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# Teleservice in Industry: Requirements and Recommendations for Vocational Education and Training

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# Part I: Teleservice in Industry

## 1 Introduction

The present study is a summary analysis of *teleservice*. The term teleservice refers to the distributed installation, operation, maintenance and repair of networked mechatronic plant and machinery. The intention of our analysis is to provide a practical guide to issues regarding teleservice work organisation and techniques. The study is based on literature research, participation at relevant conferences and workshops, as well as the exchange of detailed information with teleservice providers and customers.

The results of the analysis will provide the basis for designing appropriate vocational training concepts and suitable learning environments.

## 2 Services provided by the mechanical engineering and plant construction industries

Services provided by mechanical engineering and plant construction companies traditionally involve the elimination of plant malfunctions and the performance of repairs within the scope of normal warranty agreements and warranty commitments. In many cases, the services rendered are grudgingly seen by mechanical engineering and plant construction companies as secondary, ancillary work. However, there are signs that this attitude is changing – globalisation and a growing dependence on exports on the part of European mechanical engineering and plant construction companies is producing a situation in which worldwide customer service provision to ensure plant availability is seen as an additional factor for distinguishing oneself from competitors (Hermsen/Zuther 2000, p. 5ff). This trend is reinforced by the increasing similarities between many products. The result, in markets characterised by a high level of competitive pressure, is that the decision to buy depends not only on quality considerations, but also on the level of service provided (Maßberg et al 1998).

Another factor behind the rapid rise in the importance of service is the pace at which the complexity of plant and machinery has been increasing. That pace has been significantly accelerated by the growing use of *mechatronic systems*[1]. Mechatronics is characterised by an integrated, interdisciplinary approach to project planning, design and development of complex multi-technical equipment, systems and plant (Eversheim/Schernikau/Niemeyer 1998). Quite often, mechatronic plant and systems can only be installed and operated in conjunction with support services, because they require specialist know-how and, in the case of faults or repairs, skilled customer support by the manufacturer's specialists.

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[1] The term *mechatronics* is derived from the terms MECHAnics, elecTRONics and informatICS.

In the context of these trends, service has developed from a purely technical service for customers to a discipline comprising a broad range of industrial services.

This trend has been corroborated by empirical studies for several years already. The following table shows the results of a survey carried out in 138 companies from various sectors in Germany, and published as early as 1993 (Simon 1993). It shows that services and customer orientation are considered by companies to be more important than other factors such as price, technology, etc. It can be assumed that service is considered the most important deliverable from a customer-centred perspective.

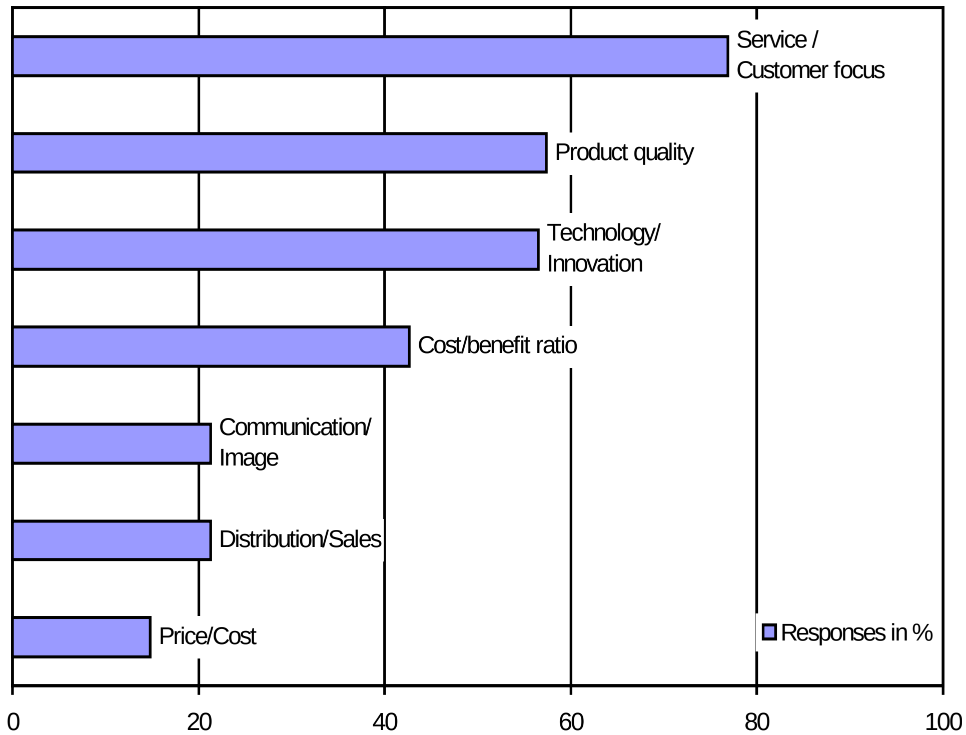


*Figure 1: Future opportunities for effective competitive differentiation in the long term (Simon 1993, p. 12)[2]*

[2] The result of a survey of 138 companies from different sectors of German industry. 30%, 23% and 22% of the companies were from the electrical, chemical and mechanical engineering industries, respectively. The remaining 25% were distributed among various other sectors.

# 3 The importance of teleservices

Against the background of the changes described in the foregoing, makers of plant and machinery increasingly realised the importance of services that enable customer proximity over large geographical distances, on the one hand, while also being practicable for the manufacturers, on the other.

Aided by the development of broadband communication networks and the growth of the Internet as a global, universally available telecommunications medium, the use of teleservice has therefore been increasing. Teleservice is primarily seen as an efficient means for remote identification of faults and errors, and for initiating the relevant action. In one survey conducted by *VDI-Nachrichten*, remote diagnosis was named as the key service of the future (see table 1). This particular survey did not yet include other forms of service support through teleservice (e.g. service hotline, advisory services, training).

| | Services | % |
|---|---|---|
| 1 | Remote diagnosis | 26 |
| 2 | Training | 12 |
| 3 | Buying and selling of used parts and machines | 12 |
| 4 | Active marketing of tools | 11 |
| 5 | Modernisation | 10 |
| 6 | Active marketing of spare parts | 9 |
| 7 | Machine hire, rental service | 9 |
| 8 | Advisory services | 8 |
| 9 | Preventive maintenance | 8 |
| 10 | Increasing personal safety | 8 |
| 11 | Service hotline | 6 |
| 12 | General overhauling | 5 |

*Table 1: Increase in importance of various services, in % (VDI 1999)*

## 3.1 Teleservice – history and definition

The origins of teleservice can be traced back to the year 1975. Kearney & Trecker, the American producer of machine tools, coined the term teleservice to describe the use of data transmission in the customer service context (Hermsen/Zuther 2000, p. 15). This involved support to eliminate faults and to service NC machines using the telecommunications technologies available at the time (slow telephone connections). With the growth of the Internet, perspectives have recently been widened as far as both teleservice in the narrower sense as well as the various fields of application are concerned. Hudetz/ Harnischfeger define teleservice as follows:

“By TeleService is meant ... the support of customer service provision by means of information and communication services and components that enable the remote diagnosis of machines and the elimination of faults. TeleService is deployed when installing and commissioning plant and machinery, when curing disruptions and for uploading new software releases. In the future, new fields of application for teleservice will also include the support of processes and the provision of advisory services to customers” (Hudetz/ Harnischfeger 1997, p. 17).

