit diagrams and flow diagrams • Reading out data on components
Customer acceptance PLV, PLA, FL, ML, customer	• Carry through test run, • check documentation, Coordination of dates: • Installation • Training in handling and maintenance • Start of production,	• MFU-control • Check parameters with measuring tools, • test production cycles, • protocols by PC Discussions with groups, Discussions with team and customers, coordination and Check:	• Handling of measuring tools, • Technical know-how, • Overview of plant, • customer relations, • Cater for customers, • Foreign languages (English), • PC handling,

Work process	Work tasks	Tools/methods	Competence/qualification requirements
	• production monitoring	• VDE, UVV, CE, work safety.	• know stipulations/laws.
Documentation of the plant	Photograph plant	Digital camera	• Handle camera, • archive images on PC
Delivery ATD, FL	Organisation of packing and transportation, finalise shipping documents.	• Plan delivery date and coordinate with RTD, • fill in documents, • send out papers by mail or fax.	• Keep an overview of dates, • communication with forwarders, • enter required data.
Assembly and putting into operation	Assembly preparation: • plan personnel assignment, • planning of delivery date, • travel arrangements, • compile tools, • involve sub-contractors, • preparation of training/briefing course.	• Check-lists, • travel documents, • Lotus Notes, • clarification of contact person • forms for work safety, • PC, telephone, fax, e-mail, • copy machine, transparencies.	• Work and check, • fill in, • plan and enter dates, • set up and fill in, • operate/handle, • handle hardware and software, • design teaching aids, • inform and advise customers (languages!).
Key:	PLV = Project manager sales PLA = Project manager order processing ATD = Plant technology, technical services FL = Production manager ML = Assembly manager PLC = Software control	AKM = Production technology mechanical construction AKE = Production technology electrical construction AV = work preparation MFU = Survey on machinability	

Source: biat

A characterisation of the relevance of ICT in automotive production is summarised in Table 2. One of the first outcomes is that ICT is highly relevant, though application orientation varies in different production plants or departments. ICT departments, sections or units are not isolated. Correspondingly employees must have ICT competences of different kinds, but focused on tasks to be performed in production.

Table 2:   *Relevance of ICT in the automotive production*

Automotive production - Fields of work -	Specific tasks	Role of ICT	Users
Design	Design of products Use of CAD/CAM software (CATIA, PRO-E, AutoCAD, Inventor, etc.), 3D-CAD; 2D-CAD	Modification and efficient use of CAD/CAM software, PPS-systems, databases	Professional engineers Highly qualified technicians
Production	Production of plants/work on projects Use of PC hardware and software, PLC-programming, 3D measuring instruments	Use of: • hotlines, • PPS systems, • CNC/HSC –systems, • 3D-quality control, • databases, • software spreadsheets.	Highly qualified technicians Skilled workers
Assembly	Assembly preparation Use of programming and measuring devices Use of PLC tools	Use and re-programming of: • PLC, • plants.	Skilled workers Highly skilled workers
Service	Assembly preparation Use of software	Use of manifold software Re-programming of plants/tools, etc.	Highly qualified technicians Skilled workers
Quality control and check	Function checks, coordination of measuring, control technology Adaptation of quality control systems	Use and modification of 3D-equipment PLC programming Use of databases	Professional engineers Highly qualified technicians

Figure 13: Exchange between plant employees in automotive production

Source: Peugeot

The following requirements for the fields of production/manufacturing can be identified:

(a) programming of PLC and CNC machines (programming oriented to geometrical objects);

(b) CNC production;

(c) use of PC and use of PPS-systems;

(d) operation of rapid-prototyping plants or other machines, e.g. high speed cutting machines;

(e) data processing for the complete production process of a product;

(f) reading of 2D-CAD or 3D-CAD files provided by the customer;

(g) conversion of data, e.g. from CATIA to PRO-E, saving of files in different formats, correction of errors after conversion;

(h) operation of 3D-measuring machines and setting up of a measuring protocol;

(i) production without visual control of the machine work area;

(j) production technological know-how of several machines ('I can do everything at every machine of the production island');

(k) use of hotlines for information transfer;

(l) execution of service, maintenance and simple repairs of production plants;

(m) coordination of work processes for the disposition of material as well as maintenance and repairs of plants;

(n) customer service.

ICT competences are user competences, operator competences and shaping competences. Both professional engineers and software developers at sub-degree and university levels are responsible for the development of hardware and software.

1.4.2. ICT fields of work in automotive service

The identification of work tasks for occupational profiles in the service sector forms the basis for curriculum conception and training solutions. Case studies and work process studies revealed that work tasks of skilled workers in the motor vehicle and repair sector can be assigned to five main work areas (see Table 3):

(a) standard service,

(b) repairs,

(c) diagnosis,

(d) additional installations,

(e) bodywork.

Fields of work within non-technical areas, for instance automotive sales and business management, add to this list. They are only included if they are oriented to specific automotive issues:

(a) order management,

(b) automotive marketing,

(c) sales of new and used cars,

(d) financial services.

These fields of work or occupational areas are characterised in more detail below.

Table 3:   *Fields of work in the motor vehicle repair and sales sector*

Work areas in the motor vehicle repair and sales sector

Service and repair field

1. Standard service:
   - care and processing tasks;
   - maintenance including summer, winter and holiday check-ups;
   - inspection tasks;
   - administrative and service tasks.
2. Diagnostic tasks:
   - routine diagnostic;
   - tasks in connection with integrated diagnosis;
   - diagnosis according to technical rules;
   - experience based diagnosis.
3. Repair tasks:
   - wear repair;
   - damage repair;
   - repair of aggregates.
4. Additional installations and configuration tasks:
   - standard amendments;
   - special amendments, retrofitting of complete systems;
   - configuration tasks.
5. Bodywork/collision damage repair.

Commercial field

1. Order management:
   - work and coordinate workshop orders;
   - spare parts management;
   - calculations, invoices, statements.
2. Automotive marketing:
   - planning and implementation of marketing strategies;
   - market analyses;
   - presentation of the enterprise;
   - controlling.
3. Sale of new and used cars:
   - disposition of vehicles;
   - assessment of vehicles;
   - warranty and guaranty.
4. Financial services:
   - working out financial opportunities for corporate investments;
   - offer of financing, insurance and guaranty services as well as leasing.

Figure 14:   Comprehensive fields of work in the motor vehicle repair and sales sector (^{14})
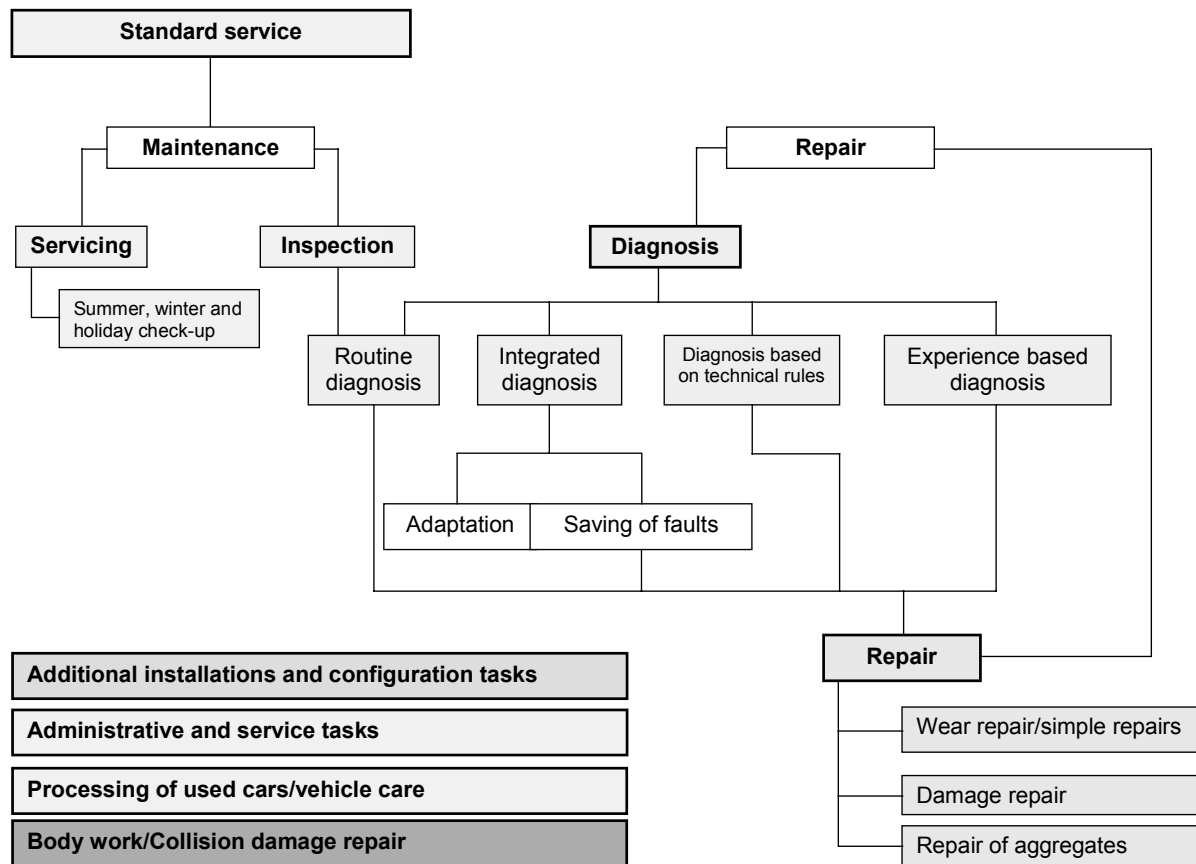
Standard service normally requires work according to standardised manufacturer schedules, often linked to quality standards to be applied, with check-lists and manuals (e.g. *Instandhaltung genau genommen* by VW). A quality-oriented performance is needed, which offers a multitude of learning opportunities for apprentices. The repair shops use information systems for standard services to identify the vehicle condition, to determine spare parts and to implement work plans. They are based on highly complex ICT systems which are, in part, networked with the manufacturer.

(^{14}) Standard services include the tasks linked to inspection and maintenance as well as additional service tasks such as summer, winter and holiday check-ups. The character of these tasks are clarified by the following definitions. Maintenance, which is the regular performance of certain tasks required for the continuous flow operation of a vehicle. Inspection, which means to perform maintenance tasks and additionally checks of proper functioning of selected systems in a vehicle (routine diagnosis).

Repair tasks are based on clear repair orders. They can be classified into three main areas:

(a)   wear repair,

(b)   damage repair,

(c)   repair of aggregates.

Typical examples for wear repair are the renewal of brake linings, tyres, the changing of the main exhaust silencer, starters, shock absorbers and clutches. These tasks have a common character, albeit the individual amount of work differs. They may be performed without marked requirements for specialisation and experience by simply adhering to the manufacturers' directions and with the aid of repair manuals.

Damage repair concentrates on the repair of aggregates, components and systems. If the location of the damage is known, the damage itself must still be evaluated. Typical repairs in this category are fractures in shafts, fixings, and functional parts of the drive train, lock failure, the electrical system or body damage after a collision.

The repair of aggregates is a complete repair of components such as the gearbox, the engine or parts or components, such as the cylinder head. Such work tasks are not only quite comprehensive, they also require a sound knowledge and know-how of diagnosis alongside repair skills.

Most repair information provided by automotive manufacturers is currently available in digital form. Repair manuals are often no longer available as hard copies but are downloaded from expert systems. Future developments could result in new kinds of support systems based on three-dimensional object presentations of the respective vehicle data (digital mockup) ([15]). The paper-free workshop may become a real prospect. Skilled workers will take the required information from digital, close-to-development databases and handle technologies such as 'augmented reality' (see Figure 15).

([15]) Digital mockup: the virtual assembly of vehicle parts with computer systems based on 3D object data of the automobile. This technique can be also used for developing software based repair manuals with the possibility of a free configuration of the view of the repair situation and process.

Figure 15:   Example for the use of Augmented Reality

Source: Lipson et al., 1998, p. 134

Diagnostic tasks are almost all performed alongside other tasks. This risks a loss of quality, because a full diagnosis requires the assessment of defective systems and the determination of detailed repair steps. Routine diagnoses have often to be carried out within the standard service (reading out and resetting of fault memories, setting of maintenance interval displays, routine sight controls, check of play, etc.). Tasks in connection with an integrated diagnosis are increasing. These include tasks such as the adaptation of characteristic diagrams, the activation of actuators for testing reasons, parametrical tasks, the evaluation of fault memory contents and an overall assessment of the state of the vehicle by compilation and use of the diagnosis data in control units.

Such diagnoses are performed according to the standards of the manufacturer, normally using pre-set approaches and flow charts. This kind of diagnosis uses computer-aided and expert-system-aided diagnostic systems. Experience-based diagnosis is applied when diagnoses according to the manufacturer standards are not successful, cannot be carried through in practice or take too much time. Comprehensive information and manuals are required to enable skilled workers to develop their own strategies and approaches against the backdrop of their own experience.

Information and communication technologies are applied for a variety of work tasks in the service sector:

(a)   standard service – workshop information systems for the identification of vehicles and the acquisition of maintenance and repair data, data on spare parts, workshop databases for order monitoring and for statistical purposes;

(b)   repair tasks – digital format repair manuals, expert systems for optimal repair processes, networked databases for up-to-date repair information, systems for the use of augmented reality;

(c) diagnosis tasks – support of diagnosis with expert systems; use, care and creation of case by case databases; fault memory reading; parameterisation; codification of vehicle systems, programming of vehicle control units/flashing;

(d) additional installations and configuration tasks – integration into vehicle systems, configuration and diagnosis of comfort systems: car telephone, navigation system, TV, Internet, telematics systems;

(e) bodywork/collision damage repair – computer-aided measuring and alignment of the chassis, damage calculation systems and computer-aided clearing with insurances including digital photography.

Figure 16:   Diagnosis with PC based tools

Source: Bosch

2.   ICT skills and training in production and their relevance for qualifications

ICT as a cross-technology plays an important role in many areas of automotive production where it has had a major impact on skill and competence needs. For future planning it is necessary to identify the trends and needs in more detail.

One of the most progressing sectors for information- and communication technologies is the automotive production sector. No other sector is marked by technological progress to a similar extent . An intensive use of ICT is to be found in production control, and comfort and safety systems in cars are electronically networked up to 100 %. Changes in the sector have considerable consequences for other related sectors, sub-sectors and technology carriers. The growing impact of ICT diffusion in recent years is depicted in Figure 17.

Figure 17:   Influence of ICT on different technology carriers
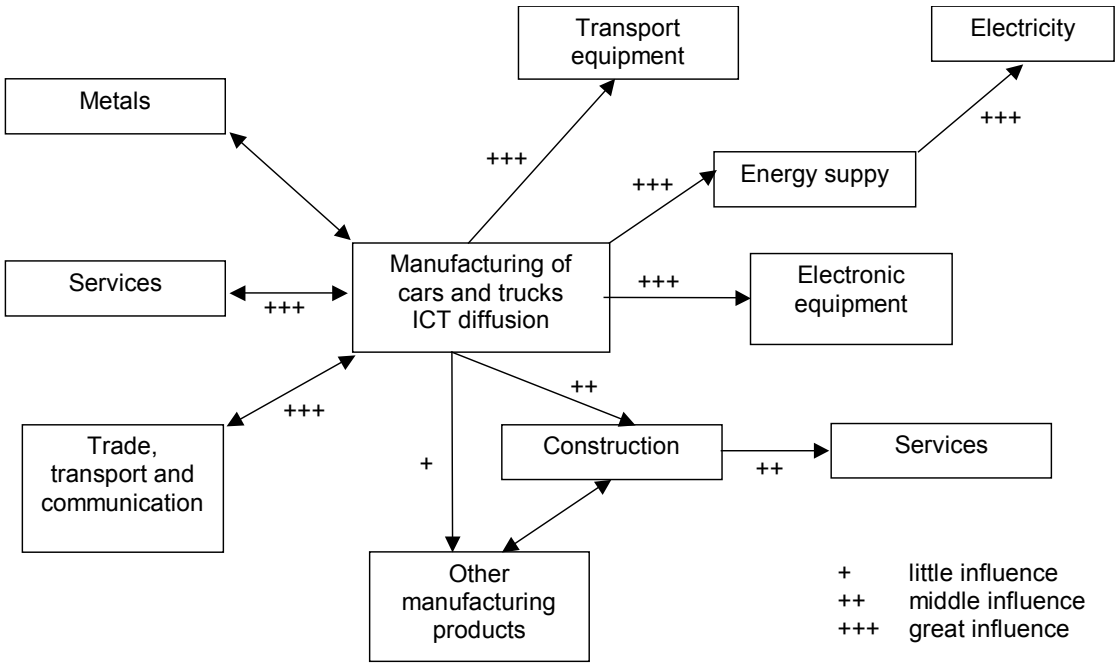
'Skills related to general-purpose technologies (like ICT, the authors) will be in high demand … especially for the extension of those technologies to new areas of application' (Hernandez et al., 2001, p. 30).

The impact of new technologies on demand for labour (^{16}) can be summarised in Figure 18. 'New technologies tend to increase productivity and subsequently reduce the demand for

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(^{16}) In this case also the demand of ICT competences.

labour, for a given level of output. On the other hand, new products and services can create new markets that in turn will require new labour. Additionally, the increase in productivity can increase competitiveness, allowing larger market shares that may also lead to a higher labour demand' (Hernandez et al., 2001, p. 35).