Maßberg and Hermsen describe teleservice as a service “that enables all customer contact in connection with the planning, installation and operation of plant and machinery to be carried out more simply, faster, from any place and more cost-efficiently using modern communications and information technologies, combined with multimedia tools. The prerequisite is that manufacturers, customers and the plant/machinery be extensively networked by computer” (Maßberg/ Hermsen 1998, p. 40).

To an increasing extent, network-based interaction between manufacturers and customers is seen as the key, central element in the service provision chain. The technological basis is provided by telemedia-aided tools for distributed cooperation[3], e.g. in the form of shared access by plant construction company and plant operator to machine controls, process visualisation or technical documentation. (see Fig. 2).

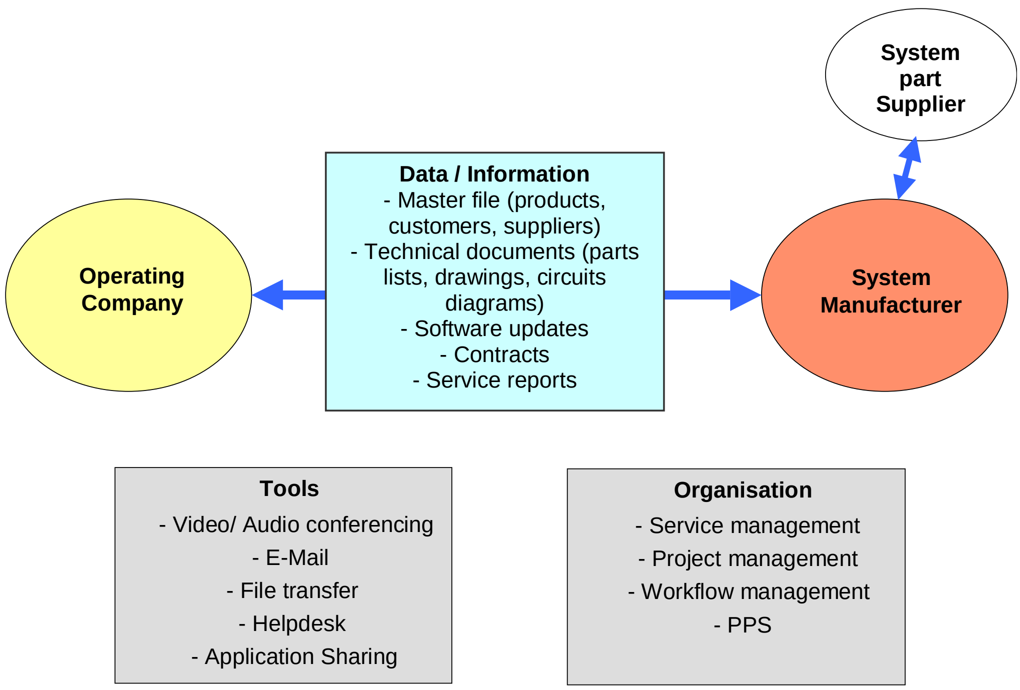


*Figure 2: Components of teleservice*

[3] Teleservice in this sense is a field of application for the Computer Supported Cooperative Work (CSCW) concept.

## 3.2 The role of teleservice in the life cycle of a plant

Teleservice is not confined to single fields of application, such as remote diagnosis and maintenance, but may cover the entire life cycle of a plant. Teleservice can essentially be used for all services in which a technical system is connected to a telecommunications network. Westkämper (1998) lists the following teleservice functions of relevance in the mechanical engineering field: (1) commissioning, (2) procuring spare parts, (3) supplying spare parts, (4) inspection / monitoring, (5) diagnosis, (6) maintenance and repair, (7) tuning machinery, (8) monitoring processes, (9) process management and (10) process tuning.

Hermsen/Zuther (2000) differentiate between different teleservices in the phases of *product development*, *production* and *assembly*, *commissioning* and *product use*. During the *product development* phase, communication between the plant manufacturer and the subsequent plant operator can be improved using teleservice, thus avoiding costly 'design loops'. A similar principle operates during *production* and *assembly*: problems that first arise on the building site in many cases can be solved by tele-cooperation. *Commissioning* can also be carried out more quickly: experts from the plant manufacturer can be integrated into the commissioning process more easily and provide support to plant operator staff on site. During the *product utilisation phase*, any disruptions that occur can be dealt with faster and more efficiently over a teleservice network. Integrating the companies responsible for performing maintenance and repair work ensures that such work is properly carried out. Improvements can be made to process optimisation, or when shutting down a plant in order to switch product, because the exchange of experience between the plant manufacturer and the operator can be designed for greater efficiency using teleservice aids. The following graph shows the main points in the life cycle of a plant where teleservice is applied.

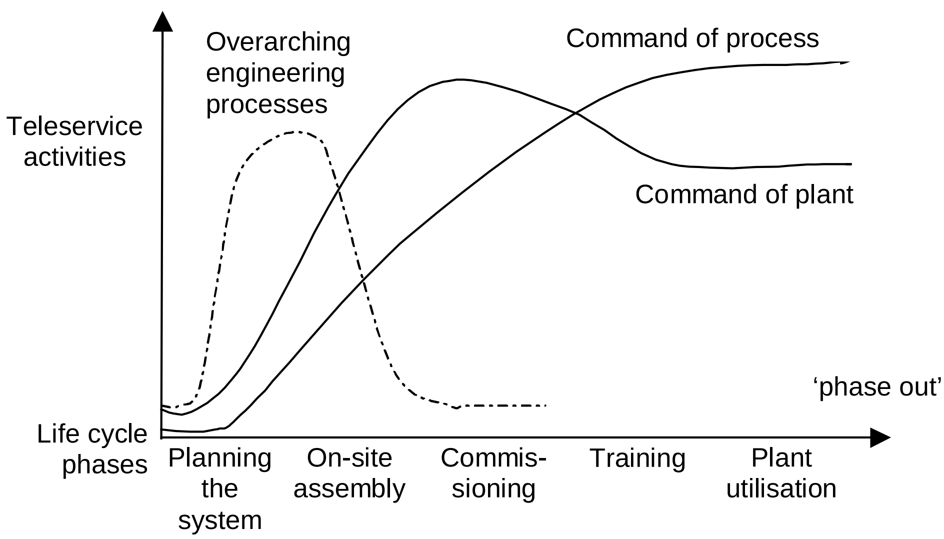


*Figure 3: Use of teleservice during the life cycle of a plant (according to Hermsen/Zuther 2000)*

Teleservices can be basically subdivided into *passive* and *active* services. Passive services encompass diagnostic or process monitoring functions that indicate, but do not modify the state of a system. Active services interact directly with the system and include, for example, remote maintenance, remote programming, process management and remote parameterisation, control and repair. Passive services are the most prevalent, due to the risk of industrial accidents and unwanted interference in the case of active services (Hermsen/Zuther 2000, p. 16).

| **Teleservices** | |
|---|---|
| *Passive* | *Active* |
| Remote recording | Remote parameterisation |
| Remote monitoring | Remote programming |
| ... | Remote control |
| | Remote maintenance and repair |
| | ... |

*Table 2: Active and passive teleservices*

## 3.3 Benefits of teleservice for producers and operators

Teleservice enables the *manufacturer* to design his services more effectively, in that skilled local workers can be supported by a central panel of experts. Aassembly at the building site, commissioning and repairs are all speeded up. Accordingly, time-consuming journeys by experts to the customer can be reduced. At the same time, communication between the manufacturer and the user of the plant is improved. This helps to reduce service costs while increasing the availability of systems. Rough estimates indicate that 20 to 30 percent of after-sales expenses can be saved using teleservice (Hudetz 1997, p. 33).

For *plant users*, down-times of machines can be shortened by means of teleservice, because maintenance work, remote diagnosis and fault elimination can be carried out faster. In particular, there are no long periods spent waiting for service specialists to arrive. Because teleservice essentially enables simpler access to the manufacturer's know-how, the productivity of the machinery user increases accordingly.

| Operator | Manufacturer |
|---|---|
| Long-term reduction of operating expenses<br>Reduction of machine down-time<br>Increased availability of plant<br>Minimal service expense beyond warranty<br>Support during commissioning phase<br>Individual support with process implementation and modification<br>Simple uploading of software updates<br>Enhancement of in-house competence to solve problems<br>Increased satisfaction of employees by expand-ing the knowledge base and broadening the range of tasks performed<br>Internal training of employees<br>Greater focus on supplier company | Cost reduction (personnel and travel expenses)<br>Increased availability of specialists within own company<br>If necessary, the right specialist can be sent to the customer's site<br>Optimisation of service structures<br>Improvements to service efficiency<br>Greater transparency of service procedures<br>Customer ties are intensified<br>Competitive leads are generated<br>Presence in distant economic regions<br>Increased level of service performance<br>Reduction in response times<br>More detailed information on plant disruptions are used to achieve continuous improvement |

*Table 3: Benefits of teleservice for manufacturers and operators (from Hermsen, Zuther 2000, p. 19)*

As part of the 'Multimedia TeleService' research project (Maßberg/ Hermsen/ Zuther 2000), a number of companies were surveyed about the potential savings that can be achieved by using teleservice. The following diagram illustrates the results of the survey:

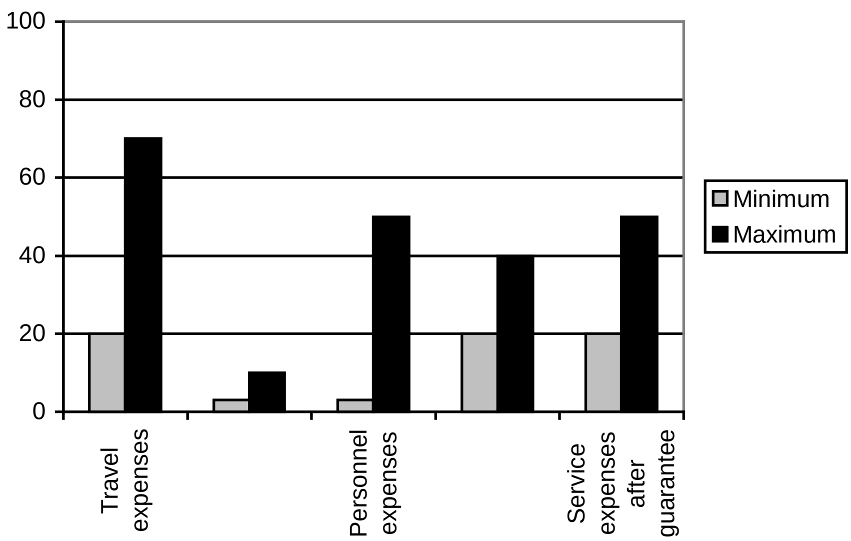


*Figure 4: Estimated savings potentially obtainable with teleservice (Schaub/Hermsen/Spiess 2000, p. 41)*

# 4 Teleservice data exchange

## 4.1 Relevant data for teleservice

In order to function properly, teleservice requires a good basis of data, including master and diagnostic data. Master data contains information on the manufacturer, customer, suppliers, the plant and the history of orders. Direct access to master data is the basis of teleservice provision. Continuous documentation of all service occurrences enables data to be searched and makes it easier to solve current problems. Diagnostic data contains information describing the state of a plant, of components and/or a process. They include machinery data, process data, status and error messages, sensor data, etc. Data for plant control include, for example, control programs, system programs or control/adjustment parameters. The data that have to be exchanged give rise to requirements that the machinery manufacturer and the operator must meet in respect of the availability, capacity and resources of their communications and IT components.

The requirements that have to be met by the teleservice and the associated exchange of data vary considerably depending on the specific field of application:

In *mechanical engineering*, visual inspections of machines and plant components play a key role. Video transmission of moving pictures and stills, as well as the exchange of visualisation data (e.g. of pressure and temperature changes over time) are important in this context.

In *control engineering*, visual control has only secondary importance, in contrast to mechanical engineering. Instead, what is important is access to particular control systems in a plant and to the malfunction logs. Accordingly, access to the control systems and appropriate access to and exchange of data must be provided.

*Production engineering* and *process engineering* are two areas in which optimal adjustment of the production process is monitored with regard to production targets (speed, quality, costs). Monitoring processes via teleservice therefore means that different requirements have to be met compared to the monitoring of control elements.