Figure 18:   Impact of new technologies on labour demand
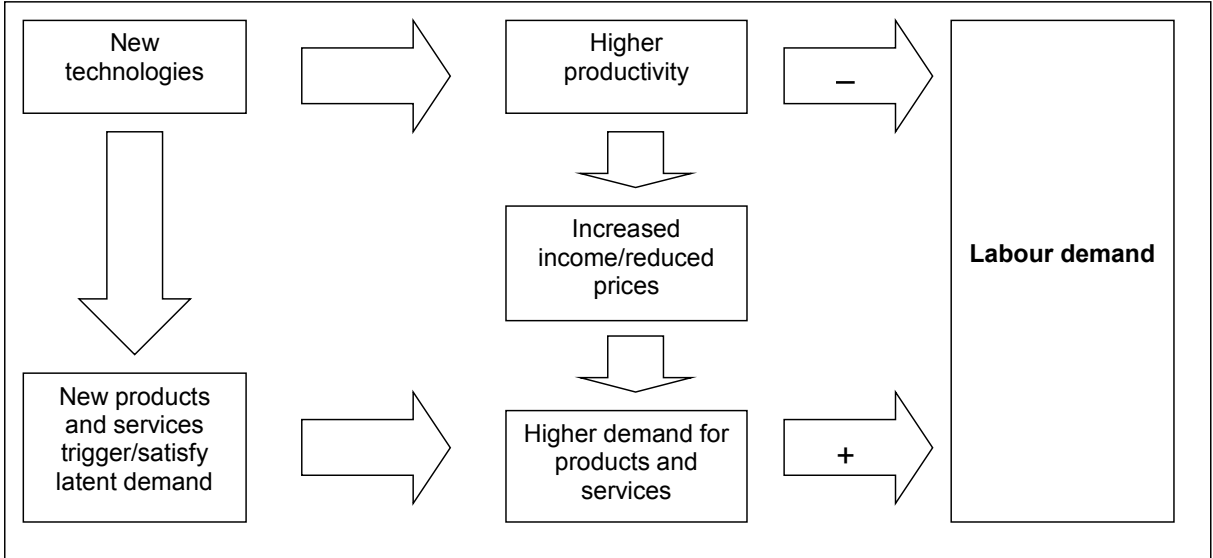
Successful application of ICT boosts productivity and leads to a need for additional and better qualified workers provided the market is able to absorb more products. In the past, however, automatisation has often lead to a reduction of persons employed in many fields of production. However, this can only be avoided if employees are able to successfully use ICT within their specific working fields. They also have to be adequately trained and qualified. So far we have shown that ICT in production is always applied with other technologies typical for the industry ([17]). Therefore it would be inappropriate to deal exclusively with ICT-specific fields of application.

2.1.   ICT relevant fields in production and skill needs analysis

Modern automotive production is characterised by the use of:

(a)   computer-technologies (production);

(b)   robotics (assembly, measuring technology, welding);

(c)   quality assurance techniques;

([17])   We will use the term 'in context with' because it means more than 'in connection with'. Context means that there are integrated links between specific fields of technology which should not be separated in studies like this.

(d)   material flow, logistics, supply chain management.

French and German automotive manufacturers are beginning to optimise structural processes according to different process standards (capability maturity model (CMM), integrated capability maturity model CMMI , ISO 12207/ISO 155504/SPICE). They aim at increasing the product quality by 'maturing' development processes. Such endeavours exert a considerable influence on areas of work and on efficient ICT applications. ICT applications will continue to play an ever increasingly important role in the automotive industry (see Figure 19 and Figure 20)

Figure 19:   Quality management and process engineering: important ICT diffusion is still to come

Source: Bauchrowitz, 2002, p. 47

An examination of production (see Figure 21) shows that quality control is a dominant aspect of the day-to-day tasks of a skilled worker (preliminary tasks are not considered here). Quality checks are now integrated into production and are no longer carried out in a separate department and/or on the finished product only.

Figure 20:   Quality check of injection valves in production
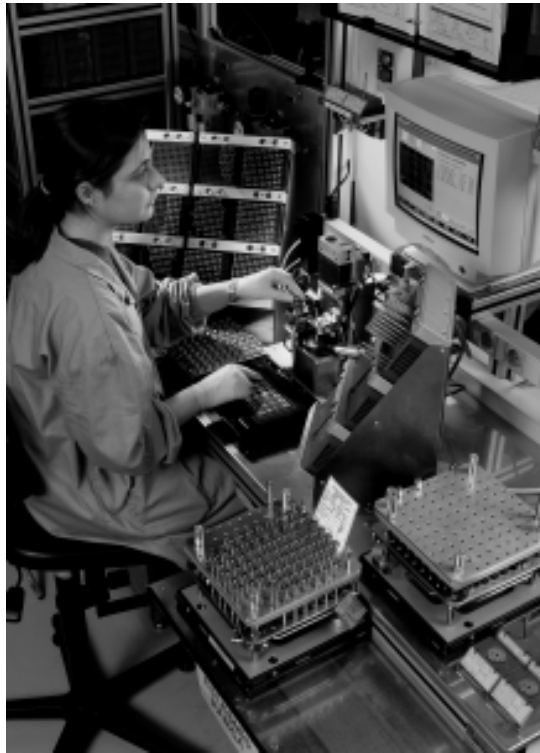
Source: Bosch

Quality control usually encompasses the following tasks:

(a)   check of the drawings/construction plans with regard to the production process;

(b)   check of draft production programmes including fine tuning;

(c)   check of the finished product for precision.

This approach underpins a gradually emerging new production culture. Frequent inspection and maintenance of factory plants (around 60 % participation) and the adjustment and programming of machines (around 80 %) prove that skilled work in production is witnessing a clear expansion of both horizontal and vertical work tasks. In addition skilled work is increasingly less dependent on support from other departments. The repair of machinery and plant – in former times a specialist job – is gaining importance for skilled workers in production (35 % 'often'; 18 % 'every now and then'). These already are, and still are to become, new core tasks.

Figure 21:   Participation in production tasks

Legend: often | now and then | never
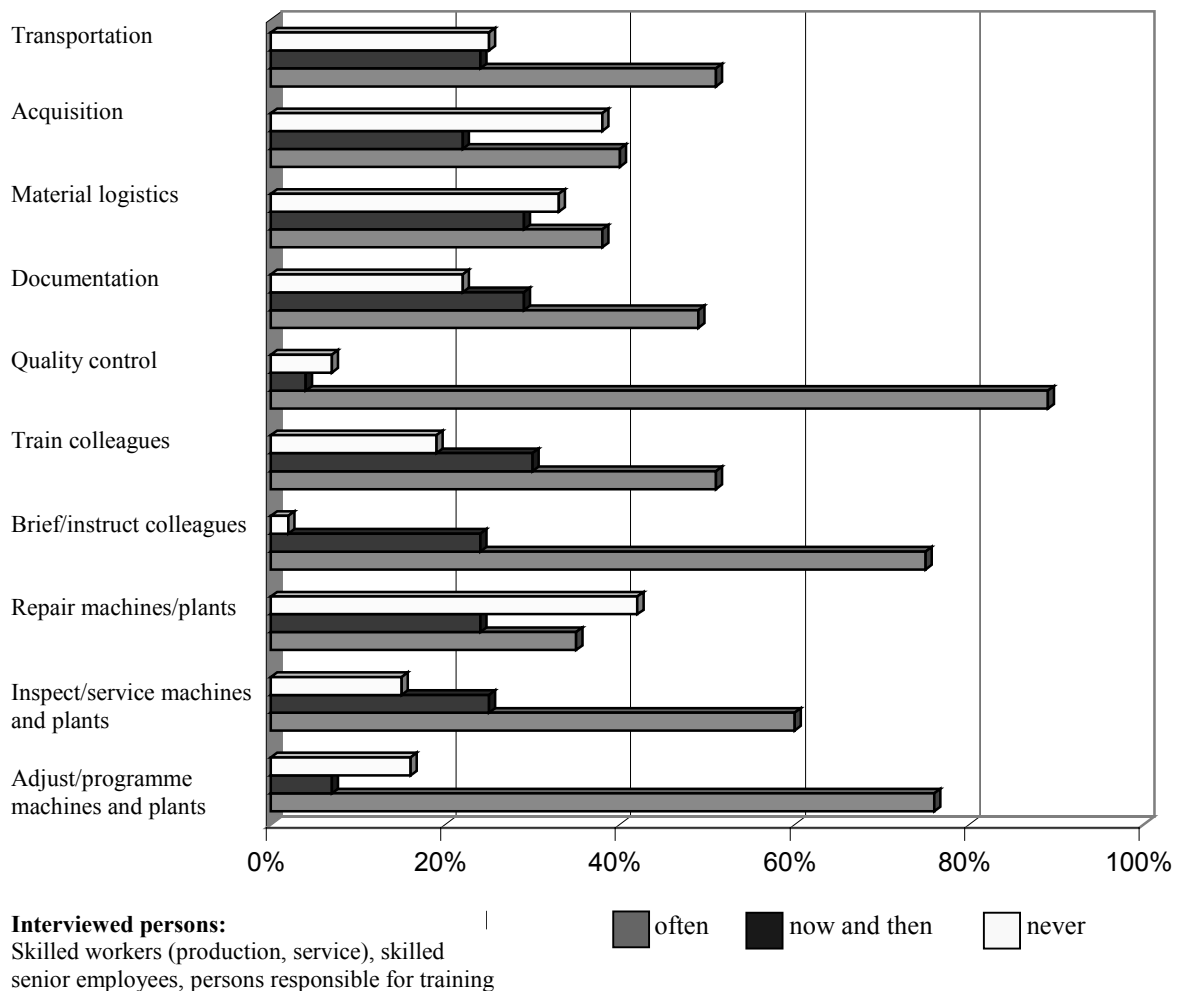
Source: biat

It is worth noting that training (47 % 'often', 33 % 'every now and then') and briefing/instruction (74 % 'often', 23 % 'every now and then') are significant tasks for employees. These immaterial tasks arise from changing production structures and frequent reorganisation. Above all qualified skilled workers are at present obliged to update and adapt to new challenges and are assigned to participate in further training of colleagues primarily within groups, teams or production units near to production or even integrated into production.

Therefore they increasingly take over production-oriented service tasks themselves: transportation (53 %), acquisition (37 %), material logistics (38 %) and documentation (47 %) remain infrastructure tasks supporting production. According to the results of this survey, they are increasingly carried out by skilled workers to safeguard the production process.

2.2. Specific target groups and their involvement in ICT

Potential fields of work for ICT practitioners such as design, production, assembly, service and quality control can be quite heterogeneous target groups. However, their use of ICT is different. Increasing networking in production (see Figure 22) Frühauf, 2003, p. 30) relies on ICT in production to make programming, configuration, maintenance, diagnosis, and optimisation everyday tasks. This assists in making ICT relevant for all employees while ICT-specific tasks and an increasing specialisation are becoming increasingly important in production.

Figure 22:   Networking supports flexible production (e.g. with mobile radio)
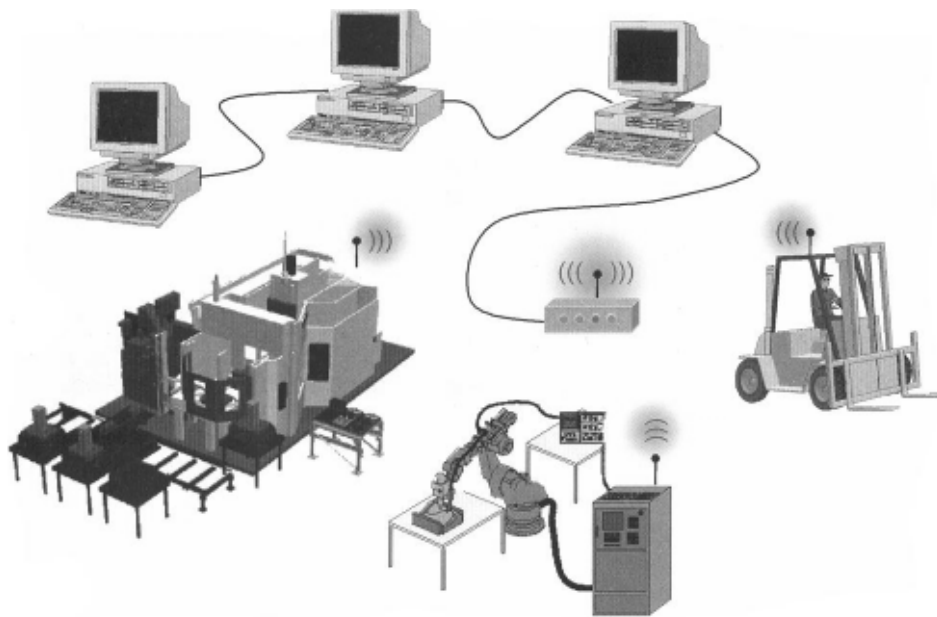
The technological challenges for employee skills is summarised in Table 4 (see Spöttl and Windelband, 2002).

The statements in Table 4 underline that ICT practitioners have to understand and master the interface between the individual steps of the entire production process (including the software) to be able to take decisions and to eliminate uncertainty, sources of error, and software faults.

The tasks and requirements are summarised as follows:

(a)   interaction with various information technologies and programmes;

(b)   knowledge of information processing and process chains;

(c)   visualisation (3D models);

(d)　cooperation and communication with an integrated development and tool-making team as well as with customers;

(e)　basic manual skills extended by information technology competences;

(f)　basic functional knowledge of machines, of maintenance and trouble-shooting;

(g)　manipulation and testing as well as geometry and function checks with the assistance of physical models.

The following changes may be mentioned in relation to higher integration of ICT in plant technology with regard to rapid prototyping processes:

(a)　even more rapid reaction to detailed customer requirements;

(b)　time reduction linked to new product development;

(c)　permanent quality improvement of the sample;

(d)　increasing the productivity of organisation and of each work place;

(e)　quicker iterative testing and improvement;

(f)　extension of descriptiveness and integration of experience knowledge;

(g)　horizontal cooperation and communication;

(h)　more flexibility and team work;

(i)　elaboration of ideas for improvements and creative problem solving during joint reflections.

Table 4:   Challenges for the work in production triggered by ICT diffusion

Production Fields of work	Specific tasks	Role of ICT	Users
ICT implementation	• Installation of machines (on site), putting into operation, technical function check • Use of various production procedures measuring technology and heat treatment	• Increase of ICT such as PLC/ CNC/CAD/ CAM I production plants/production processes/measuring instruments for quality control • Implementation of ICT networks	Engineers Highly qualified technicians
Production processes Production technology	• Execution of production tests • Elimination of standards malfunctions, diagnosis, FMEA • Apply know-how on tools and materials • Creation of production aids • Creation/optimisation of programmes/service programmes SPS and CNC-machines oriented to geometrical objects • Application of PPS Software • Operation of rapid prototyping plants or other machines as, e.g. HSC machines • Modernisation of plants • Data processing for the complete production process of a product • Reading of customer 2D-CAD or 3D-CAD or their design/development • Operation of 3D-measuring machines and set-up of measuring protocols • Use of hotlines for information transfer	Manufacturing equipment • Rapid prototyping • High-speed machining • complete machining • micro treatment • hard metal cutting • dry metal cutting • laser-cutting • retrofitting • further new production procedures Latest technology • laser treatment plants • near-net-shape-forming • robot technology • cutting techniques (e.g. water torching, laser cutting) • linear direct drives • measuring techniques (e.g. laser measuring technique) • parallel kinematics • other new production technologies	Highly qualified technician Skilled worker

Production Fields of work	Specific tasks	Role of ICT	Users
Process innovation	Optimisation of process • flexible production automation • automated maintenance • process control systems • simultaneous engineering • development teams across departments • continuous improvement process, etc.	• use of networks • implementation of networks • use of databases • enhancement of databases • use of PC/PLC for documentation • use of databases for diagnosis, technical figures, etc.	Highly qualified technician Skilled worker
Products	New innovative products (with complete service) • development of prices for machines • use of new materials (plastics, ceramics) • new service offers such as teleservice, training courses …	• common use of ICT	Highly qualified technician Skilled worker

2.3. ICT challenges for employees

All production plants and production processes make use of ICT tools and instruments, including hardware and software. The consequences can be summarised as follows:

Technology	Consequence
ICT diffusion; production processes with ICT; production technologies; process and product innovation	• Permanent innovations in the company are common as almost all products are linked to new production methods according to the latest technology. This starts with processing speed, and continues with the different production materials and latest control technologies. The employees are thus faced with a continuous further development of their skills within a highly specialised occupation. • The plants are becoming more and more complex, for example: - milling machine with seven controlled CNC axes; - complete fabrication (turning, boring, milling, grinding) in a vertical production unit; - heavy chipping in machine tool production; - high speed production tools. Skilled workers, therefore, must have in-depth knowledge of the functioning of machines, they must be able to read complex drawings, etc. To react to this swiftness and at the same time to keep an overview is a task to be learned by experience in everyday work processes. This is normally supported by training managers. • Almost all machine tools use the latest and most sophisticated information technologies. Even older plants and machines have been modernised with the assistance of specific service departments. New control systems, measuring systems or positioning displays are installed • More and more ICT competences are also demanded of skilled workers employed in final assembly. They must be able to operate the machine and to adjust minor programmes (individual components), e.g. small tool change programmes including a change of machine data. They must be able to read and operate SPS programmes. • Constant changes and further developments in control units lead to an increased need for continuous learning. The need for training depends on the specific area and can be quite different. Those who commission must know the control unit very well in order to carry through small changes or optimisations in cooperation with the programmers. Skilled workers in final assembly (industrial mechanics), however, have to know only how to operate the control units. • The future target may be the complete networking of the company (renewal of the PPS system). All work places would be linked to this networked and comprehensive system. • Complex tasks of a commissioner exert a high influence on ICT, above all in various control units. Programmes are taken over and are thoroughly tested. Faults should be found and explained to software systems analysts or developer. • The majority of the machine tools used by the surveyed company were CNC-controlled. The trend clearly abandons the individual input mask of an individual machine and favours the computer-aided input mask which just alters input data. The programming of this kind of software is much easier and more user-friendly. As a consequence, linking and even integrating of different (fields of) tasks is possible. The skilled worker operates, programmes and optimises CNC controlled machine tools, 3D measuring tools and rapid prototyping machines.

The manifold, complex, and ICT-permeated tasks in production can be further described by a concrete case in rapid prototyping:

The central developments in the field of technology at the workplace have taken place in closed process chains at the customers' firms. The company reacted to this development by the qualification of one of the employees who is currently assigned a workplace called 'Programming, CNC production, rapid prototyping'. The development of technology at this work place has mainly influenced data processing and the applied machines (e.g. Spöttl et al., 2003).

The customers supply drawings on paper, 2D-CAD files or 3D-CAD files. Further processing, however, requires 3D-CAD files. Therefore the respective files must be produced first. For smaller orders and if there is enough time, the files are generated in the company itself. Otherwise the order is passed on to the above mentioned engineering company. 3D-CAD files originating by customers must generally be converted in order to be processed on the company's own system (Pro-E). Customers often supply CATIA files which have to be converted into the CAD-system PRO-E. The exchange of data, information, and order details with the customer and the engineering company is done via e-mail, fax, or remote data transmission (Fritz data).

All data are further processed in a closed process chain in the model or tool making department. In addition to CNC-machines and the Rapid Prototyping machine, the company runs a 3D measuring machine used for the realisation of measuring protocols of each individual part.

The operation of 3D-CAD programmes is of central importance for the programming of machine software (CAM software). The programming of CAD software oriented to geometrical objects is similar for all CNC-machines and the Rapid Prototyping machine.

After the purchase of the HSC milling machine the control of the CNC-machine has become more complex due to the now five axes to be programmed. The skilled workers are facing special challenges due to the fact that the production area of the new machine is completely closed and that the visual control of the production process is therefore getting even more difficult. The new HSC milling machine requires the acquisition and mastering of all sophisticated production technological skills.

The skilled workers master the various requirements by a consequent use of the hotline, of service for maintenance, repair and operational issues as well as further customer service offered by the suppliers of the machine and related software (see Spöttl and Windelband, 2003).

A summary of challenges linked to fields of production is given in Table 5 (see Spöttl and Windelband, 2003). While all areas include ICT-oriented challenges to be mastered by employees, it has become clear that less sophisticated or non-autonomous ICT practitioner profiles are playing an increasing role. ICT practitioner competences are more or less relevant

for all employees working in or closely linked to production. New ICT specialisations play a role but they are always embedded in the context of other production-oriented tasks.

Table 5: *Core tasks in production with ICT challenges*

Fields of tasks	Challenges linked to an increasing ICT diffusion
Quality	• Basic principles of quality-conscious acting with respect to product, work and environment • Autonomous safeguarding and check of product quality • High transparency in processes/optimised information flow • Use of precise self-control and of quality assurance techniques such as statistical process control • Electronic data saving procedures • Check of norms, plausibility checks, check plan consultation • Administration of inspection equipment, checks in accredited laboratories, • Continuous quality-promoting and safeguarding measures • Continuous reflection and communication with colleagues for improving process and product quality • Highest possible adherence to delivery dates
Organisation/work preparation	• Planning of order processing and processes • Flawless coordination of order processes • Setting-up, programming, optimising, adjusting, re-adjusting • Reading of customer specific 2D-CAD/3D-CAD • Preparation for order processing (safeguard stocks, machine time, etc. • Application of PPS-software, • Detailed planning of production steps/direct acquisition of materials and tools • Use of hotlines
Safeguarding production	• Contribute to solve technological problems with regard to production and assembly-friendly construction and by taking into consideration costs and automation aspects • Advise/support with problem solving in general • Development of specific problem solutions • Maintenance including preventive maintenance • Assembly of aggregates, plants, machines, retrofitting • Repair of plants/machines • Creation of a company internal and external customer awareness • Use of quality management systems • Work safety/ecological awareness/smooth handling of material
Technical tasks	• Installation of machines (on site), start-up, technical function check

Fields of tasks	Challenges linked to an increasing ICT diffusion
	• Use of different production procedures, of measuring technology and heat treatment • Use of CATIA/Pro-E • Execution of production test runs • Repair of standard malfunctions/diagnosis/FMEA • Apply know-how of tools and materials • Production of equipment • Setting-up, optimisation of programmes/service programmes • Operation of 3D-measuring machines • Use of PPS software • Modernisation of plant machinery
Optimisations	• Product and process optimisations in a sense of a continuous improvement process • Culture of readiness to take over responsibility • Flexible, situation-oriented shaping of processes • Motivation, enthusiasm and personal commitment • Ability and opportunities to learn • Make use of 'practical' intelligence for the shaping of production processes and for process and product innovations • Prevent a loss of cooperation by the integration of tasks • Optimisation of product designs (customer-friendly, production-friendly)
Coordination/ responsibility	• Cultivate and safeguard a culture of responsibility • Responsibility for products and company • Product production always aimed towards a comprehensive result • Establishment of dialogue structures non-existent so far • High grade of self-organisation • Safeguarding of corporate success by entrepreneurial thinking and acting.

3. ICT skills and training in vehicle repair and sales and their relevance for the qualification

The integration of ICT in modern vehicles accounts for 30 % of the car's value in medium sized and up to 50 % in luxury cars. This chapter analyses the challenges to work tasks due to the high rate of ICT diffusion, focusing on the car itself and the workshop and applied tools.

3.1. ICT-systems in automobiles and respective skill needs

ICT is used for different purposes:

(a) management of vehicle functions (signal registration, signal processing, actuator control, diagnosis);

(b) networking of vehicle systems (see Figure 23);

(c) provision of information and communication solutions (audio, video, TV, DAB, telephone, telemetric services).

In addition to vehicle manufacturers, suppliers are also involved as system developers (Bosch, Hella, LuK, Magneti-Marelli, Siemens) as well as development service companies (e.g. Bertrandt, ETAS, Vector Informatik). Safety and integration aspects require a sound knowledge of vehicle architecture. This is why computer scientists are rarely involved and the field is dominated by vehicle and electronic engineers and software engineers. Employees without degree level qualifications do not feature in the development of ICT in automobiles.

Figure 23:   Networked vehicle
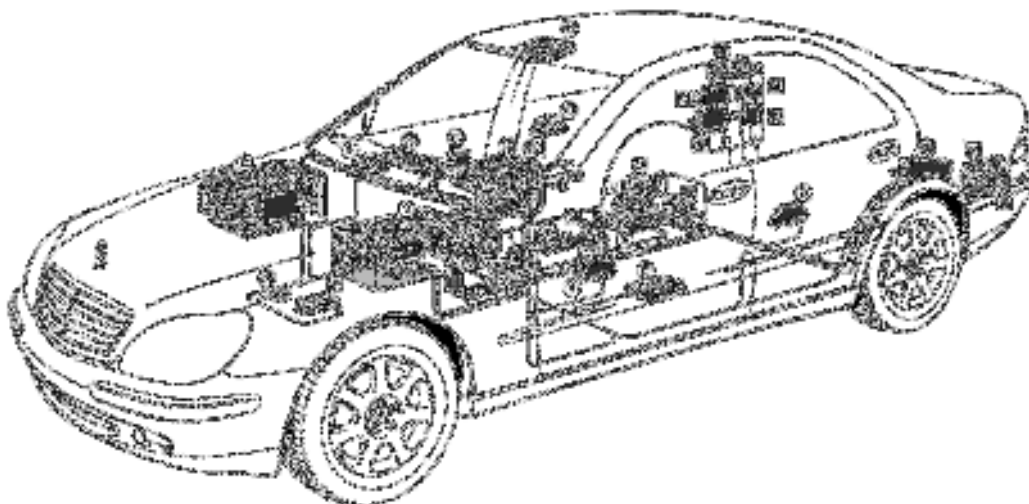
Source: DaimlerChrysler

There are two steps to adequately consider ICT as a content of occupational work. First it is necessary to clarify the term vehicle communication technology and how it influences vehicle technology. The next question is how and to what extent skilled workers encounter it during their daily work. German studies on this issue have been carried out in vehicle repair workshops with the aid of work process studies and expert conversations helping to clarify the question of how information and communication technologies have become an object of skilled work.

Vehicle communication technology can be divided into the following categories:

(a) communication technology for an exchange of data between the vehicle systems/ aggregates and the memory for vehicle information;

(b) communication technology for multimedia applications (infotainment) and for the assistance of the driver;

(c) communication technology for the development and configuration of vehicle systems including their diagnosis.

The communication technology for data exchange between vehicle systems/aggregates is characterised by the networking of the system's components by bus systems and the determination of system and vehicle properties by control units. Sensors and actuators play an important role in this process.

The second dimension of technology deals with the:

- entertainment and information of the vehicle user as well as with the communication possibilities of the passengers (infotainment, see Figure 24).

- Support of driving functions as well as of systems of active and passive safety (driver assistance).

Figure 24:   Infotainment
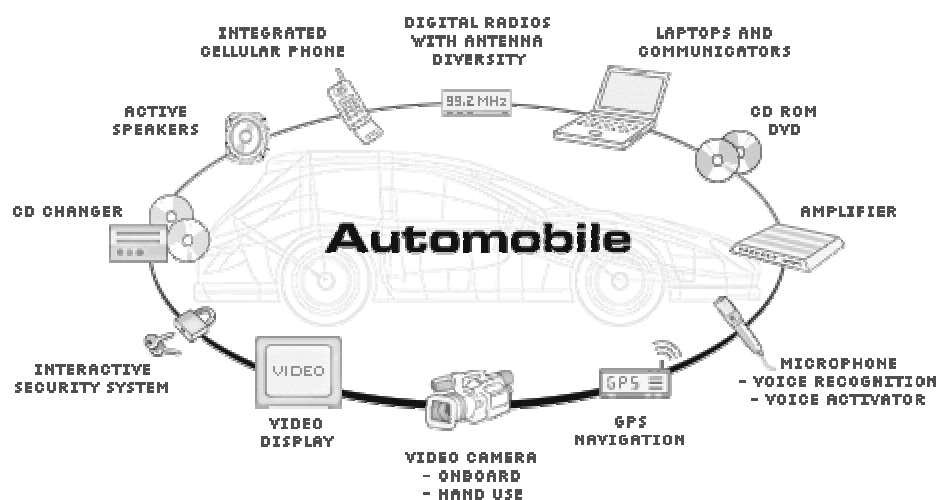
Source: MOST Cooperation

The following are examples of technology for driver assistance:

(a) rain sensor, automatic switch-on of lights, door lock function;

(b) Distronic (control of distance), parking distance control;

(c) user support (i-drive, windscreen monitor, etc.);

(d) active drive train, drive dynamic systems, brake assistant;

(e) X-by-wire (support of driving functions: braking, steering, lateral guidance, changing of gears);

(f) airbag, belt pre-tensioner, safety energy concepts (battery-terminal clamp, fuel tank safety valve).

The third type of technology covers tools which allow for the development, the configuration and the diagnosis of vehicle systems. These include hardware-in-the-loop, test and configuration environments, programming tools, diagnostic tools.

Technical subjects covered are:

- bus systems (LIN, CAN, MOST, Flexray, Firewire, Bluetooth, Byteflight) and control units as well as networked sensors and actuators;

- vehicle operating systems (radio, CD, navigation system, voice entry and output, Internet and PC-interface) and the systems for the realisation of driver assistance;

- diagnosis, test, simulation, programming and configuration tools.

Another dimension of communication technology lies beyond the vehicle: in the exchange of communication in the workshop with information providers, manufacturers, parts suppliers, etc., using computer systems, telecommunication and other installations.

The importance of vehicle communication control systems and future networking of vehicles was discussed with experts focused on the architecture of the vehicle and the intended properties of vehicle technology. The networking aspect is just one out of a number of technologies. When questioned on the most important knowledge for skilled workers the experts emphasised knowledge of the vehicle architecture, the virtualisation of signals ([18]) and the relevance of sensors and actuators, plus related measuring and access possibilities.

Four workshop core tasks were identified for the automotive service:

(a) check of data bus systems (communication) and the measurement of transfer properties;

(b) telediagnosis – trouble-shooting with networked diagnostic systems in coordination with the manufacturer;

(c) configuration of vehicle communication technology and repair of faults;

([18]) This means that digital signals often cannot be measured directly and have to be interpreted by a software analysis.

(d) retrofitting of vehicle communication technology.

Tasks three and four were broken down into specific actions.

Configuration of vehicle communication technology and repair of faults includes:

(a) digital radio technology/digital audio broadcasting (DAB);

(b) codification of anti-theft devices;

(c) adaptation of keys;

(d) memory function of seat and mirror positions;

(e) air conditioning;

(f) extension and adaptation of interior equipment;

(g) programming of characteristic diagram;

(h) distance control systems (parking distance control, Distronic);

(i) mobile phone systems.

Retrofitting of vehicle communication technology includes:

(a) car telephone;

(b) mobile phone –docking station/hands-free set;

(c) navigation system;

(d) onboard computer;

(e) Internet, onboard-TV, audio-/video-interfaces;

(f) Tempostat (cruise control);

(g) comfort extensions such as centralised door locking, theft warning device, anti-theft devices, interior release delay, etc.

3.2.   ICT in the automotive service sector and skill needs analysis

Work methods in the automotive service sector are changing slowly, in spite of technological innovation. However, this development is likely to gain momentum and the influence of computer-assisted work will soon be paramount. Therefore conclusions on the use of ICT technologies must not be solely drawn from current demand and supply.

3.2.1.   ICT-assisted solutions for measuring and diagnosis

A variety of computer-aided tools are used in automotive servicing. Traditional workshop devices have been upgraded with computer-aided interfaces and diagnosis has been changed by the introduction of computer-aided diagnosis systems and measuring tools.

Automotive experts plus ICT (see Section 1.1.) face additional challenges beyond standard use of these systems because of the need for:

(a) start-up of workshop devices;

(b) installation of software;

(c) configuration of hardware and software;

(d) calibration of measuring instruments;

(e) networking of workshop devices internally and linked to company networks;

(f) diagnosis in the event of communication interferences between diagnostic tools, vehicles and manufacturers' head offices;

(g) start-up and fine-tuning of remote maintenance solutions (see Figure 25).

Figure 25: Remote maintenance and telediagnosis. Example of Siemens self-diagnosis and remote maintenance
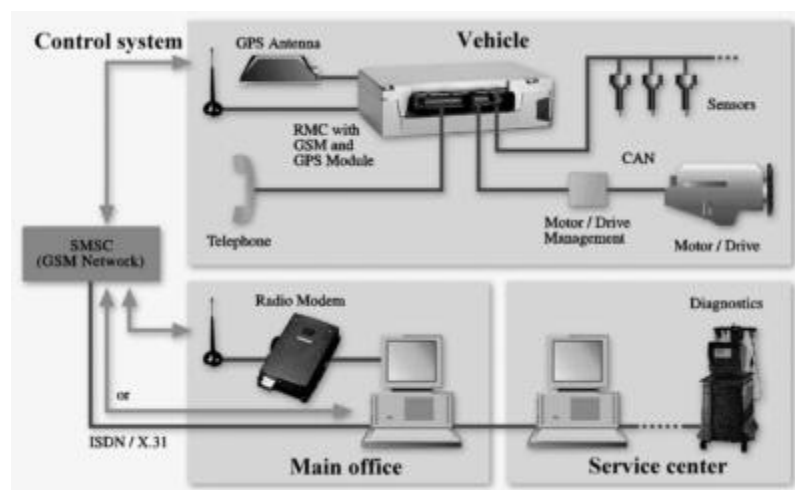
Source: SIESaR, Siemens

Although these tasks do not require programming knowledge, skilled workers are nevertheless confronted with various interface and configuration problems. Knowledge of operating systems is crucial as the ICT solutions are normally based on prevailing operating systems such as Microsoft Windows ™. Wherever databases cannot be centrally operated, it is often the skilled worker who has to implement interface and software configurations.

Currently, skilled workers are often overworked. As a consequence even simple tasks must often be assigned to sub-contractors. The frequent problem of inadequately programmed driving devices leading to malfunctions of the system requires reconfiguration by skilled workers, often without adequate documentation from the system provider. Below is an example of the instructions for the configuration of a computer-assisted fault memory read-out device:

In this example an adaptation of parameters in file 'b248.par' is often required in order to ensure communication with the vehicle control unit.

3.2.2.   The influence of EDP-systems on work methods

The implementation of personal computers in services craft and trade companies is at the same time both a potential revolution in work methods and a breach of the traditions of the trade. The trade traditionally deals with real objects and products but these have now been permeated by ICT, the use of which has become crucial for the occupation.

The computer can only be regarded as an important tool of the trade since around 1990. At first it was used in order acceptance, in storage and perhaps in the master craftsman's, service manager's or foreman's office. Word for Windows was only launched in 1989 and the first really usable version of Windows (3.0) was not available until 1990. At that time the only software programmes adequate for an automotive workshop were based on DOS and still were poor, even for producing standardised invoices. Computerised storage control required considerable efforts. Big computer systems were only found in large automotive workshops (AIX, UNIX-systems). Small workshops have only recently introduced the PC. It is expected, however, that the use of computers will increase in the future, as revealed by the overview below. As work methods are changing there is an opportunity to support learning. ICT competence is meanwhile playing an important role in coping with tasks.