The following table, adapted from Westkämper (1998a), provides an overview of various teleservice functions and data in the mechanical engineering field:

| | | 1. Commissioning | 2.Identification of spare parts | 3.Ordering spare parts | 4.Inspection/ Moni-toring | 5. Diagnosis | 6. Maintenance | 7. Machine tuning | 8. Process monitor-ing | 9. Process man-agement | 10. Process tuning |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Still pictures** | **->** | o | + | | | o | o | | | | |
| | **<-** | o | + | | + | + | | | | | |
| **Moving pictures** | **->** | | | | | o | + | o | | | o |
| | **<-** | o | | | o | + | o | + | + | + | + |
| **Voice** | **->** | + | o | | | + | o | + | | | + |
| | **<-** | + | o | | | + | o | + | | | + |
| **Sensor data** | **->** | | | | | | | | | | |
| | **<-** | o | | | + | + | | + | + | + | + |
| **Control data** | **->** | | | | | | + | + | | + | + |
| | **<-** | | | | + | + | | + | + | + | + |
| **Administrative data** | **->** | | | + | | | | | | | o |
| | **<-** | + | + | + | | | | | | | |
| **Tech. Docum.** | **->** | + | | o | | + | + | + | | | o |
| | **<-** | | | | | | | | | | |

-> to operating company, <- form operating company, (o = useful, + important)

*Table 4: Teleservice functions and data (from Westkämper 1998a)*

## 4.2 Diagnosability of plant and components

One prerequisite for teleservice is that the respective plants, machines or components be diagnosable. In order to diagnose malfunctions, it is essential to have online access to as much internal control data as possible, such as

- inputs/outputs
- data fields (settings, machine parameters, tool parameters ...)
- control programs and their respective statuses
- editing programs (NC programs)
- bus configuration, bus information,
- data from decentral components, and
- log data (error messages, etc.)

Where relevant, these data must be supplemented by audio-visual data showing the process and plant environment. This data access requirement is the reason for using machine components with appropriate hardware and software interfaces, open control design and a communication network with the requisite capacities.

Analysing malfunctions in a complex plant is a complicated business in many cases: detailed knowledge about the process, the plant and its components are necessary. Faults and malfunctions can be classified into various groups:

- systemic errors (cause is located in the plant/components)
- process errors (technological errors affecting the plant)
- operating errors (operating, input errors).

# 5 Basic technologies and standards

## 5.1 Open control structures in automation engineering

Teleservice is based on a constant flow of information between the process itself and the human-machine interface. The human-plant/machine and human-process linkage points are particularly important. It is via these linkages that a human agent can intervene in a system or a process. Based on this fundamental principle, a typical structure has developed within industry that comprises three relatively independent and hence separately operable levels:

- the plant management/factory level: WAN (Wide Area Network)
- the process management/cell level: LAN (Local Area Network)
- the field level: FAN (Field Area Network)

The networks and buses for these levels have been standardised to a large degree. The following diagram shows the structured levels for communication systems[4].

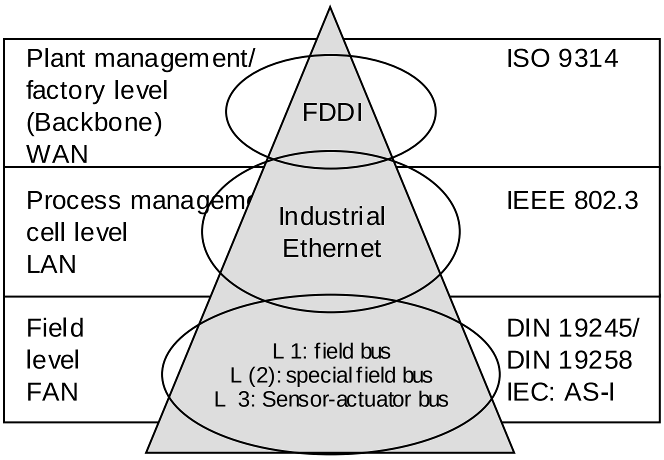


*Figure 5: Multi-level communication (Kriesel/Telschow 2000, p. 211)*

In recent years, 'Industrial Ethernet' has become increasingly common at the process management level. Industrial Ethernet is an Ethernet system with the following characteristics:

- industrial-standard cables and connectors,
- industrial-standard switching modules,
- compliance with industry requirements regarding ambient conditions and fail-safe operation,
- fast, almost deterministic response times (unlike classical Ethernet),
- use of switching technology.

[4] The level-based structure for communications systems must not be confused with the 7-layer ISO/OSI reference model that at the time provided a framework structure for any bus system (Kriesel/Telchow 2000, p. 211).

Automation experts assume that Industrial Ethernet will quickly assert itself as far down as the field level, and that it will take over functions normally performed by classical field buses. Industrial Ethernet provides a high level of support to standardised communications solutions, from the sensor/actuator level to the Internet, thus facilitating the implementation of teleservice functions in heterogeneous automation settings.

Within this context, leading German automation companies have come together in the *IDA* initiative (Interface for Distributed Automation). The aim of *IDA*, besides improving collaboration of industrial installations, is to enhance 'machine intelligence' – modular entities in the factory, such as control units, operating equipment, drive systems or robots, are to be capable of cooperating autonomously. At present, such cooperation is organised by central control computers at the middle MES (Manufacturing Execution System) level. In future, these MES controller computers will disappear and the respective functions will migrate to the lower field levels where machine control is located. The field level will then be able to interact with the 'Enterprise Resource Planning' (ERP) software itself. The basis for such interaction is provided by the *IDA* standard. It describes a real-time communications structure linking the controlling computers, on the one hand, and providing standardised interfaces for applications, on the other hand. The *IDA* Group uses standards and protocols from the IT world, but adapts them to industry-specific conditions. Some manufacturers are now installing the first *IDA*-compatible control systems in their machines, and the US standardisation body Iaona (http://www.iaona.com) intends to adopt parts of the *IDA* standard later this year (See *Computer Zeitung* 2001, Issue no. 20, p. 14).