Table 6:   Time grid for the influence of computers on the work methods in the automotive workshop

Time	Electronic Data Processing systems (EDP) for the automotive trade Support for work
up to 1990	One of the best known EDP systems for the trade is the *package* published by SAGE/KHK. SAGE/KHK, founded in 1983, was the first to launch an EDP-aided financial bookkeeping programme not to be installed on big computer systems. In 1984, a software package for order processing and one for stock keeping followed. In 1985 the package was released, an EDP solution specially tailored for the needs of the trade. The fields of application, however, were confined to bookkeeping and order processing (offer, order, invoice). The first boom leading to a comparatively wide distribution of this software took place in 1989. Ever since the system has a DATEV link. In addition the functionality of the software has considerably increased (e.g. accounting book, turnover lists, administration of open accounts, etc.). The first Windows version by SAGE/KHK

Time	Electronic Data Processing systems (EDP) for the automotive trade Support for work
	was only released in 1996. In automotive workshops the use of EDP systems was still rare up to 1990. Some company owners and a few sales departments of larger enterprises made use of EDP. The workshop area and thus the mechanics were not yet confronted with EDP.
1990	Various car manufacturers introduce the first EDP systems in their authorised workshops. A DAT (*Deutsche Automobil-Treuhand*) system offers a simple cost calculation for damages. A spare parts catalogue on CD-ROM TECDOC is being developed by transnational Bertelsmann group co-funded by the European Union. Stock keeping and the preparation of standard invoices are tasks carried out with the aid of computers in authorised workshops of the car industry. Independent workshops do not yet widely use computers, unless for invoicing.
1994	The EDP system WERBAS goes into serial production. This EDP system widespread in automotive enterprises (1994 = 500 installations; end of 2003 = 13 000 installations, 85 % of which in independent car workshops) reveals what is possible at that time: • master data (customer and vehicle database); • order acceptance; • invoicing; • stock keeping; • parts acquisition; • sales promotion (word processing); • information system for technical vehicle data. In the meantime the computer is also used in independent workshops, however, mostly for invoicing and for tasks within the field of spare parts' acquisition. The workshop and thus the work of the car mechanic remain largely untouched. BMW launches a workshop information system based on PCs in the workshops. This system combines diagnosis (DIS), technical information (TIS) and information on spare parts (ETK) within a single device. In addition this software is based on an expert system aiming at helping the skilled worker with troubleshooting. In BMW workshops the introduction of this system has an impact on work organisation and on the opportunities of an integration of working and learning (see Becker and Isermann, 1997; Schreier, 1998).
1995	The Dutch enterprise Olyslager releases a workshop information CD which permeates the independent automotive workshops under different denominations such as ATRIS-technology, Gidis Kfz info system (Grundig), AC-Tech (AutoCrew), SAIS D (SUN), TWIS (TüV) and in different variations (VID-CD). This CD offers a repair handbook for the major part of the vehicles currently available on the market. It concentrates, however, on the increasingly important data for diagnosis of motor management systems and the ABS. Till today these tools are primarily available and used at the master craftsman's office and not directly in the workshops.
1998	Audatex: The Audatex Datenverarbeitungs GmbH (based in Germany and Belgium) has converted existing databases for the calculation of vehicle damages into an electronic version. In the meantime software is available which allows for a cost estimate within a few minutes and not only when it comes to damages. Further products mostly based on the database of Audatex (Schwacke PC-autocalc, DAT/Silver/Dat II, UCS) are permeating automotive management systems. In addition there is a trend towards direct settlement of claims with the insurance companies. The damage assessment is broadcasted with the aid of video images (DAT-

Time	Electronic Data Processing systems (EDP) for the automotive trade Support for work
	system) from the workshop to the appraiser. This can be realised with digital cameras via ISDN networks or in future via satellite networks. With the aid of calculation programmes the automotive workshops will soon take over the task of an on-site appraisal expert. TECDOC GmbH and Siemens Business Services cooperate on the development of an Internet and electronic business solution for the online processing of spare parts acquisition. Diagnosis systems for exhaust gases and wheel alignment analysis will soon be created for the workshop based on a PC. With the SMART the first vehicle enters the market whose workshop and repair data are only available via the computer. It can be predicted that the working methods will change considerably within the next few years. Nevertheless the computer as a working tool for all mechanics has still not been made compulsory.
1999	ASA ([19])-network: At least theoretically (i.e. the technical solution has already been realised) workshop devices and enterprise resource planning systems up to system solutions such as WERBAS can work together within an EDP network. The future of the trade might include that an order set up (at the order acceptance desk) flows along the network via the various workstations. Required spare parts and data can be directly taken from the order and necessary information on the status of the order can be retrieved at any place and at any time. After the finalisation of the work a customer invoice would be automatically printed out. In due course, all relevant data and information for the work process would be provided by and/or entered into the computer from the very beginning of the chain until the end product and its delivery including after sales services. Different providers (manufacturers, supplier organisations and independent businesses) offer workshop information available for clients via the Internet. BMW started to introduce this comprehensive process in November 1999.
2000-	All vehicle manufacturers switch their information management to networked EDP systems for the workshops. Intranet and internet solutions for the repair business and the automotive trade are introduced increasingly and comprehensively.

([19]) ASA = *Bundesverband der Hersteller und Importeure von Automobil - Service Ausrüstungen e. V.*

Figure 26:   Expansion of the TecCom B2B-Platform
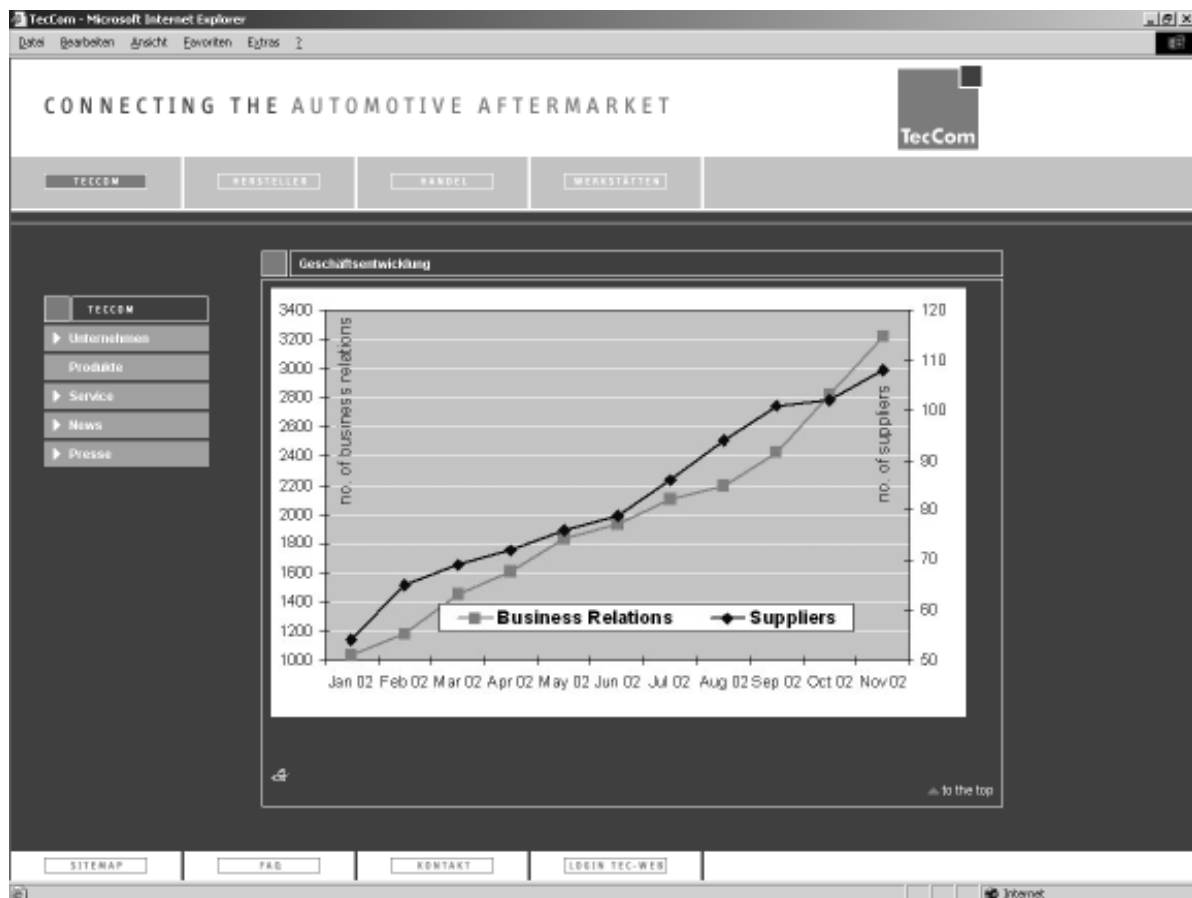
Figure 26 shows the dynamic increase of the Internet B2B-Platform TecCom. Spare parts logistics (manufacturer, supplier, retail) and spare parts ordering (workshops) based on B2B and B2C platforms respectively.

The development of such platforms requires core ICT competences without special branch-specific profiles. Development teams as described by Petersen and Wehmeyer (2003) take part in this process.

The use of computers, however, is not solely responsible for changes in working methods and organisation. Customers' demands for better service levels , legislation on environmental protection against vehicle emissions and extended service intervals all require improved service quality . Computer aided tasks call for ICT competences for employees in the automotive sector. Company structures in smaller enterprises indicate that the flexible all-round service will continue to dominate. Enterprises with 5 to 11 employees rely on the fact that everyone – from the manager to the apprentice – can perform a variety of functions. Organisation based on a strong division of work is likely to reduce the overall efficiency of the workforce and would thus jeopardise the competitiveness especially of smaller enterprises. Therefore a specialisation in ICT work is not in great demand in a service sector dominated by SMEs. All employees need ICT competences in a way to carry through diagnoses, to point out faults in a car network and to handle the databases as well as the online work.

3.3. ICT Challenges for the employees in Europe

Skill requirements for employees are revealed by work which can no longer be carried out without the use of ICT and which goes beyond the pure operational level. Service personnel face a multitude of challenges, with close to 100 % of tasks in the automotive service connected with ICT ([20]). Table 7 shows the challenges in specific areas of automotive work resulting from the introduction of computer-assisted work systems.

The work methods of such tasks have changed substantially with the use of ICT, demanding skills and competences which ought to be primarily in close relation to the work process. There is a need to address provision of these skills in spite of the vast variety of available product information, repair manuals and electronic devices including software support. Such tools can only help to cope with the routine functions, being mainly conceived for a very limited range of tasks. Increasing diversification of software solutions can result in service personnel being charged with software adaptation and installation, troubleshooting and carrying out a range of configuration tasks. These tasks are not seen as core actions for service personnel but are necessary because of the lack of uniform software solutions applicable in practice and harmonised with each other. Software is released by different producers and networking is virtually impossible or only achievable with difficulty. The sort of system integration introduced in production is not available to the services sector.

Another aspect is the increasing importance of cooperation between members of the team during the whole working process. Telediagnosis, the supply of spare parts and the handling of warranty cases using ICT solutions requires coordination between information providers, operational staff and clients.

([20]) Due to the worldwide assimilation of automotive technology, the requirements for skilled workers in production and repair are increasingly similar. Cars are a global product with increasingly identical challenges.

Table 7:   Challenges for the work in the automotive service sector triggered by ICT diffusion

Fields of tasks	Challenges in relation to ICT diffusion
Internal services	• Administration of customer and vehicle data • Order creation and monitoring • Delivery date planning
Standard service	• Acquisition of maintenance and inspection plans • Access to change intervals • Access to fault memory • Quick access to standard checking and adjustment data • Provision of spare parts
Diagnosis	• Customer interview with the aid of workshop documentation systems and workshop planning systems (WPS) • Brainstorming for diagnosis by research in malfunction databases and digitally processed service information • Help with the delimitation of the malfunction by online systems and use of hotlines • Apply vehicle independent inspection methods with computer-aided measuring systems • Acquisition of check data from manufacturer and supplier databases • Computer-aided diagnosis techniques (oscilloscope, storage measurements, process measurements …) • Diagnosis plans provided by the manufacturer; use of expert systems • Start-up of workshop devices • Installation of software • Hard- and software configuration • Calibration of measuring instruments • Networking of workshop devices with each other and link to company networks • Diagnosis in the event of malfunctions of communication between diagnostic devices, vehicle and the headquarters of the manufacturers • Set-up and fine tuning of remote maintenance solutions • Telediagnosis
Repair	• Acquisition of repair and adjustment data • Explanations for difficult work processes • Determination of work data
Additional installations	• Selection of adequate systems, e.g. navigation system, auxiliary heating, tow bar, car telephone, HiFi system, additional lighting, retrofitting of catalyst, additional parts of interior equipment, optical tuning, etc. • Market overview and performance characteristics • Computer-aided integration, configuration and diagnosis
Stock keeping and spare parts management	• Spare part identification • Acquisition/re-ordering of spare parts • Delivery of spare parts according to work process • Bookings • Stock keeping of spare parts
Damage expertise	• Documentation of damages • Value analysis/calculation of work units
Invoicing	• Amendment of order • Handling of vehicle, customer and spare parts databases • Taking into consideration important information for customer

Skilled workers with the occupational profiles mentioned in Table 8 face the above challenges. What is especially interesting – and at the same time underpins the hypothesis of the identical challenges independent of the respective market – is the fact that there are only minor differences in job and occupational profiles. Whereas Table 8 shows the initial training, this trend can be even more clearly seen in CVT competences. These are dominated by manufacturers, across frontiers and independent of cultural diversities. Structurally seen there are hardly any differences to be identified between the individual producers (Peugeot, Renault, BMW, DaimlerChrysler, Ford, etc).

Table 8: *Occupational profiles and job titles in automotive services in France and in Germany*

	France	Germany
VET (Technology)	L'électricien électronicien automobile Technicien de maintenance auto Technicien de maintenance moto Technicien de maintenance V.I Spécialiste du pneumatique	Car Mechatronic (from 2003 onwards) Mechanics for the technology of body maintenance/mechanics for body work and automotive construction technology Mechanic for motorbikes Painter

3.4. Summary

The idea of the networked car implies that in terms of technology cars are increasingly identical. This is also true for the product quality. As there are no more standardised forms of work organisation in the technical areas of the small workshops, problems are solved in many different ways – in spite of a convergence of the formal qualifications in Europe. Above all the Dutch, French and German service and repair market is witnessing an increasing importance of expert systems and highly developed diagnostic tools. These devices are linked to comprehensive support measures such as hotlines, online support, manufacturer management systems or workshop support systems. The networked car and the technical data networking of the cars with manufacturers and workshop support systems means that skilled workers can only cope with their tasks with the aid of considerably enriched ICT competences.

4. Profiles and training fields for ICT practitioners in the automotive industry

4.1. ICT profiles for production and service

The necessity for independent profiles for automotive ICT competences exists only in education and training at professional or degree level and within a few segments in production and service. However, virtually the entire workforce needs basic ICT competences related to respective domains. There is a distinct separation between ICT hardware and software development for the industry and the application of such technologies. The industry needs complex ICT structures whose development is confined to IT professionals trained in higher education and at technical universities. Trained personnel at sub-degree or vocational level (in Germany the *Fachinformatiker* or skilled computer expert) for programming tasks are only found in areas where routine tasks predominate and/or encapsulated software modules are developed. This is true of solutions that can also be applied in other sectors, i.e. predominantly B2B platforms/e-business solutions. Nevertheless there also seems to be an increasing need for ICT-trained personnel, with an education or training below university level, for the development of in-company information and communication solutions.

There are no fields of activity for sub-degree level employees when it comes to comprehensive software development and microprocess-oriented solutions for vehicles (software for control units, diagnostic software, network technologies for the vehicle). These solutions are strongly automotive-oriented and require a sound knowledge of automotive technology; most employees are former skilled workers with an additional degree as professional engineers. Even computer scientists are rare in such fields concentrating on structural and core ICT structures and problems. The occupational profiles or job titles/job profiles used in the field of automotive development are[21]:

(a) technical computer scientist;

(b) engineering computer scientist;

(c) engineer ([22]) for information processing;

(d) computer scientist engineer;

(e) software engineer;

(f) project engineer (test systems, application and measuring technology, embedded software).

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[21] This is the outcome of an analysis of negotiations of Social Partners, decisions of industry, job descriptions and empirical data from research projects by the authors.

[22] The term engineer in Germany covers what in UK is currently called professional or chartered engineers.

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Additional titles are electro-technical engineer or car technology engineer or even mechanical engineer with knowledge of information processing (Table 9).

Table 9:   Classification of occupational profiles in fields of application

	ICT development and innovation	**Professional use of ICT**
ICT in the vehicle	Engineers (vehicle technology)	technical skilled workers in automotive service
ICT for automotive production	Computer scientists, engineers	all employees in production (skilled workers; technicians; master craftsmen)
ICT for automotive service	Computer scientist	all employees in services (skilled workers; technicians; master craftsmen)

The rough matrix given in Table 9 indicates that for the development of software there is a strict differentiation of occupational profiles below university degrees. This is not the case for applications that optimise business processes or for web-applications and information and communication solutions for the industry or its suppliers. The Internet presence of a supplier or an automotive dealer is essentially the same as the Internet presence of a bank or a publisher. If the Internet offers other possibilities for the registration of a vehicle for inspection, these applications can also be assigned to the field of e-business (CISCO, 2001).

The use of ICT by professionals is quite different. ICT practitioners require a highly developed knowledge of networking structures up to skills in programming. However, the programming of a robot in an assembly line requires programming skills which are closely interwoven with the knowledge required for the assembly itself. Therefore no special ICT occupational profiles can be identified as an important requirement. Mechatronics, production mechanics or industrial mechanics (from 2003 on electronics for automatisation technology) need to acquire the necessary programming competences as a transversal content for their basic tasks: trouble-shooting in production plants, adjustment of robots necessary to safeguard given product quality standards. More details on the relation of the fields of work, applications for ICT and working positions are given in Table 10 and Table 11.