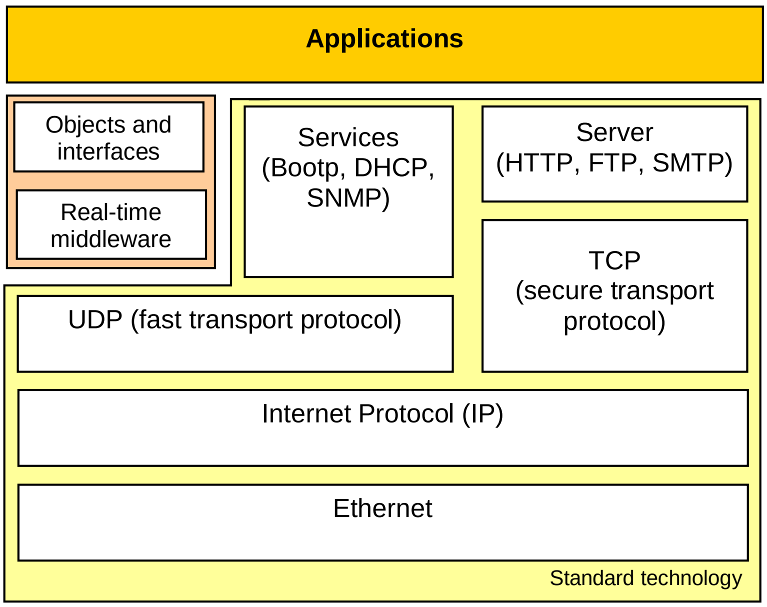


*Figure 6: Structure of the IDA standard (Source: IDA)*

The trends in automation engineering described in the foregoing make it easier to implement open systems for control, in terms of both the internal and external openness of machine control systems (see Table 5). This, in turn, will foster and speed up the spread of teleservice in practice.

| **Internal openness** | **External openness** |
|---|---|
| Open software interfaces (open both to the process and to the human-machine interface)<br><br>Configurable hardware and software | Programs compliant with standards<br><br>Standardised communications interface<br><br>Integration within IT environment |

*Table 5: External and internal openness of machine control systems*

## 5.2 OLE for Process Control (OPC)

OPC (OLE[5] for Process Control) has become the established standard in the applications layer for the exchange of production data using Ethernet-TCP/IP. Originally developed for linking operating interfaces and software tools like SCADA[6] or production control systems to controllers and network cards, OPC is also being used to an increasing extent to regulate the exchange of production data over Ethernet-TCP/IP.

The OPC standard mainly defines a functional interface between two software systems. A production data server – also termed an OPC server – provides a methods interface that must be operated by a data user, the OPC client. Such a methods interface is then implemented on top of a (semi-) standardised component model such as CORBA[7] or COM, which regulates communication between two software systems. By implementing the OPC standards on the OPC server and the client side, a vendor-independent link is created between two software tools.

If the component model supports Remote Procedure Calls (RPCs) – i.e. enables server functions to be requested by a client over Ethernet-TCP/IP – then OPC also provides the option of exchanging production data over Ethernet-TCP/IP. Many

[5] In the Windows operating system, OLE (Object Linking and Embedding) is the interface for the internal exchange of data between objects in different Windows applications, thus enabling such objects to be linked and embedded. OLE technology is based on (D)COM ((Distributed) Component Object Model), which enables the (distributed) handling of objects. ‘ActiveX’ is the general term embracing the OLE/COM/DCOM family of technologies.

[6] SCADA (Supervisory Control And Data Acquisition): systems for process visualisation and control.

[7] CORBA (Common Object Request Broker Architecture) is a component of OMA (Object Management Architecture) and specifies the creation and use of distributed objects. There are many CORBA-compatible applications owing to the possibility of using different platforms. For example, CORBA-compatible objects in the Internet can be addressed in WWW browsers using IIOP (Internet Inter-ORB Protocol – a component of CORBA).

different companies are now marketing OPC servers and clients based on the DCOM (Distributed Component Object Model) that forms part of the Windows operating system. Such systems enable an item of process data to be used on any Windows platform at any company location over the corporate Intranet or even the Internet.

## 5.3 CANopen

CANopen[8] is gaining in importance as a new technological standard for networking controllers at field level (see CiA). CANopen can be viewed as the further development of first-generation field bus systems. Many of these bus systems are based on a Single Master structure. In order to regulate data transport on the bus, it is necessary to have a central governing instance called an ‘arbiter’. In the classical control architectures, this is implemented in the controller. The existence of a central arbiter generates enormous obstacles if the aim is to have independent, decentral entities and to network, autonomously plan, operate and commission them without a central controller.

CANopen overcomes these obstacles and paves the way for decentralised automation. It does so by taking the central arbiter and distributing it across the network at every single network user’s workstation. This is made possible by the arbitration mechanism known as CSMA/CA (Carrier Sense Multiple Access with Collision Avoidance). By using this message-based, prioritised collision avoidance method, each network participant may actively request permission to broadcast.

CANopen thus becomes a multi-master network. It is now possible, without having to have a central controller or a central arbiter, to form functional units comprising several CANopen participants and to plan and launch these separately. It is now easier than it previously used to be to form modules by distributing controller functions at the field level, and to create communication ports for teleservice down to the field level.

[8] CAN (Controller Area Network) was originally developed by Bosch and Intel for fault-free networking in road vehicles (Kriesel/Telchow 2000, p. 215).

# 6 Sample tools and systems

## 6.1 Basic teleservice requirements

The structure and functionality of teleservice systems are derived from the requirements of teleservice providers and users, as described in the preceding sections. Accordingly, teleservice systems are predominantly used on mobile systems operated by service technicians and in cooperation between several partners (manufacturer/customer, manufacturer/supplier/customer, manufacturer consortium/customer, etc.).

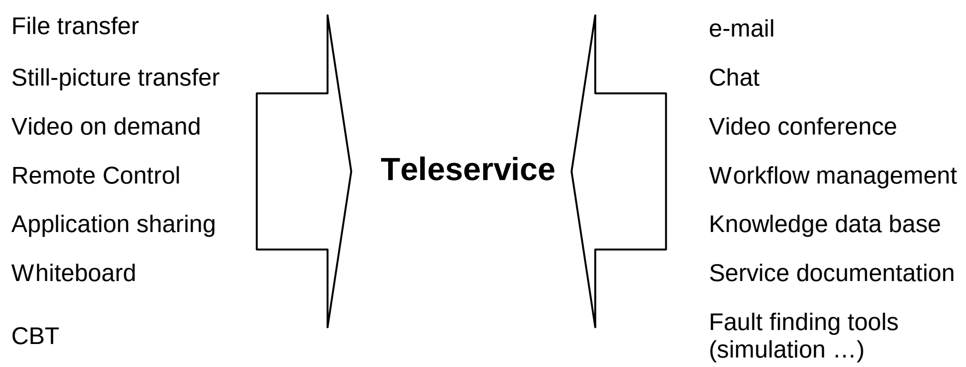


*Figure 7: Basic teleservice functions/tools*

The basic functions of teleservice systems (see Figure above) can be easily achieved nowadays with conferencing systems or application sharing software (NetMeeting, pcANYWHERE, etc.). Special systems are needed to perform complex functions. Two examples of teleservice systems are described in the following.

## 6.2 Teleservice system 'TeLec'

A teleservice system for stationary machine tools and plants was designed in a research project entitled 'Multimedia TeleService (TeLec)' and implemented in the form of a prototype (Maßberg/ Hermsen/ Zuther 2000). The following diagram shows the structure of the system.

The TeLec system is modular in structure and designed for different organisational environments (manufacturers, operators, service technicians, etc.). The manufacturer system has the greatest functional scope. In addition to a communications switchboard, this particular module also provides functions for administration, evaluation and forwarding of service jobs. The operator system is limited to communication, diagnostic and data procurement functions, but can be extended if required and provided personnel with the relevant skills are available.

For service technicians in the field, the TeLec system provides a mobile client. This enables both access to the manufacturer and the operator system (access to plant, with additional audio and video components). In addition to standard functions, the software is also divided into four basic modules that are logically connected with each other: TELservice, TELstamm, TELreports and TELflow (see Figure).

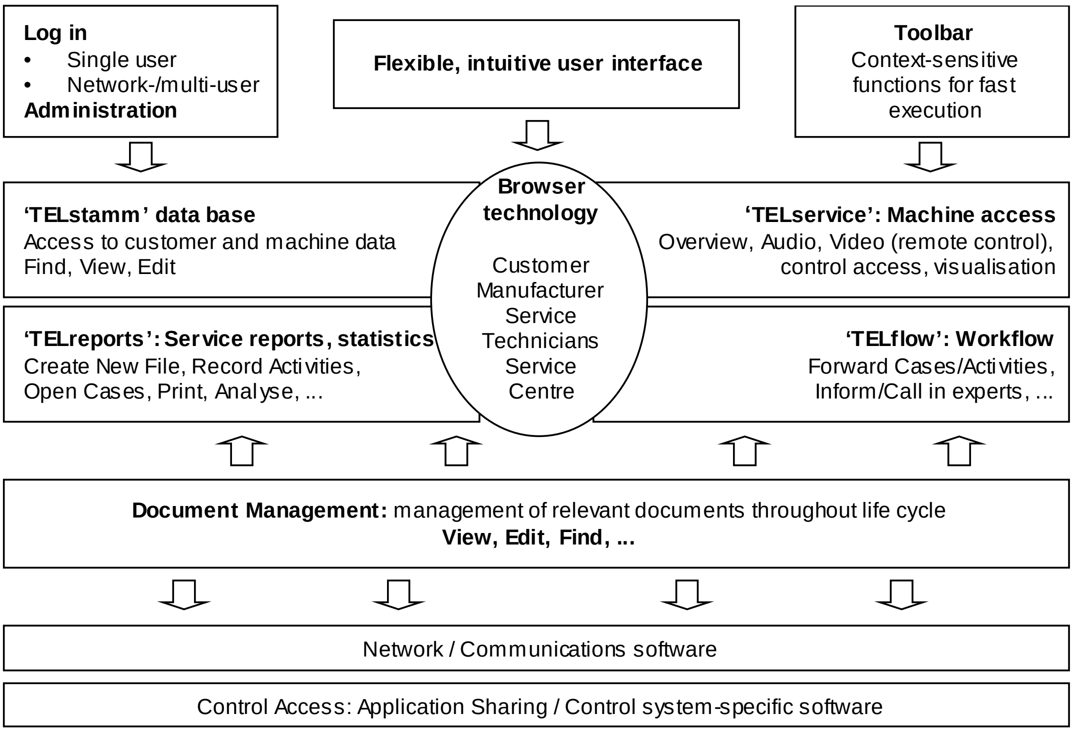


*Figure 8: Structure of the modular TeLec system (adapted from Zuther 2000, p. 80)*

The main functions of the modular TELec system are, of course, to support core teleservice functions, such as video/audio transmission, establishing connection to remote control systems, or process visualisation. The software supports the H.320 (ISDN), H323 (LAN) and T.120 (Application Sharing) communication standards. The data used for connections or for selecting the transmission medium (POTS, ISDN, satellite, Internet, GSM, ...) are included within the system. A remote-controlled camera can be used, if so required. The functions for audio and video transmission are based on the systems made by AlgoVision Systems GmbH, Bremen. Algovision has launched a mobile, notebook-based teleservice system with analogue functions that is used by teleservice users (www.algovision.de)

*Figure 9: Notebook-based teleservice system from Algovison*

## 6.3 IPK machine diagnosis system

The technical status of teleservice systems is now relatively advanced, as shown by the following plant configuration developed at the Fraunhofer Institute for Production Plant and Design Technology in Berlin (IPK 1998). This is an Internet-based machine diagnosis system for servicing production plant.

The application is aimed at implementing distributed software objects in the memory of an ‘intelligent’ drive computer, in order to provide PC-based visualisation devices with consistent access to configuration parameters of the drive. The benefit of such a configuration is that specific visualisation functionality is available in the memory of the automation components. Access to these components is effected in a standard manner for each system using a load routine available on a visualisation platform (PC, workstation, etc.). This distribution of software enables a service technician with a basic device, for example a PC notebook, to address components of the machine or plant without first having to check whether specific software necessary for data access is available on his computer. The diagnostic functionality is extended in this drive system by functions for automatically notifying about malfunctions on the displays of mobile telephones (D1, D2, E-Plus networks) using the ‘Short Message Services’ standard (SMS), and on so-called ‘pagers’ (e.g. Scall).