Development of branch-related software applications of the information and communication technology (ICT) and involved actors

Table 10:   Software applications, their development and working positions

	Fields of work	Applications of ICT	Positions confronted with ICT		
			Vocational occupation (level 2/3)	Highly qualified technician (level 3/4)	University graduation (incl. universities of Applied Science) (level 4/5)
ICT solutions for the automotive industry	ICT for the automotive service	Networked tools Diagnosis Measuring technology Workshop information systems Workshop management, CRM	No	No	Computer scientist Software engineer Computer sciences engineer
	ICT for automotive development	Computer aided software engineering (CASE)tools Digital mockup SIL/HIL Development of control unit On-board networks Network diagnosis	No	No	Software engineer Computer sciences engineer
	ICT for automotive production	Supply chain management Automation, PPS Product data management (PDM) Process visualisation B2B/B2E/E-Business 2D/3D-CAD (CATIA/PRO-E)	No	No	Computer scientists Engineers Automation technicians
	ICT for mechatronic systems in the vehicles	Micro system technology	No	No	Engineers (e.g. micro electronics, micro system technology)
	Vehicle communication technology	Telematics	No	No	Computer scientist
	General IT solutions (Production and service)	Typical IT application cases: accounting, correspondence, information management, databases, PC and server solutions ... Order processing programmes (PPS ...)	Specialised computer engineer	ICT-technician level	Computer scientist

Professional tasks in the field of information and communication technologies (ICT) in the automotive industry

Table 11:   Advanced use of ICT, their implementation and working positions

	Fields of work	ICT relevant work processes	Vocational occupation (level 2/3)	Highly qualified technician (level 3/4)	University graduation (incl. universities of Applied Science) (level 4/5)
ICT solutions in the automotive industry	ICT in the automotive service	• Start-up, configuration, software support, computer-aided diagnostic systems • troubleshooting in networked vehicle systems • Diagnosis communication with fault memory read-out tools • Fault diagnosis with data transfer via bus systems • Flashing of control units (updates) • Parameterisation, codification and programming of control units • Adaptation of diagnostic systems for different vehicle accesses • Telediagnosis in cooperation with the manufacturer • Integration of infotainment into the vehicle system network	Car mechatronic	Car service technician	Automotive engineer Software engineer Computer sciences engineer
	ICT in automotive development	• Simulation of vehicle systems • Hardware in the loop/software in the loop • Diagnosis on CAN • Fault simulation • Application of control units • Data on diagnosis tasks • Rapid prototyping	not required	not required	Automotive engineer Software engineer Computer sciences engineer
	ICT in automotive production	Computer aided quality assurance, process visualisation and control CNC-programming Teaching of robots PLC programming CATIA/Pro-E 2D-CAD; 3D-CAD 3D-Measuring/SPC PPS systems PC networking	Domain related: Mechatronics Production mechanics Cutting mechanics Process control electrician Electronic technician (from 2003 on) Electronic technician for automation technology (from 2003 on)	Technician or master craftsman	Computer scientist Engineers Automation technician
	IT-solution for the support of business and work processes	See IT-branch	Specialised computer scientist	ICT technician level	Computer scientist

4.2. Training fields for employees linked to production and service

There is a clear necessity to put more emphasis on diagnosis and work on networked vehicles (vehicle networking) and on the different production areas during initial and further training in both the field of automotive service and of production. The number of bus systems in the vehicles and production is constantly increasing (see Figure 27 and Figure 28) as is access to additional installations and diagnosis. Employees must have sound background knowledge on bus systems, system functions influenced by software, bus protocols, transfer protocols and measuring technological accesses. The need for skills in this segment is considerable.

Unfortunately there are no adequate training opportunities on offer with a focus on the importance of information and communication technology for the work process and work with ICT itself. Most of the courses deal with technological content, with limited value (fibre optic cables, CAN-bus: layout, protocol, arbitration, product briefings on software installation, etc.).

Figure 27: High variety of bus systems as a challenge for training in the automotive service sector
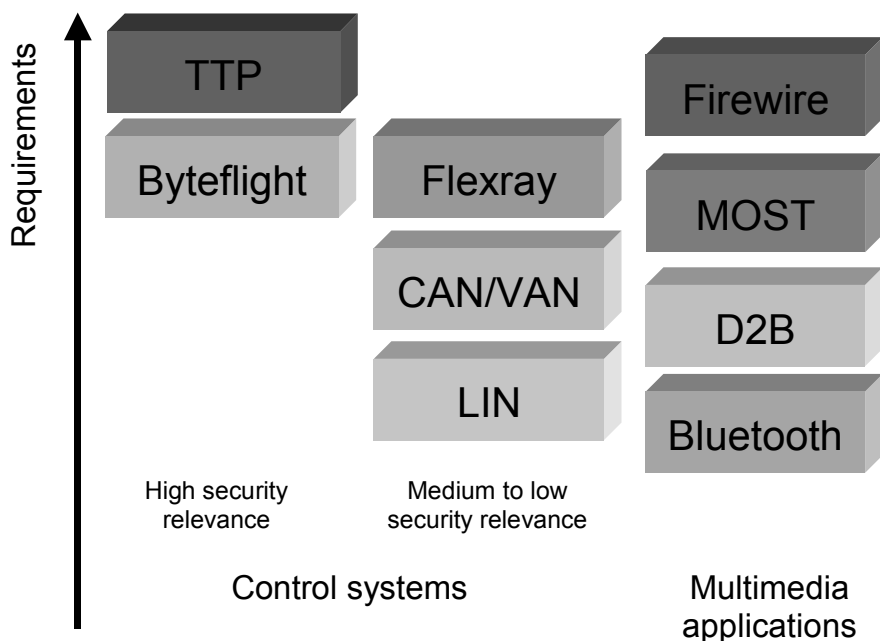
4.2.1. Training for ICT skills in automotive services

The training needed for different activities is listed below.

Start-up, configuration and software support of computer-aided diagnostic systems:

(a) start-up of computer aided diagnostic systems;

(b) configuration and implementation and parallel use of different measuring systems and workshop information systems;

(c) execution of software updates and safeguarding of system stability.

Trouble-shooting in networked vehicle systems:

(a) access to fault memory according to ISO 15765 (diagnostics on CAN), ISO 14230 (see KWP2000), ISO 9141, SAE J1850, OBD;

(b) specific vehicle values transferred by bus systems and their impact on the behaviour of adjacent vehicle systems;

(c) fault images with different transfer media: one-wire-bus (LIN), two-wire-bus (CAN), optical fibre cables (MOST).

Diagnosis communication with fault memory read-out tools:

(a) diagnostic interfaces: OBD, E-ODB, K-duct, L-duct and manufacturer-specific solutions (KWP1281);

(b) importance of standardised and non-standardised diagnostic failure codes (DTC), above all P0 and P1-codes;

(c) diagnostic modes and wake-up of control units; changes in communication parameters, timing.

Troubleshooting in data transfer via bus systems:

(a) measuring technological access to passive, active, and smart sensors of the third generation;

(b) detection of communication failures;

(c) measurement reading blocks and online recording of sensor information and actuator control via diagnostic interfaces;

(d) measuring technology for the diagnosis of data transfer with different bus systems: measurements with oscilloscope, CAN data logger.

Flashing of control units (updates):

(a) flashing tools;

(b) background information on manufacturers' solutions (e.g. Volcano by Volvo);

(c) differences between software update, codification and parameterisation and consequences on fault diagnosis;

(d) software as a product.

Parameterisation, codification, and programming of control units:

(a) range of coverage of interference on the function of the vehicle;

(b) diagnostic tools and depth of diagnosis.

Adaptation of diagnostic systems for different vehicle accesses:

(a) K-duct, L-duct, standardised and OBD-interfaces as well as vehicle-independent interfaces.

Figure 28: Mounting and checking of car Xenon headlight

Telediagnosis in cooperation with the manufacturer:

(a) communication solutions: telephone, chat, remote control via the Internet;

(b) handling of augmented reality;

(c) cooperative problem solving.

Integration of infotainment into the vehicle system network:

(a) integration solutions by manufacturers and impact on diagnostic accesses: island solutions and integration solution;

(b) customer consulting with regard to retrofitting of network compatible appliances; car telephone, integration of mobile telephones, navigation systems.

4.2.2. Training for ICT skills in automotive production

The training needed for different activities is listed below.

Software applications and their use with different machine technologies:

(a) use of data of different formats for different machines;

(b) CAM software, Master CAM;

(c) rapid prototyping software;

(d) lightyear, CAD, CATIA, Pro-E;

(e) machine technology: CNC/HSC, rapid prototyping, measuring machines.

Aim: local networks, technical documentation, make use of standards for optimisation.

CAD construction and CAM data processing:

(a) CAD construction/CAD data processing;

(b) 3D-CAD supplies as CATIA files;

(c) programme optimisations;

(d) online exchange of data (e.g. between Unix and PLCs).

Aim: use of CAD and databases for CAM.

Quality assurance in the production with ICT tools:

(a) process control with quality control card (SPC);

(b) FMEA-systematic procedures for fault-risk-analysis;

(c) supervision of checking tools;

(d) use of measuring tools.

Aim: assure quality by the use of ICT tools.

Networks for manufacturing and production:

(a) concepts for local area networks;

(b) integration of PLC and CAD/CAM concepts into the networks;

(c) troubleshooting;

(d) use of standardised products via databases and networks;

(e) use and re-organisation of the application of operating systems (Windows NT and Unix).

Aim: mastering of operation and installation of networks.

Databases and their use:

(a) figures for tool pre-adjustment;

(b) selection and integration of CAD standard parts;

(c) integration of standardised tools into production;

(d) data saving.

Aim: apply databases efficiently for different tasks.

Visualisation of processes:

(a) in touch programmes (ITC-wonderware);

(b) factory link (US Data), Ctect;

(c) Visio;

(d) precision engineering.

Aim: visualisation of processes to safeguard process flow.

Diagnosis communication with fault memory tools as well as measuring technology:

(a) test of production cycles, use of special software;

(b) troubleshooting in data transfer bus systems;

(c) apply expert systems for diagnosis.

Aim: ensuring the function of the process.

Optimisation of production process:

(a) optimisation of production control by the use of PPS-systems/software;

(b) management of databases;

(c) management of machine data of customers;

(d) troubleshooting.

Aim: ensure efficient production.

4.3.   Summary

Above all domain-oriented occupational profiles can be identified in the automotive industry. Self-contained ICT profiles only exist in certain niche areas and in places where typical tasks in the field of information and communication technologies (software development and integration, network installations, web design, etc.) have to be tackled. Employees with a self-contained ICT profile support automotive manufacturers with the conception and the structuring of their business and work processes: company networks, intranet-solutions, company communication, software-aided logistics, PC configuration and much more. These tasks are virtually the same as those in ICT departments of other enterprises and other sectors. Accordingly employees dealing with these tasks can be found at all levels (specialised computer scientist – L 2; ICT technician – L 3/4; up to computer scientist – L5) and are typical for the ICT sector.

The development and the construction of ICT for vehicles is assigned to automotive engineers and excludes employees with a degree below university and university of applied science level. Applications (programming of vehicle control units, diagnosis data, etc.) are too automobile-specific tasks to be taken over by computer scientists who support vehicle engineers by the development of software structures or actual software (CAD, programming tools).

The professional application (adaptation, configuration, putting into operation, troubleshooting) of application-oriented programming of software and hardware in the automotive production and service sector is assigned to skilled workers with automotive and production-specific occupational profiles. Corresponding ICT competences are required for tasks in the production sector and repair of vehicles in workshops. It is crucial that these tasks must not be divided. ICT-oriented and production or service relevant tasks cannot be separated (e.g. by the adaptation of a CNC program or the configuration of a computer-aided diagnosis system). They are too closely linked to automotive specific domains.

The fact that almost all skilled workers have to deal with ICT determines the need for ICT during vocational education. For the described target group this means a work process oriented integration of ICT contents into the existing training contents. Special attention must be given to the increasing importance of networked systems in the vehicles (in the field of automotive service) and the emerging shift and integration of tasks (in the field of automotive production). So far the automotive industry has responded to these challenges with comprehensive CVT concepts.

5. General guidelines for curricula development

The purpose of the following curriculum development guidelines for ICT skills-practitioners' profiles is to support and assist the development of VET and CVT courses at European level which will cover the range of ICT practitioner profiles relevant to the automotive sector. It includes the full range of companies from SMEs to large enterprises. The description of the profiles is based on areas of employment and on the business and work processes of ICT practitioners.

5.1. ICT skills and competences and a structure of profiles

The influence of information and communication technologies calls for an improved streamlining of existing occupational profiles, not just defined ICT profiles in addition to the curriculum structure.

A number of general and specific recommendations for the shaping of training profiles and curricula can be made based on the results of this study (see Table 12).

For professionals and higher education graduates there should be more emphasis on project management, cooperative work between automotive manufacturers, system-/module suppliers and development service companies. Use of modern ICT technologies and structures is important:

(a) digital mockup;

(b) augmented reality;

(c) hardware in the loop (HIL);

(d) software in the loop (SIL);

(e) rapid prototyping for software development;

(f) data recording during diagnosis;

(g) product data management;

(h) diagnostic processes, by including the entire concept for development;

(i) production (final acceptance);

(j) service workshops/customer service.

Also required are control unit applications and software development for vehicle control units adhering to automotive-specific standards (OSEK ([23])-VDX, ASAM ([24]), ASAP ([25])).

([23]) OSEK stands for *Offene Systeme* and their interfaces for the *Elektronik im Kraftfahrzeug*.

The target group for this is classical engineering studies: vehicle technology; mechanical engineering; machine technology; electrical technology; software engineering; physicists.

For professionals, technicians and skilled workers, consideration of information and communication technologies is essential (see Table 12):

(a) as transversal contents for all skilled, highly skilled and professional workers in production and repair, keeping in mind that ICT is highly relevant and supports work and business processes oriented to the fields of work in both production and repair; the target groups are ICT technical supporter, 'knowledge manager' (handling both data as well as data bases to make them available within the field of work), software engineer;

(b) as a supplement for certain fields of work in production and repair and services where existing profiles could be amended in view of a professional handling, which may include an autonomous adaptation and (further) development of ICT-configurations and applications; target groups in motor vehicle repair and sales are car mechatronics (skilled worker level), car service technicians (service technician level), sales staff; target groups in production are production mechanic, construction mechanic, maintenance mechanic, certain production and electrical/electronically oriented traditional industrial and crafts occupations and trades;

(c) as a self-contained ICT profile for professionals and highly skilled workers in automotive specific fields of production and repair (see Table 12); so far there are no clearly defined ICT profiles available but a target group could be named ICT developer of various applications.

Table 12:   Heterogeneous challenges for ICT practitioners in the automotive industry

ICT CLUSTERS		
ICT as transversal competence	**ICT as supplement**	**ICT as self-contained profiles**
Highly skilled worker/professionals in the repair workshops and in production fields	Car mechatronic/skilled and highly skilled worker in repair workshops and production fields	ICT support and ICT development (ICT infrastructure of repair workshops and production). Professionals and highly skilled workers
Revision of existing curricula according to the identified ICT needs and fields of skills in a work process oriented way (see Chapter 4/5) Definition of ICT transversal competence following the work processes and work tasks	Revision of existing curricula according to the identified ICT needs and fields of skills in a work process oriented way (see Chapter 4/5) Definition of ICT supplements following the work processes and work tasks	Development of ICT for specific ICT supported factory and support solutions which require a high production-oriented and repair-oriented level of ICT competences. Examples: self-developed production planning system (PPS) (see www.tdk-m.de) Implementation of ICT solutions for the support of repair workshops with service know-how.

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(24) ASAM: Association for standardisation of automation and measuring systems
(25) ASAP: Applications systems standardisation working group

Both production and motor vehicle repair and sales areas are characterised by the fact that ICT diffusion has not only increased but is now integrated into all plants and that despite of this traditional technologies will prevail in combination with ICT applications ([26]). Consequently it is insufficient to look at ICT in isolation. The study clearly reveals that there are many task profiles that require sophisticated ICT skills and competences and there are only a few highly specialised autonomous ICT task profiles.

The summaries in Table 13 (motor vehicles repair and sales sector) and Table 14 (production) underpin the variety of work areas where certain tasks can only be successfully tackled with by ICT competences.

The difference lies in the level of ICT competences, i.e. degree or a sub-degree level? Level one competences in the simple use of ICT devices will not be dealt with in detail as we presume that every employee should be able to master this kind of task. No special efforts are necessary to reach this level and it is therefore not justified to conceive special training courses. Simple ICT applications are part of all training courses (e.g. the standard use of a PC).

Tables 13 and 14 name tasks with a high ICT orientation. However, these involve only ICT application, not development. This gives rise to the question of which ICT skill profiles are necessary for the automotive sector and to which levels they should be allocated: sub-degree or higher education (HE) level such as BA, MA or MSc (Bachelor, Master of Arts or Master of Science). The concentration on ICT applications in Tables 13 and 14 indicates that sub-degree and VET levels are dominant rather than degree levels. The comments on Table 12 already suggested that considerable development work must be done by ICT professionals with regard to both motor vehicle repair and sales and production. The correspondent tasks are given in Table 15. The fact that different competence levels are required for each field is stressed. There is, however, a huge gap between user-oriented ICT tasks (and appropriate ICT skills) and development-oriented tasks. For user-oriented ICT skill profiles, the context of motor vehicle specific access is extremely important. No profiles can be identified without this aspect.

For development work, however, the context is no longer the focal point. Typical developers usually settle for overview knowledge to deal with development tasks. These professionals, often described as ICT producers, face serious challenges and they cannot do without motor vehicle or production specific know-how. The characterisation of structurally different ICT skill profiles is once again confirmed. The differentiation in real areas of application is admittedly manifold. Table 13 shows four sub-sectors for motor vehicle repair and sales and six fields of tasks for production in Table 14 with differing ICT permeation levels.

An allocation of the three ICT clusters discussed so far (ICT as transversal competence, ICT as supplement, ICT self-contained profiles) to the ICT fields of tasks confirms that different

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([26]) The diffusion of ICT was adequately justified in the preceding chapters.

ICT skill profiles are important. Table 15 and 16 summarise and indicate that production and motor vehicle repair and sales require varying amounts and levels of ICT competences.

The core statements of Table 15 and Table 16 are as follows:

(a) not every employee in the automotive sector needs to be an ICT practitioner but all of them use ICT applications;

(b) separation of ICT applications and of the other contents was not envisaged due to the fact that production and repair are dominated by a clear process orientation and by abandoning a former segmentation of work task specifications. A differentiation in ICT tasks and non-ICT tasks is not in question. There is, however, a continuing assignment to levels but level one (the insertion level or unskilled level) has no practical importance;

(c) ICT-challenges and the related work task specifications correspond mainly to levels two and three; even these differentiations are sometimes difficult to handle;

(d) a clear-cut assignment to levels is only possible via the definition of training units; during work experience these differences become less important as with experienced technicians and professional engineers;

(e) the tables show how ICT emphases and tasks may be assigned to different characteristics of ICT practitioners. It becomes evident that there is a necessity for autonomous ICT profiles, though they have had little qualitative importance up to now. However, there is practically no field of tasks untouched by ICT. Therefore it is necessary to take a closer look at them.

Motor vehicle repair and sales sector

Table 13: *ICT fields of tasks, the relevant competences and levels for ICT skill profiles in the motor vehicle repair and sales sector*

ICT related working areas	ICT relevant categories	Competences	Levels 1 to 5
Diagnosis	Diagnosis communication Troubleshooting Use of networked diagnostic systems/Telediagnosis	Diagnosis interfaces Diagnosis modes Measuring technology Diagnostic trouble codes Expert systems Communication modes in different networked systems (vehicle; with manufacturer)	L2 L2/L3 L2/L3/L4
Integration of ICT in the vehicle architecture	ICT integration Infotainment configuration	Impact of the installation on the entire vehicle system Interfaces Programming and software updates	L2/L3 L2/L3
Software applications for the service process	Workshop process systems (WPS) Software adaptations (data exchange, interfaces)	Handling workshop/service tools with ASA interface Use of (web based) software and databases B2B solutions and their adaptation on WPS	L2 L2 L3/L4/L5
Network implementation and software oriented support for workshop management	Networked workshop Knowledge management	Software configuration Programming user-oriented hardware support	L4/L5

Automotive production

Table 14: *ICT fields of tasks, the relevant competences and levels for ICT skill profiles in the automotive production sector*

ICT related working areas	ICT relevant categories	Competences	Levels 1 to 5
System automation	Optimised production control Integration of networks Network installation Network functions	Use of PPS PPS optimisation Databases administration Network concepts Network organisation Network standards Troubleshooting	L2 L3/4 L3
Process quality	CAD/CAM processing Visualisation of processes Data saving	Data transfer Process regulation Fault-risk-analysis Software applications Safety systems	L2/L3 L2/L3 L3/L4
Diagnosis and troubleshooting	Diagnosis communication Troubleshooting Ensuring data transfer	Diagnosis interfaces Diagnosis modes Measuring technology Failure codes Expert systems Data transfer, CAN bus, etc.	L2 L2/L3 L2/L3
Software applications and machine technology	Use of HSC/CNC-CAD/CAM Rapid Prototyping Software adaptations (formats, interfaces)	Machine tools with ICT integration Use of software Use of databases CAD/CAM transfer of data CAD/CAM adaptation	L2 L 3 L2/L3
CAM construction and databases/data processing	Online use of data CAD/CAM software Databases: standardised parts, data saving	Online transfers Use/reconfiguration of software Database integration Database redesign	L2 L3 L2/L3 L3/L4
Network implementation and software oriented support for production infrastructure	Network programming Interface programming Programming of Internet links	Programming of hardware and software Creation of networks/ Internet infrastructure	L4/L5

Table 15: *ICT competences for motor vehicle repair and sales and their links to ICT practitioners* ([27])

ICT combined fields of work	ICT as transversal competence	ICT as supplement	ICT as self contained profile
Diagnosis	x	x	–
Integration of ICT in the vehicle architecture	x	x	–
Software applications for the service process	x	–	(x)
Network implementation and software oriented support for workshop management	–	x	x

Table 16: *ICT competences for automotive production and their links to ICT practitioners*

ICT combined fields of work	ICT as transversal competence	ICT as supplement	ICT as self-contained profile
System automation	(x)	–	x
Process quality	x	x	–
Diagnosis and troubleshooting	x	x	–
Software application and machine technology	x	x	–
CAM construction and databases/data processing	–	x	–
Network implementation; software support for production infrastructure	x	–	x

5.2. ICT skills profiles and competences and the ICT curricula structure

Four ICT positions of working in and on core ICT-tasks can be identified in automotive production and vehicle repair and sales (see Figure 29).

Figure 29: *Fields of work of ICT practitioners with different profiling in the automotive sector*

ICT Practitioner

ICT knowledge and skills

Focus: ICT

I

Approx. 4 % of workforce

Automotive Expert PLUS ICT

Context knowledge & skills

Focus: context of automotive area

III

Approx. 85 % of workforce

plus ICT know how

plus context knowledge

ICT Practitioner PLUS

ICT knowledge & skills

Focus: ICT

II

Approx. 4 % of workforce

ICT User

Simple context and ICT user knowledge & skills

Focus: context of automotive area

IV

Approx. 7 % of workforce

This leads to ICT skill profiles with very different characteristics.

The ICT practitioner has a focus on independent development of ICT applications, such as software for rapid prototyping or for infotainment systems in the car. Professional ICT skills and competences are essential for programming of software in different languages, different development tasks, problem solving and applications requiring special profiled competences. The proportion of the workforce featuring these competences is estimated by the authors at around 4 %.

The ICT practitioner plus deals with ICT developments very closely linked to production or the requirements in a vehicle. The assembly of a digital factory requires hardware and software infrastructure such as servers, clients, and networks which have to be adapted to corporate and workflow specific framework conditions (Haller et al., 2003, p. 22 et seq.). During the configuration of spreadsheets, the link with assembly work flows to DC systems and so on, it is very important that the ICT practitioner plus not only has access to existing production structures but that his developments are carried through in close coordination with existing systems. This is what the context orientation, the 'plus' of the ICT practitioner is all about. The authors estimate the proportion of the workforce working in this field as similar to the ICT practitioner at 4 %.

The automotive expert plus ICT has a contextual field of tasks. He is working in service and repair, with the product, looking for malfunctions, carrying through repairs, maintaining and checking cars. Similar to production, where he assembles and checks the car or its system units, he must master his domain, i.e. he must be able to repair a car or to safeguard a functioning assembly of the cable harness or to find a default in a bus system or in the networking of control units. ICT applications, however, must be applied such as diagnostic tools for troubleshooting, digitalised measuring systems for wheel suspensions or logistic software for material management in the production. The ICT competence of the automotive expert plus ICT concentrates on the competent application, the competent use of ICT. Consequently every employee working in production or repair should have these competences. According to estimates by the authors, around 85 % of the workforce engaged in the automotive sector belongs to this category.

ICT users are employees who take care of very simple registration tasks, data input or routine enquiries in firmly installed ICT plants, i.e. skills at level one. These skills may be acquired during training phases – learning on the job. Special training programmes are not required. The authors estimate that around 7 % of the workforce can be assigned to this group.

The four task-oriented ICT profiles show that the employee encounter with ICT can vary. ICT skills at a degree level are required for advanced software development, the development and the implementation of networks and the design of software systems for engine, infotainment, brake and steering controls. However, the recent integration of ICT hardware and software into existing areas such as the car, the machine tool, the production planning system, requires ICT profiles with different characteristics. Apart from the ICT practitioner these profiles have

been named ICT practitioner plus, automotive expert plus ICT and ICT user. ICT skill profiles are designed below.

5.2.1. Relevant ICT skill profiles

The various ICT skill profiles differ according to their competence profiles, their competence levels and the shaping of the contents. They are explained below based on the fields of work depicted in Figure 29.

ICT practitioners (I)

Emphasis: ICT knowledge and skills only

Main task: Development, creation, support of hardware and software solutions in and within the framework of automotive production and automotive development.

Selected ICT skill profiles

1. Communication network design/Network design (levels 3/4)

Communication network designers deal with the networking of the various departments, the suppliers and manufacturers and with data transfer between different users. During the build-up of the digital factory, emphasis is on data integration (integration of EDM and ERP systems), work flow management and on the development of production planning systems and the corresponding standardisation.

In addition to competences in programming and in the setting-up of a variety of hardware, coordination of the different organisational units of a company is highly important.

Tasks

- Identification of the needs of data transfer between departments (design and construction, work organisation, production) and/or supplier and manufacturer.

- Working with staff of different departments to analyse their communication requirements and to determine the optimised cost-effective solution, e.g. for the shop-floor, the communication between suppliers and manufacturers, etc.

- Assisting in the specification of suitable hardware architectures as the basis of networks.

- Developing software architectures for the efficient use of suppliers and manufacturers.

- Providing advice and guidance on the use, operation and design of systems or solutions by using specific products.

- Providing advice, guidance, and support on the use, operation, and design of systems or systems solutions for use in different applications.

- Determining the size of networks for production planning, use for production, use for communication between suppliers and manufacturers.

Recommendation: ICT network designers may be employed for the optimisation of production processes and for the build-up of the networked factory.

2. Software development and services (levels 2/3 and 5)

Persons engaged in software development and services in or for production and service within the automotive sector; supporting the development and the use of branch-specific software for the support of business and work processes (service: workshop management systems; production: supply chain management, PPS and workflow-management systems; sales: e-business platforms).

They have a comprehensive knowledge of programming and of the conception and transfer (according to the level) of software. They have competences for the integration of software into corporate structures (technical) and corporate processes (organisational) and have specific skills for the investigation of customer requirements. They maintain and configure software systems on customer sites and set up and configure security and access concepts for branch-specific systems.

Tasks

- Investigation of customer requirements and customer service.
- Description and transfer of customer requirements into IT concepts.
- Programming and testing of company-specific software solutions.
- Design of software architecture for the control of network operations.
- Integration of systems and software and adaptation of software to customer requirements.
- Maintenance of software and safeguarding of interfaces to other sector systems.
- Development of safety concepts and their company-specific realisation.
- Building prototypes of software products for use in systems, design of modules, integration and installation of the modules, executing system integration.
- Executing technical introduction, the installation, final testing.
- Arranging/evaluating maintenance and support.
- Developing software for the control of the operation of telecommunication networks.

Recommendation: finding solutions to interface problems and data exchange.

3. Multimedia and web design (levels 3/4)

Multimedia applications and web design are very important for both the manufacturers and the car repair workshops. Multimedia applications for different purposes such as

documentation of assembly processes, design of training programmes, simulations, etc. can be developed at both institutions. Web design can be used for different applications such as company presentations and means of communication. The ICT practitioners of this profile should be responsible for such tasks.

Tasks

- Analysing company needs and customer interests.

- Identifying requirements for a sufficient transfer of company products and know-how to the customer.

- Designing user interfaces and creating prototypes with various multimedia technologies.

- Producing graphics, animation, audio, videos for product presentation, training, communication within sub-organisations of the company.

- Redesign of traditional products for use in multimedia systems.

- On-site installation of multimedia products customers including training and support.

Recommendations: shaping of the external presentation of a company, public relations, training measures, etc.

ICT practitioners plus (II)

Emphasis: ICT knowledge and skills as well as context knowledge of production and vehicle repair and service.

Main tasks: Direct support of production and the car assembly with hardware and software solutions, knowledge management and product design. Support of repair workshops by adapted solutions.

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1. Automotive software engineer (level 5)

Software engineers work for car manufacturers (e.g. Volkswagen, PSA), system suppliers (e.g. Bosch, Siemens, Magneti-Marelli) or development service companies (e.g. ETAS, Vector Informatik) that develop, configure and service software and hardware solutions for networked vehicles. They also create the necessary development and test environments.

Automotive software engineers have competences in professional programming and in the development of networked environments based on the standards of the automotive industry. In addition they have a sound knowledge of vehicle architecture and on the function of vehicle systems.

Tasks

- Coordination with vehicle engineers in simultaneous engineering teams, project management.

- Programming and set-up of test environments (HIL, SIL).

- Development and integration of solutions for vehicle electronics: operating systems for vehicle control units, bus-systems, diagnosis processes and algorithms, advice for diagnosis, development and adaptation of interfaces, development of chips (application specific integrated circuit (ASIC)).

- Design of new solutions for the development of vehicles such as rapid software prototyping, augmented reality, digital mock-up.

Recommendation: the link to the context enables degree holders to cope with challenging development tasks. They should be assigned these tasks.

2.   Automotive technical supporter (levels 3/4)

Automotive technical supporters are employees with vehicle manufacturers, suppliers, tool makers, and providers of supporting concepts as well as software service companies (e.g. Werbas) that support repair workshops with the introduction and maintenance of EDP solutions and computer-aided tools for problem solving on vehicles.

They have specific knowledge and skills in software-aided tools, the interplay between software and hardware, the structure and the use of branch-oriented databases as well as the computer-aided business and work processes in a car dealership. Their competences encompass the professional processing of images, photos and texts for the creation of technical documentation up to Internet-aided data management. Automotive technical supporters are also able to take over the adaptation of interfaces and smaller programming tasks necessary to create EDP-aided technical documentation.

Tasks

- Support of repair workshops with problem solving using diagnosis or repair databases; documentation of customer data, problem solving, and verbal communication (hotlines) with the aid of EDP tools; evaluation of databases.

- Putting into operation, maintenance and repair of PC-aided workshop devices.

- Processing and creation of technical documentation for electronic repair manuals, diagnosis guidelines, teaching materials, technical data sheets, internet-aided databases.

- Advice and coaching of ICP-aided workshop processes such as teleservice, application of augmented reality, etc.

Recommendation: universal employment for simple development tasks and a broad support of application.

3.   Automotive knowledge manager (levels 4/5)

Automotive knowledge managers deal with the key know-how of a company (manufacturer or repair workshop) and process this information with the aid of databases. The challenge is to

produce transparent documentation. The most important tasks are the compilation of process-oriented data, access-friendly data processing and the ensuring of a flawless information flow.

Tasks

- Investigation of communication structures and information flows.

- Design of company communication structures.

- Redesign of work processes.

- Development of knowledge databases.

- Development of telecooperation platforms.

- Management of projects for safeguarding and documentation of information as well as for the optimisation of document structures (document management) and information flows.

- Selection, coordination, and introduction of content, and operate management systems involving the workforce.

Recommendation: comprehensive employment for the compilation and processing of data and work process oriented know-how.

Automotive expert plus ICT (III)

Emphasis: Production or repair specific know-how (context-oriented) amended by ICT skills with user orientation.

Main Task: Coping with production and repair tasks with the use of ICT applications as well as an optimisation of ICT support.

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1.   ICT in vehicle repair and sales (levels 2/3)

The car mechatronics/car technicians employed in vehicle repair and sales have to be able to carry through all tasks related to a high-tech car. The use of expert systems or software-controlled tools are among the most important tasks, with successful use of modern diagnostic tools in a networked vehicle and the identification of malfunctions in mechatronic systems among the major challenges.

Tasks

- Start-up, configuration, software support, computer-aided diagnostic systems.

- Trouble-shooting in networked vehicle systems.

- Diagnosis communication with fault memory read-out tools.

- Fault diagnosis with data transfer via bus systems.

- Flashing of control units (updates).

- Parameterisation, codification and programming of control units.

- Adaptation of diagnostic systems for different vehicles.

- Telediagnosis in cooperation with the manufacturer.

- Integration of infotainment into the vehicle system network.

Recommendation: employees in vehicle repair and sales must be equipped with ICT competences to be able to work on complex cars.

2. ICT in automotive production (levels 2/3)

There are few areas in automotive production without ICT applications. This requires all employees to master core tasks such as the production of shafts, the assembly of complex modules, and quality control. They must, however, also be able to program ICT controlled plants, to make use of ICT for troubleshooting, repair or to simply apply ICT. According to the core task this can be CNC programming, PLC programming, programme configuration, use of 3D-measuring/SPC and so on.

The challenges are considerable as the domain-oriented core tasks have to be combined with ICT-oriented tasks such as chip removal with programmed assembly steps with programming. In addition there are ICT-oriented tasks which can only be mastered with a sound ICT know-how.

Tasks

- Computer aided quality assurance, process visualisation and control.

- CNC-programming.

- Teaching of robots.

- PLC programming.

- CATIA/Pro-E.

- 2D-CAD; 3D-CAD.

- 3D-Measuring/SPC.

- PPS systems.

- PC networking.

Recommendation: all employees engaged in metal-technological and mechanical occupations must be equipped with ICT competences. This should be envisaged in a task-oriented way to ensure a sound knowledge. A production orientation must be ensured for occupations with an electronic and ICT background.

ICT user (IV)

Emphasis: General and simple use of existing simple ICT plants.

Main tasks: Operation of simple ICT plants.

This covers simple operation knowledge and skills already in place in ICT-oriented courses, therefore no profiles are detailed.

5.2.2.   ICT skill profiles and their integration in production and repair

The surveys carried through so far revealed that not only ICT competences for all persons engaged in production and vehicle repair are of crucial importance. Moreover profiles of very differing contents and quality are currently emerging. The characteristics of competences ([28]) for

- ICT Practitioners,

- ICT Practitioners PLUS and

- Automotive Experts PLUS ICT

can be allocated to the three clusters presented in Tables 12, 15, and 16:

- ICT as transversal competence,

- ICT as supplement,

- ICT as self-contained profile.

Table 17 shows the competence characteristics for the sector in comparison with the clusters detailed earlier. It is apparent that the various profiles correspond with each other ([29]) as mentioned in the overview just below:

([28]) ICT users are not explicitly described (see Section 6.2.1.).