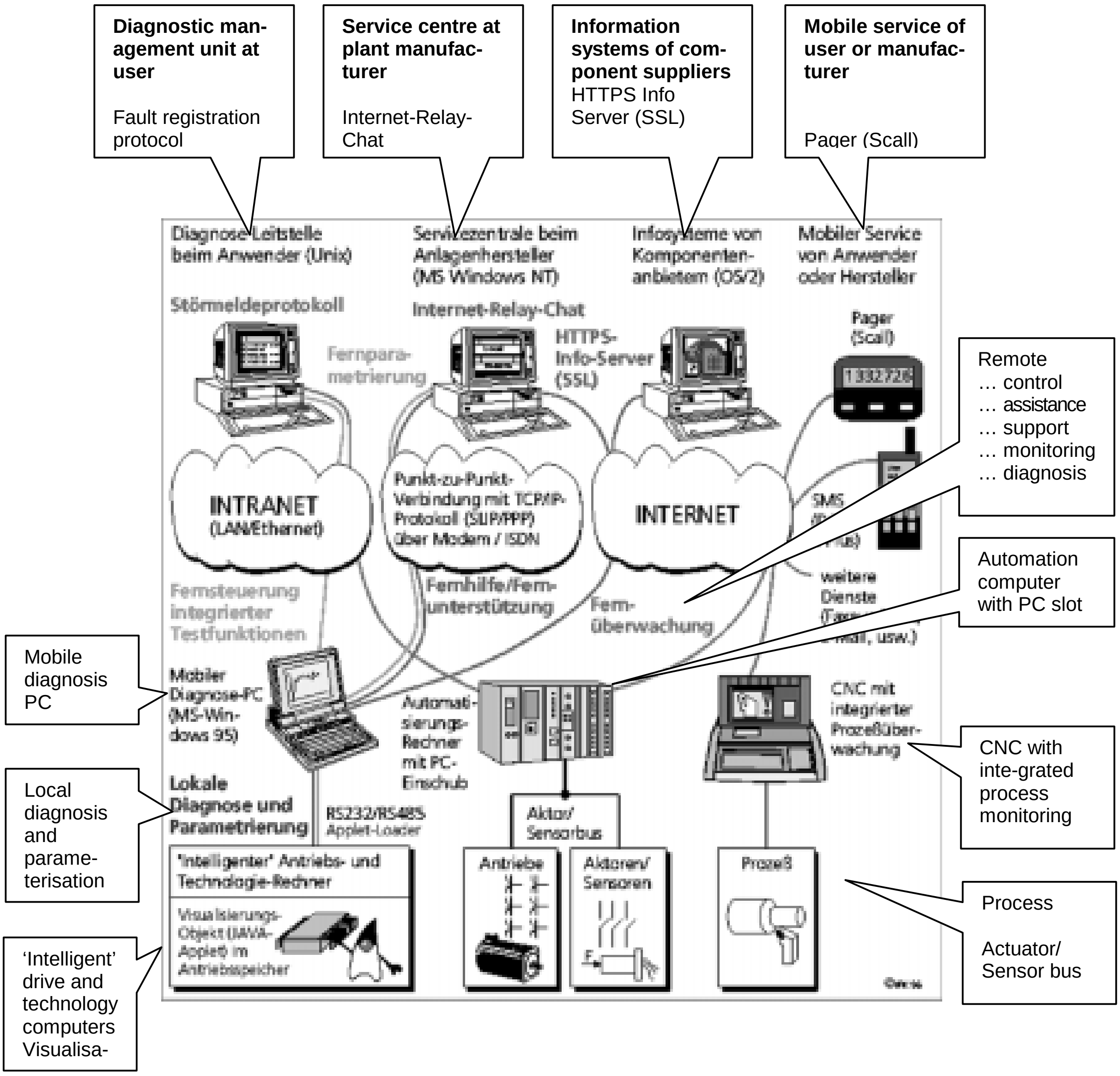


*Figure 10: Telemedia machine diagnosis system (IPK 1998)*

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# 8 Appendix

## Multimedia-based comunication technologies in teleservice - basic functions

*File transfer*

The ability to transfer data between two members of a network is an elementary function in communications technology. In the teleservice context, program code is often transferred by control systems, mostly in order to load a new version (update) of a program into a control system. Technical documents (e.g. drawings, service instructions, electronic manuals, etc.) are exchanged by file transfer.

*Still-picture transfer*

Transferring still pictures is basically only a special form of file transfer. In this case, the file is a still. In the teleservice context, the picture may be a photograph of a particular detail on a machine, visualising the condition of a faulty plant

*Remote Control*

Various objects can be subjected to *remote control*: e.g. cameras, single programs, or an entire plant. Other activities can also be triggered remotely – for example, it makes sense in teleservice to request a still picture from a remote system and to transfer that picture for precise analysis.

*Application sharing*

In Application Sharing, two geographically separated users work on a file using the same application. The file and the application in question exist physically on only one of the two communicating computers, but are displayed simultaneously on both. Modifications to the file can be seen immediately on both workstations. In teleservice, *Application Sharing* is used, for example, to troubleshoot for errors in control programs and to correct those errors once they have been detected.

*Whiteboard*

A whiteboard is an electronic board on which geographically separated communication partners can write and draw. A whiteboard is a useful facility in teleservice wherever problems are to be raised and jointly discussed on the basis of a sketch (e.g. manufacturer and operator of a plant are looking for a fault on the basis of a sketch of the plant).

*Chat*

The Chat function enables different communication partners to exchange short messages directly. These messages are displayed on the monitor screen. This enables a dialogue to be conducted – albeit in very reduced form.

# Part II: Training for Teleservice

## 1 Introduction

One important objective in the RADIO project is to develop and test new learning concepts for telemedia-aided maintenance and repair of complex mechatronic plant and networked production facilities (teleservice). In the present study, vocational training concepts for the teleservice field are presented and explained. Against the background of experience gained in the RADIO project, we describe practical examples and provide recommendations on how distributed learning between different groups or locations can be realised in vocational training on the basis of telemedia-aided learning (‘Remote Action’).

## 2 New training needs in the service field

### 2.1 New work content

Numerous studies have shown that, in the future, telemedia-based work systems will be enormously important in the context of geographically distributed commissioning, installation, maintenance and repair of plant and machinery. Remote maintenance, telediagnosis, remote support, maintenance and repair are all catchwords for the various concepts that are generally subsumed under the term *teleservice*. Besides new technical concepts, teleservice involves a modified service organisation due to the use of telemedia-based systems.

Before teleservice functions can be exploited, the skilled personnel employed in this environment must conform to a skill profile with many new elements. Service experts assume that, in the teleservice sector, not only engineers but also technicians and skilled workers will need new, additional skills and qualifications (see Schmidt 1999, p. 18). The first to be affected are service experts in the field of mechatronic systems and plants, because in many cases, due to their complexity, these can only be installed and operated in conjunction with support services[9].

As teleservice becomes increasingly important, there is also a growing need to train employees in maintenance departments, in production, in customer service and in other fields. In initial and continuing vocational training, therefore, it is

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[9] With the definition of the occupational profile for *mechatronic technicians*, a new vocationally trained occupation was established in Germany in 1998 to cover this particular range of tasks. Training for this occupation is centred on MECHAnics, elecTRONics and informatICS. According to the framework syllabus, the required knowledge and skills are not to be conveyed in isolation from each other, but in an integrated manner that gives special consideration to the fostering of occupational competence (see framework syllabus, 1998).

essential to train not only the competent use of teleservice technologies but also their implementation.