([29]) In spite of this clear-cut formal allocation, the practical coping with tasks will reveal dynamic situations. This means that the neighbouring fields will be crossed and that tasks cannot always be clearly separated.

I	ICT practitioner	exclusively to self-contained profiles
II	ICT practitioner plus	exclusively to transversal competences
III	Automotive expert plus ICT	exclusively to supplement

This statement has significant consequences for recommendations on the design of new ICT curricula. Each cluster has its own curricular reflections as self-contained profiles. However, the profiles represent an amendment of existing occupations or skill profiles.

Table 17: *Clustering of the ICT skill profiles as a basis for a generic structure*

ICT Practitioner	Level	**ICT Practitioner PLUS**	Level	**Automotive Expert PLUS ICT**	Level	**ICT User**	Level
1. Communication network design / network design (+)	3 4	1. Automotive software engineer (++)	5	1. ICT in vehicle repair and sales (++)	2 3	Common user (+)	1
2. Software development and services (+++)	2 3 4 5	2. Automotive technical supporter (++)	3 4	2. ICT in automotive production (+++)	2 3		
3. Multimedia and web design (++)	3 4	3. Automotive knowledge manager (+++)	4 5				

Profiling ICT Practitioner / ICT skill profiles

Cluster	**ICT as self contained profile**	**ICT as transversal competence**	**ICT as supplement**

+ profile or element/module exists already
++ will be established or added in due course
+++ will presumably be established or necessary in the medium and longer term

Individual profiles may demand different levels of competence that have to be kept in mind during their detailed shaping. Work tasks, however, are not always clearly segregated and do not exactly correspond to a level. Defining the levels of skill profiles should be handled with care since too great a number of profiles and levels may result in an inefficient work organisation or a clash with the existing flat organisational structures.

5.3. Recommendations for the design and structuring of ICT curricula for the automotive sector

Examination of the current developments, of existing ICT skill profiles, and of training efforts at sub-degree, degree and VET levels indicates a need for ICT skill profiles and ICT competences for approximately 93 % of the workforce in the automotive sector. The following recommendations for curriculum guidelines for ICT skill profiles aim at assisting the development of VET and CVT profiles and courses in a European perspective across the automotive sector, including manufacturers, suppliers, repair and sales shops of all sizes. The guidelines are based on work areas and work processes to ensure a close link to the needs of the industry.

Learning objectives, teaching methods, relevant learning processes, and certification are not taken into consideration in structuring the curricula which reflect innovative contents. There is also no differentiation between full-time courses, part-time courses, formal programmes, informal learning, etc. These are didactical decisions which cannot be discussed in detail here.

The heterogeneous ICT challenges in the sector imply the need for a flexible curriculum structure that respects work process orientation. At the same time it should be possible to adapt ICT skill profiles within the framework of competence development measures for various target groups. This is important because the profile holders are assigned tasks of differing challenging demands according the requirements of the work process.

5.3.1. Basics of the curriculum structure

Due to the very different challenges identified in the automotive sector there is no homogeneous ICT platform for a formally based curriculum structure. However, methodical, social and learning competences are to be found in all training and qualification measures ([30]). They are not shown in the curriculum structure below.

Another important aspect is the fact that the ICT skill profiles shown in Table 17 cover several competence levels. The description of the skill profiles does not consider differentiation within a profile but illustrates the entire range of competences with respect to work tasks. Further curricular considerations are based on the fact that training measures always call for the development of competences. This means that a profile – e.g. software development and services – can be finalised during a qualification process at one of a number of levels. A lower level indicates a respectively lower skill quality. This would require the development of both a core and a detailed curriculum and the objective of this study is purely to lay down curricular structures.

([30]) Among them are special training measures for the development of competences to work in and with projects, to work in teams, to build up communication structures, etc.

5.3.2. Comprehensive level related structure of the curricula

The following figure illustrates a proposed curricular structure for the sector based on ICT core profiles and specific challenges. The differentiation between ICT practitioners, ICT practitioner plus, and automotive expert plus ICT is maintained (see Figure 30).

Figure 30: Generic structure of ICT skill profile curricula

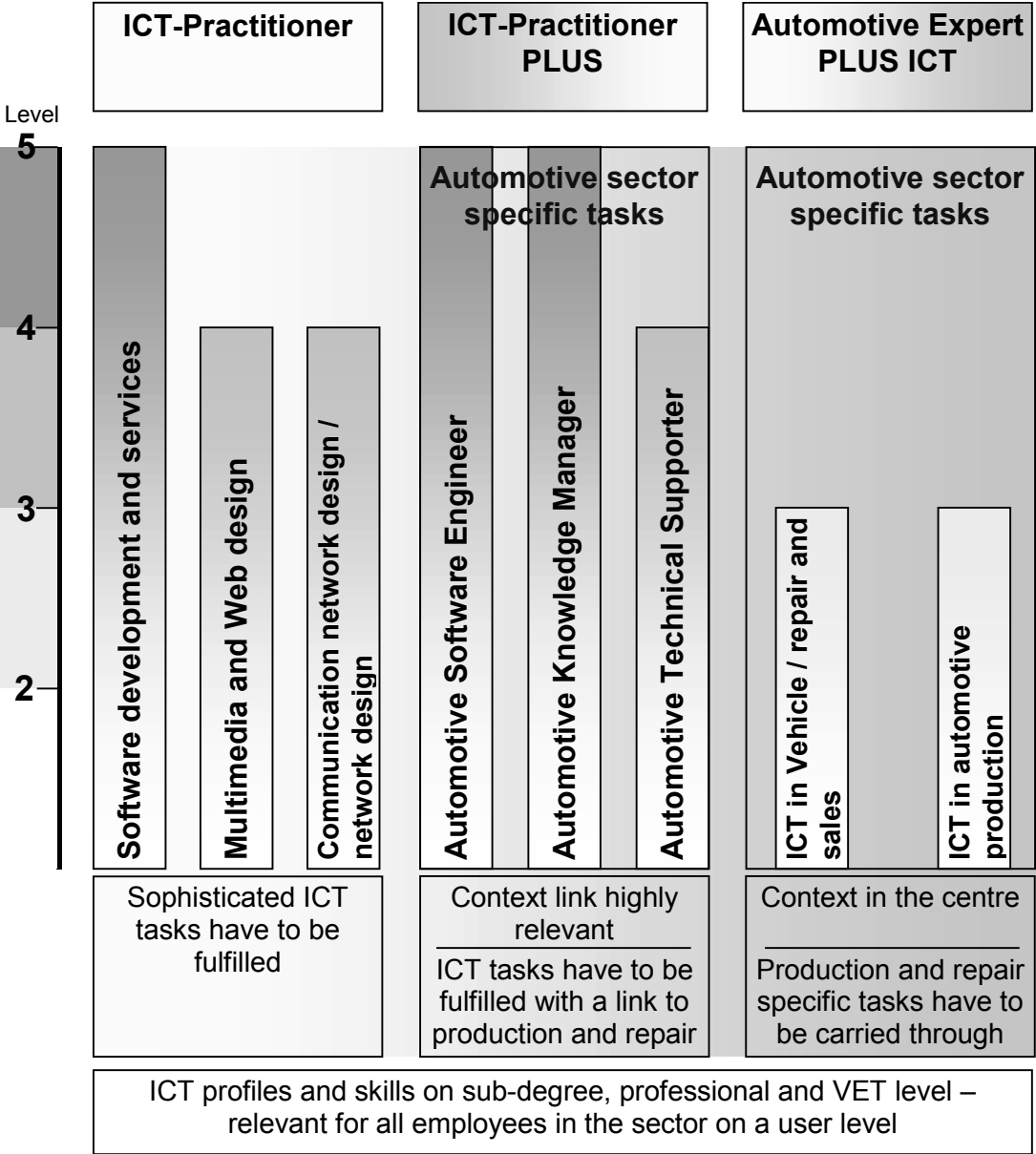Figure 30 stresses the general need for ICT-knowledge and skills and a basic framework to ensure ICT skill development. It is crucial to have a context relation to vehicle technology. According to the profile, this relationship can have different emphases. None of the profiles can, however, be regarded independently from vehicle technology. This fact must be considered with the development of curricula.

For ICT practitioners it is important to focus on ICT relevant issues during the development of competences. The core modules with scientific and technology orientation (^{31}) developed by Career Space (see Career Space 2001) might serve as a basis with adaptations to ensure suitability. All profiles include a sound development of competences at least up to level 3 or 4, or level 5 for software developers. Level 2 is not relevant for ICT practitioners as the requirements are theory oriented.

ICT practitioners plus must ensure a convincing link to sector specific requirements in addition to ICT oriented competences. Development of competences over various levels is necessary with levels 4 and 5 recommended as professional levels. An academic background with automotive context links is required.

The ICT profiles of the automotive expert plus ICT complement the already wide-spread (occupational) profiles. Existing profiles must be amended and the principles entirely rethought owing to the fact that technologies have merged into system structures. ICT often increases the complexity of the systems as a result of networking.

Occupational and skill profiles to be amended by ICT dimensions should be structured according to work processes though this can only be accomplished during work on a core and detail curriculum.

5.4.   Summary

The complexity of work tasks and occupational profiles in the automotive sector presents a challenge with respect to the question of which ICT skill profiles and curricular structures can be recommended to compensate for ICT deficiencies. The study revealed the need for profiles for ICT practitioners who focus on the development of software, network structures and multi-media applications. Their work is purely depending on ICT oriented knowledge and skills and so they must be qualified to cope with such tasks. It has to be noted that this group accounts for just 4 % of the workforce in the automobile sector.

A second target group are the ICT practitioners plus. They require sound, sector-oriented knowledge and skills and ICT skills. Only this combination results in successful problem solving. The qualification of this target group represents a very special challenge as they eventually have to master networked and mechatronic systems.

The qualification of the automotive expert plus ICT concentrates on a reasonable integration of ICT dimensions into existing occupational and skill profiles. The range of tasks of this

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(^{31})   It must be stressed that the challenges in the automotive sector are not taken into consideration as scientific and technology make up for 60 % of the curriculum. This volume must be considerably reduced in favour of sector-specific issues. Sector-specific issues have to be the focal point of all ICT practitioner profiles in the automotive sector.

target group will still concentrate on work at robots, CNC, CAD plants within the production field or on diagnosis and fault analyses within the field of vehicle repair. The employees must, however, increasingly master ICT applications. The largest group of the workforce in the automotive sector – approximately 85 % – is the group of automotive experts PLUS ICT who also need a sound, sector-oriented knowledge of ICT issues, however, not as context-free ICT skills. The focus of the curricula has to be on the work processes of service and repair of vehicles and to work in the production of vehicles on different tasks. The curricula should include ICT challenges for all training issues combined with the core competences of the automotive sector. The development of sophisticated curricula for these two fields – service and repair and production – requires expertise in these fields as well as a differentiation of the curricula due to the heterogeneity of technology and work organisation.

6.   Summary and conclusions

The automotive sector is dominated by structurally diverse ICT profiles. The range is from the simple ICT user to the ICT professional. Moreover there are major differences in the fields of tasks and the domains.

A closer reflection on the ICT tasks in the sub-sector motor vehicle and repair reveals four clusters with a high ICT permeation and six for production sector. This is a clear indicator of the considerable differences in the necessary competences. According to our findings three ICT clusters may be named:

(a) ICT as transversal competence;

(b) ICT as supplement;

(c) ICT as self-contained profile.

In terms of ICT applications and tasks the following conclusion can be drawn:

(a) a high-level separation of the ICT-applications from other contents was not envisaged due to the fact that production and repair are dominated by a clear process orientation and by abandoning a segmentation of work. A division of work in the individual fields of production and repair is no longer existent . There is, however, an assignment to levels but it should be emphasised that level one (the insertion level or unskilled level) has no practical importance;

(b) the ICT-challenges and the corresponding work task specifications correspond first and foremost to levels two and three. Levels four and five are assigned to development tasks. Given the requirements, also these differentiations are sometimes difficult to handle due to the fact that the individual tasks are swiftly changing;

(c) a clear-cut assignment to levels is only possible via the definition of training units. During work experience these differences become less important as this is the case between experienced technicians and professional engineers;

(d) the ICT emphases and tasks may be assigned to different characteristics of ICT practitioners. It becomes evident that there is a necessity for autonomous ICT profiles, although they have had little qualitative importance up to now. However, there is practically no field of tasks untouched by ICT.

It seems advisable to extend existing traditional profiles with ICT challenges and to develop self-contained ICT profiles for special tasks.

ICT diffusion in the automotive sector and the persistence of traditional fields of tasks is no contradiction.

Superficial discussion often gives the impression that the swift and comprehensive diffusion of ICT in the automotive sector results in the fact that only information science engineers are employed as software developers and users. The real picture is quite different. There are in fact fields of work that exclusively require the work of ICT professionals and ICT practitioners (degree and sub-degree holders). Other fields of work, however, employ experts who have a domain or a context competence (vehicle related) and also have ICT competences. Based on selected indicators, the authors estimate that there are three fields of work for ICT practitioners and one for ICT users in the automotive sector. ICT practitioners have profiles in two fields in which they could not work without intensive orientation to the context of production and/or service and repair. There is only one self-contained ICT employment profile. The task oriented profiles in detail are:

(a) ICT practitioner: development of ICT; emphasis is on developing ICT competence. Includes around 4 % of those employed in the sector;

(b) ICT practitioner plus: adaptation, partly development and use of ICT as central tasks. Professional, user oriented competences are necessary. Specific knowledge of production or cars is not required. Includes around 4 % of those employed in the sector;

(c) automotive expert plus ICT: the counterpart to the ICT practitioner plus. Use and partly adaptation of existing software and hardware products. Application knowledge and occupational competences are to be combined here: i.e. sound knowledge of production and cars are necessary. Includes around 85 % of all those employed in the sector;

(d) ICT user: simple use of ICT applications. Deeper competences are not required; operational knowledge is sufficient. Around 7 % of all persons engaged in the sector may be described as ICT users.

Almost 93 % of all persons engaged in the automotive sector encounter information and communication technology during their work in a professional sense, beyond pure application.

Europe has around 2 million employees in automotive development and production and around 2.5 million in vehicle repair and sales. These areas include a number of self-contained sectors which may be separated though boundaries are sometimes blurred:

(a) automotive development: research, pre-development, series development, construction/design;

(b) automotive production: production of vehicle parts, car production (carcass, engine production, assembly of aggregates, etc.), assembly;

(c) vehicle repair and sales: sales, vehicle sales, repair workshops, parts suppliers.

In addition there are various activities that supply the three sectors named above and which merge to varying degrees. This is especially true for the ICT service companies in all three areas. The ICT sector and the automotive sector partly overlap. Part of the ICT development and service tasks is internal to the automotive sector, other parts come from ICT companies of the ICT sector. Approximately 4.1 million employees of the automotive sector in Europe use ICT in a professional way.

The automotive sector is entirely permeated by ICT. The development towards flat hierarchies and optimisation of processes necessarily leads to a mediating function of ICT. This mediating function can only be generated and developed with the aid of competences acquired in the sector.

The production process is no longer controlled centrally but increasingly decentralised due to the networking of computers and production tools. Skilled workers are increasingly taking over more responsibility for product control. This is done with the use of ICT for logistics, material flow control, tool supply, correction of construction data, documentation of production processes, data saving and processing for quality management and much more. The applied hardware and software is generally highly dependent on the specific production processes in the automotive industry. Without a sound knowledge of the production process itself, ICT cannot be developed, used or optimised.

Two development strands can be identified in service and repair. ICT decisively dominates the functions of the vehicles through software in the control units and the application and function of service tools. While the development of ICT for vehicles is a clear-cut task for engineers with a high software competence, software and hardware service tools can only be developed and optimised in cooperation with the skilled workers.

In production, the vertical shift of tasks to lower levels comes along with the necessity of more ICT competences for skilled workers.

The networking of production has led to tasks from work preparation and design being transferred to skilled workers. These tasks require ICT competences which were reserved for engineers (degree holders) until a few years ago:

(a) use and optimisation of production planning systems (PPS);

(b) participation in the adaptation and integration of production tools in network structures;

(c) adapting of production and construction data with CAD/CAM systems;

(d) data saving;

(e) process visualisation and monitoring;

(f) computer-aided compilation of measuring data and use of the data for quality assurance;

(g) troubleshooting with computer-aided diagnostic tools;

(h) use and production or adequate adaptation of machines (HSC, CNC) with ICT interfaces,

(i) programming and/or data processing of/for production machines (HSC, CNC, rapid prototyping);

(j) adapting of software for the use in different PPS, CNC, CAD and CAM systems;

(k) adapting of databases for the saving of production process data.

Here we can talk about the new ICT paradigm, the integration of ICT into application. The skilled production worker must now acquire more ICT competences. This group has been denominated automotive experts plus ICT.

In the vehicle repair and sales sector there are tasks of putting into operation, adapting (calibration, configuration) and carrying out fault repair using ICT which cannot be taken over by ICT experts. The same is true for some areas of software and hardware development for vehicles and for tools in the product development.

ICT experts provide software and hardware solutions for a variety of sectors: for the ICT sector itself, for automotive production, for automotive service and repair. To deal with these tasks they need sector knowledge, which they try to achieve by the formation of interdisciplinary teams. With regard to development and vehicle service there are clear boundaries in some areas.

The development processes for software and hardware for the vehicles or the development of tools are so specific that information scientists often cannot deal with them. A sound knowledge of automotive technology is required and information scientists can only rarely acquire this knowledge. Even the formation of teams cannot ensure the necessary knowledge for software and hardware development. Therefore, vehicle engineers must master clear-cut user-oriented ICT competences directed at development processes.

Within the service sector, vehicle-specific ICT solutions for repair and diagnosis (workshop information systems, diagnostic tools) have to be put into operation, have to be adapted, parameterised and programmed. The required know-how is integrated into the work processes of the car workshop and the sales department and requires knowledge of vehicle specific solutions which can be realised with the aid of ICT. ICT skilled workers are not able to carry out these tasks. Mechanics and technicians employed in the car repair shop need know-how of software and hardware as an amendment or a transversal competence. In addition there are a few ad hoc tasks such as:

(a) network configuration;

(b) installation of updates;

(c) adapting software to operation system environments;

(d) configuration of interfaces for the data exchange between different software products;

(e) problem solving during communication and data transfer via networks.

In these cases the employment of an ICT expert is not profitable for SME structures with a European average of five to seven employees.

The development and installation of e-business platforms (b2x supply chain, e-collaboration, etc.), enterprise resource planning systems, web presentations and PC networks for the automotive sector does not differ from development in other sectors and remains reserved for ICT experts.

Many solutions specially developed for the automotive sector demand only slight knowledge of the sector or can be achieved with secured and documented knowledge bases. These software developments, software integrations, and network installations are realised by ICT experts who:

(a) are employed in separate ICT departments in the automotive industry (enterprises of automotive production);

(b) work in ICT service companies specialising in the automotive sector;

(c) are employed in enterprises of the ICT sector.

The increasing volume of these tasks guarantees the existence of ICT departments or ICT service providers within the automotive industry. These are the typical fields of work for ICT practitioners.

Two developments are emerging in the automotive industry which exert an unpredictable influence on ICT skill profiles and underline their importance.

The implementation of the digital factory and the continuous growth of networking technology will result in an intensification of processes of ICT diffusion in the automotive industry.

The objective of the digital factory is a continuous and integrated use of digital planning and control methods beginning with product development up to production in the form of defined workflows and based on an integrated data model. It is obvious that planning support, data integration and workflow management play a central role. The emergence of the digital factory results in intensification of network technology and hardware and software applications are becoming important drivers for the industry. If this development trend persists it will result in a clear increase in the need for ICT practitioners and ICT practitioners plus and an increasing integration of ICT applications. The automotive experts plus ICT must then not only clearly extend their range of qualifications but they must focus on the structuring of work processes.

Above all, the integration of ICT hardware and software applications will result in the fact that virtually everyone in the automotive industry will need to improve their ICT competences.

Continuous changes in the structures of vehicles and production, and the increasing integration of ICT hardware and software, require additional training measures at various levels.

The automotive sector offers a great number of ICT oriented training courses, both during initial vocational training and as continuing vocational training (CVT). The latest technological developments such as multimedia applications, the increasing number of bus systems in vehicles and production, measuring systems, safety systems, etc. act as a catalyst for training measures. The exclusively technological orientation of a great number of courses has the disadvantage that the sustainability of the explicitly technologically focused competences is very low. Such competences become obsolete with new technological innovations. Therefore we recommend that training measures should be better adapted and oriented to work processes without neglecting the technological dimension.

A major challenge is the identification of training-relevant work processes and to create an adequate and sustainable concept for competence development. The demand for quality employees calls for the creation and the use of alternative training concepts.

The manifold and increasing use of ICT in automotive production and in vehicles calls for the development of a number of skill profiles with a specific profile for each field.

As laid down in the study, the automotive sector is marked by a high permeation of ICT. There is hardly a task which does not require ICT competences. Therefore coping with tasks in a repair workshop often leads to the claim that training as an information scientist at university level (degree level) would be necessary. This demand is, however, irrelevant as it does neither deal with the development of products nor with functional details. It is moreover the basic understanding of interrelationships which have to be used for problem solving. It has to be underlined that experience knowledge (tacit knowledge) is often more important than specialised knowledge. As for the tasks in production, it is presumed that only ICT competences are required. This again is an error. Normally context-related knowledge is very important, amended by specialised knowledge. The present study, however, proves that:

(a) ICT oriented tasks can be tackled with just a few special ICT oriented skill profiles;

(b) context orientation, access to and the visualisation of vehicle-specific tasks (troubleshooting in the motor management system, quality control of the assembled vehicle, etc.) is of high relevance for a multitude of tasks. ICT-oriented tasks may be tackled from this perspective;

(c) a high number of ICT skill profiles might support Tayloristic forms of work organisation which rather reduces than improves the efficiency of an enterprise.

The findings of the automotive sector clearly indicate that a few but universally marked ICT skill profiles are preferred as they are suitable for the existing flat hierarchies (low vertical division of work) and the low horizontal division of work. Three more or less self-contained ICT profiles with a number of quality levels, and three ICT profiles with clear-cut orientation

to the automotive sector (ICT practitioner plus, ICT as transversal competence) at several quality levels are enough. In addition, traditional occupational profiles must be enriched by ICT competences and have to be completely restructured. ICT profiles with the above mentioned structure present a very distinct vertical and horizontal division of work, they support the efficiency of enterprises and open the opportunity for a joint development for ICT experts.

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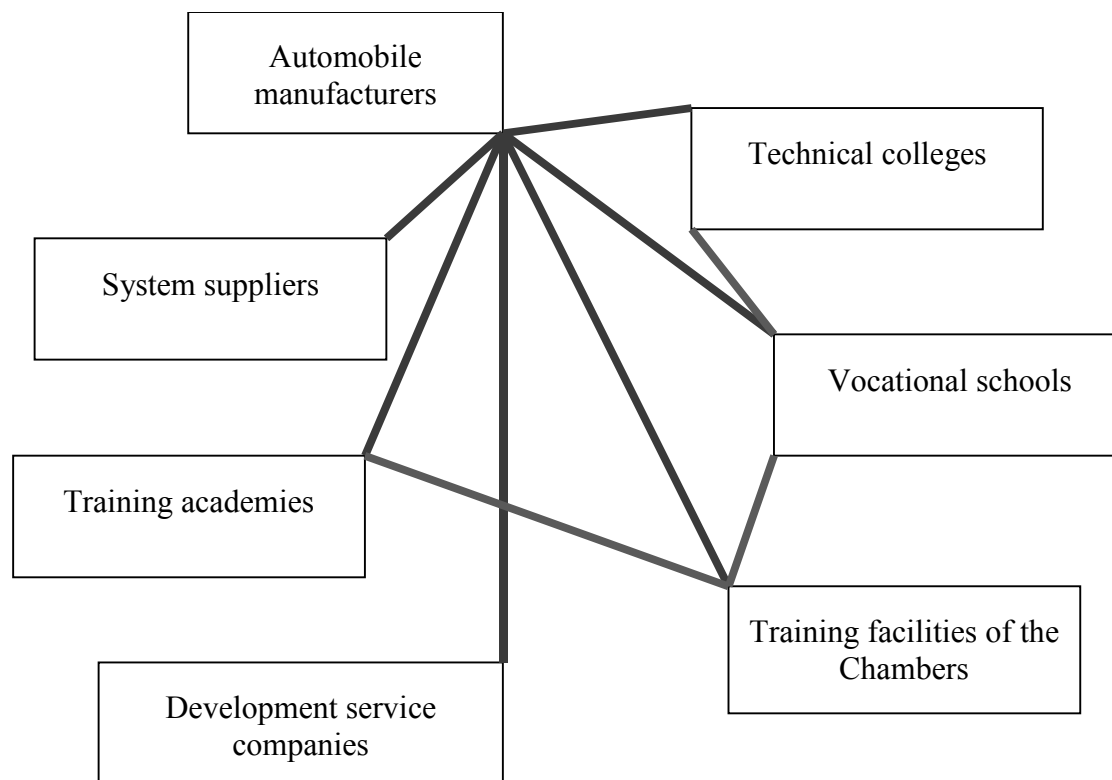
Appendix:
Cooperation in initial VET and CVT

In view of the challenges implied by information and communication technologies in the automotive industry, cooperation is one of the key factors for ensuring quality in initial and further vocational training. This includes:

- standardisation and comparability of graduation;

- financing and updating of the equipment in educational institutions;

- preparation and common use of teaching materials;

- common use of training institutions for initial and further training;

- cooperation between teachers, trainers, know-how-carriers at automotive suppliers and manufacturers;

- further training of trainers, instructors and teachers.

Across Europe, severe problems with respect to the creation of adequate learning environments can be found in initial training in the automotive sector. While large automotive enterprises and supplier companies are very well equipped in their in-firm training units, the increasing costs for ICT-dominant training contents in the automotive service are difficulty to cover without cooperation agreements. A diagnostic system/expert system from a quality manufacturer can costs as much as EUR 75 000. ICT-oriented training can thus only be ensured through cooperation between enterprises, vocational schools and colleges (see Figure 31). Automotive manufacturers who specify diagnosis and computer-aided workshop information systems in their training courses have to be aware of the implications and their own responsibilities in this respect.

Figure 31:   Network of cooperation for training offer for ICT relevant competences

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        ┌──────────────────┐
        │   Automobile     │
        │  manufacturers   │
        └──────────────────┘        ┌────────────────────┐
                                     │ Technical colleges │
                                     └────────────────────┘
 ┌────────────────────┐
 │  System suppliers  │                    ┌──────────────────────┐
 └────────────────────┘                    │  Vocational schools  │
                                            └──────────────────────┘
 ┌────────────────────┐
 │ Training academies │
 └────────────────────┘
                              ┌──────────────────────────┐
                              │  Training facilities of the │
          ┌────────────────────┐  Chambers                │
          │ Development service │──────────────────────────┘
          │    companies        │
          └────────────────────┘
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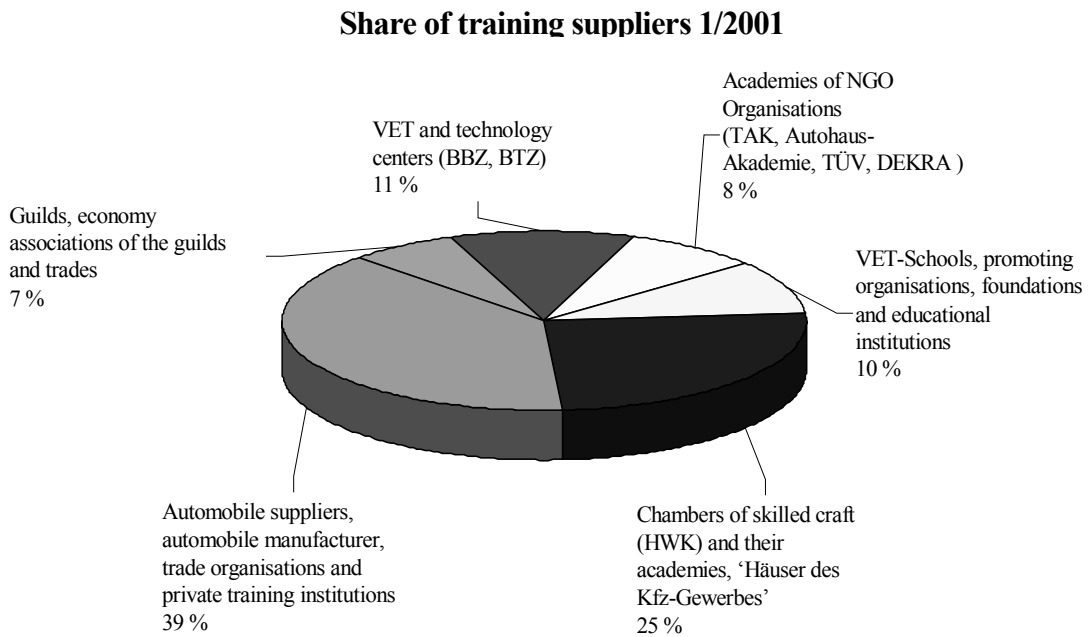
In an automotive production company, further training measures are mostly covered in-house. Development service companies are playing an increasingly important role as they offer training courses in time for the introduction of new ICT systems. Even teachers and trainers of technical colleges and vocational schools depend on such training courses.

The central associations of the automotive service sector are offering some CVT courses in their academies. In Germany, this segment covers around 40 % of the opportunities, jointly with private training providers (see Figure 32). Innovative information and communication technology is introduced for serial production at shorter and shorter intervals. As a consequence, only product courses offered by the manufacturers are available. As these offers often do not take into consideration the real work processes in the workshops during work with ICT, these courses are often not appropriate for the target groups. On the other hand the professional teaching staff in vocational schools and technical colleges are not directly involved in technological innovation and have only a limited access to this know-how in order to be able to develop training offers.

The French national association for training in the automotive sector (ANFA) provides CVT for the whole service sector in France. Each year ANFA finances 22 000 continuous vocational training courses and supplies financial and educational support for the training of 73 000 young people and 1 200 trainers.
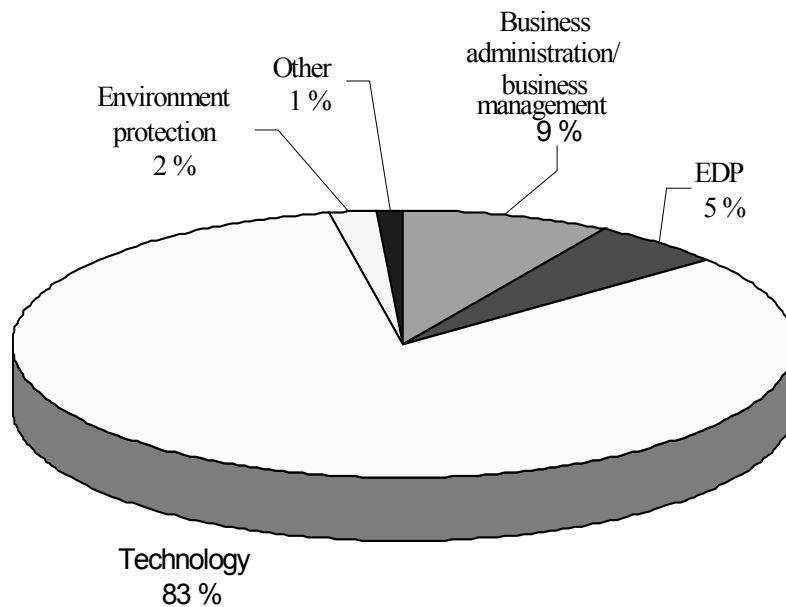
Figure 32:   CVT providers for automotive service in Germany

Share of training suppliers 1/2001

Academies of NGO
Organisations
(TAK, Autohaus-
Akademie, TÜV, DEKRA)
8 %

VET and technology
centers (BBZ, BTZ)
11 %

Guilds, economy
associations of the guilds
and trades
7 %

VET-Schools, promoting
organisations, foundations
and educational
institutions
10 %

Automobile suppliers,
automobile manufacturer,
trade organisations and
private training institutions
39 %

Chambers of skilled craft
(HWK) and their
academies, 'Häuser des
Kfz-Gewerbes'
25 %

Source: CVT database, biat

Figure 33:   Distribution of CVT offers for the automotive service in Germany in training areas

Business
administration/
business
management
9 %

Other
1 %

Environment
protection
2 %

EDP
5 %

Technology
83 %

Source: CVT database, biat

Part IT solutions are used for the training as cooperation platforms, e.g. with the in-house and interactive broadcasting at DaimlerChrysler (AKUBIS: Automobil-Kundenorientiertes-

Broadcast-Informations-System – automotive-customer oriented broadcast information system) or with the aid of distant learning (www.autotrain.org, albeit only for engineers).

Figure 34: *Distribution of CVT offers in ICT relevant technological fields for the automotive service in Germany*
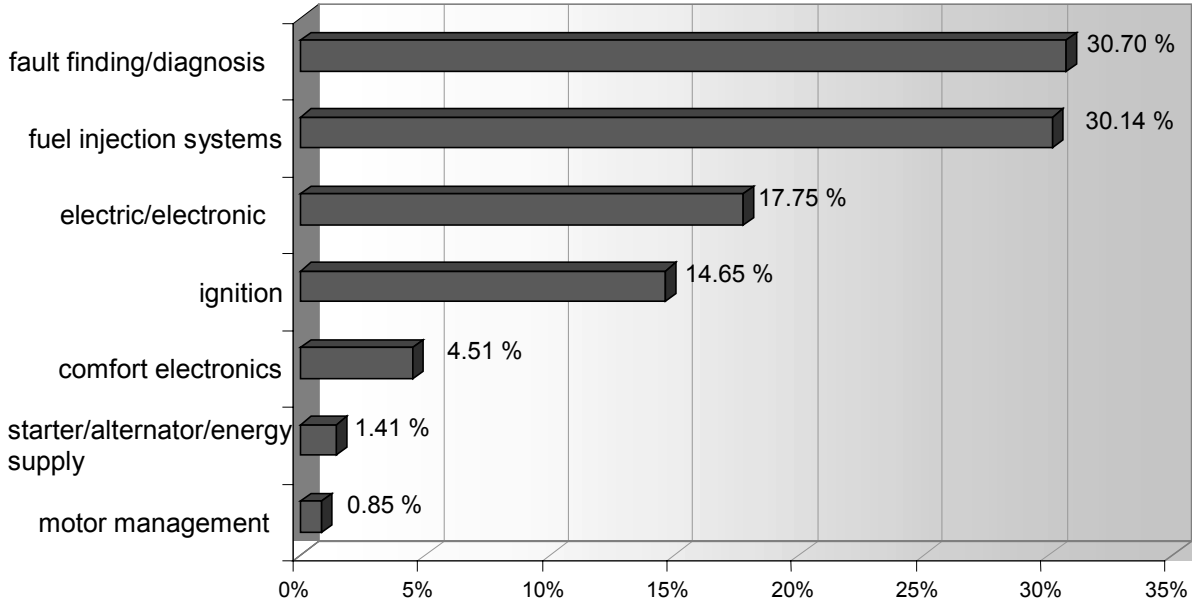
Source: CVT database, biat

Cedefop (European Centre for the Development of Vocational Training)

ICT practitioner skills and training: automotive industry

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