Proceeding on this basis, relevant literature and pioneering approaches were evaluated as part of this pilot project with regard to new training requirements. One key source of information was the 'Multimedia TeleService' research project (Maßberg/ Hermsen/ Zuther 2000), which was conducted on behalf of the Federal German Ministry for Education and Research, with involvement by research institutes and major industrial enterprises. Further pointers were obtained from other key publications (e.g. BMWi, Reichwald/ Möslein 1997, Schmidt 1999, Westkämper 1998a, 1998b). The current status of teleservice among professional users and manufacturers was also explored[10] in order to obtain specific information about skilling requirements in the teleservice field (see overview in the Appendix). The outcome of this analysis is summarised and discussed in the following section, in four separate points and with specific reference to occupational *competence*.

## 2.2 Occupational competence in the teleservice field

Occupational *competence*[11] is a multi-dimensional concept based on the assumption that different sub-competences do not exist in isolation from each other, but are always networked with each other (see Laur-Ernst 1984). In relation to activities in the teleservice field, the following fields of competence can be identified as being of central importance:

1. Professional competence in the mechatronics field
2. Professional competence in the telemedia services field
3. Tele-cooperation competence
4. Foreign language competence
5. Intercultural competence
6. Customer focus

*1. Professional competence in the mechatronics field*

Professional competence in the field of mechatronics is the basic foundation for teleservices. This type of competence generally relates to the assembly and maintenance of complex machines, plants and systems in the field of plant construction and mechanical engineering, and in the companies that purchase and operate such mechatronic systems (for an overview, see for example the training profile for mechatronics technicians in the Appendix).

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[10] To prepare for the visits to users of teleservice, a set of guiding questions were developed (see Appendix).

[11] By occupational competence is meant "a person's being able and prepared to act in occupational situations in an appropriate, expert manner following due personal reflection and with a sense of social responsibility" (Bader 2000). In the debate over modern forms of initial and continuing vocational training, fostering occupational competence has become a core aim of vocational training and education (in Germany).

*2. Professional competence in the telemedia services field*

Service activities have always been an important element in plant construction and mechanical engineering. What is new is the application of teleservice systems for error analysis and possibly for helping customers to help themselves. The plant construction company (and to a certain extent the user of such plant) needs trained personnel that possesses not only traditional service know-how, but is also able to handle telemedia systems for diagnosis, maintenance, monitoring and repair. As far as service know-how in the narrower sense is concerned, the following are important areas of skills:

- knowledge about potential and probably causes of malfunctions in mechatronic systems (thinking in terms of cause-effect chains)
- knowledge about system-related service procedures.

In order to handle service tasks in the telemedia environment, the teleservice expert must also be able to combine classical service know-how with knowledge about telemedia technologies. The main aspects here are:

- installing and using teleservice systems, service software and remote diagnosis systems,
- creating and operating communication access points,
- acquiring data for teleservice purposes,
- providing teleservices in different network and communication structures.

Teleservice tasks are more complex than conventional servicing, in that teleservice experts must also have a command of telemedia technologies in addition to traditional service technologies. As in other IT professions, skills such as networked thinking or systemic thinking are gaining in importance within the complex formed by traditional service technologies and telemedia environments. Systemic thinking involves handling both “indeterminateness and complexity” (Dörner 1995) as well as problems that are bound up with side-effects and remote impacts.

*3. Tele-cooperation competence*

In contrast to ‘traditional’ skilled maintenance workers, personnel in teleservice are deployed in a relatively broad range of activities that also spans different sectors of industry. They typically work in locally distributed teams and coordinate their work amongst themselves: “In this occupational field, users and appliers use ... their ability to achieve objectives in (tele-)cooperation with others, and to cooperate in virtual and supranational forms of organisation” (BMWi, p. 89). Telemedia communicative competence means being able to overcome communication problems and loss of information due to disorganised or incomplete data and information. This requires not only competent handling of telemedia systems for diagnosis, maintenance, monitoring and repair, but above all the ability to communicate effectively with others (e.g. customers, users, appliers) with the help of computer-aided means of communication. Skilled teleservice workers must solve the ‘mutual knowledge problem’, for example by integrating the know-how of others in order to accomplish the set tasks using appropriate aids (e.g. electronic conferencing or groupware systems). Special focus must be placed on the option of accessing distributed information from suppliers, customers and manufacturers over the Internet. What one finds in practice are different variations of the service process (structural and workflow organisation) using different tools.

*4. Foreign language competence*

In the provision of teleservices, the human being remains the central and most important element of the entire service process, and clear communication between those involved in teleservices is the most important prerequisite for a successful service process. Besides normal communication problems, one should not under-estimate the role of language barriers that may arise when performing teleservices.

Language problems may be inevitable in certain service situations. A typical tele-service situation might be the following: experts from the German company that manufactures a complex production system, on the one hand, and skilled workers and engineers at a Korean operator company, on the other hand, are communicating with each other between the two countries about how to solve a service problem. They use a videoconferencing system to communicate. A skilled worker or engineer in Germany cannot be expected to understand Korean. Nor can the skilled workers in Korea speak German. They have to try and communicate in English. Although there is the option of calling in an interpreter to help, this is usually very difficult to arrange in practice, because in many cases the interpreter does not have the specialist knowledge relevant in this situation, with the result that misunderstandings arise during such communication. Good training in foreign languages, especially in English, seems imperative in the context of globalisation. This is also true today for skilled workers in the service field.

*5. Intercultural competence*

In addition to adequate foreign language competence, ‘intercultural competence’ is also important in order that service personnel be aware of cultural differences between European and other countries, for example in Asia or South America.

*6. Customer focus*

Because teleservices are primarily immaterial, the quality assessment made by customers is highly dependent on those employees who perform such services. For this reason, skilled teleservice workers must also be trained in customer orientation – to a greater extent that production workers, for example. Such training mainly focuses on communication training and customer-centred action.

To summarise: in addition to system-related and technical know-how, teleservice particularly requires occupational competence, also referred to as *non-technical skills*.

# 3 Learning concepts

## 3.1 Didactical principles

The educational concept in RADIO is geared to a learning concept that is based for its part on the following didactic principles or premisses. These are: (1) action orientation, (2) teamwork, (3) focus on business/work processes, (4) focus on customer orders and (5) focus on design.

*1. Action orientation*

The didactic principle of action orientation applied to vocational training – also to formal, school-centred learning: learning and work assignments should be so designed that active actions and activities on the part of learners are initiated and fostered. The range of action extends from involvement in specifying the task set, (co-)planning the project mission, working on the project without supervision and in a cooperative spirit, up to and including the evaluation of the project outputs.

*2. Teamwork*

Teamwork is the core element of teleservice. The ability of students to work in teams must therefore be fostered and trained. However, since teamwork or the ability to work in teams can only be experienced and practised within a system that is itself organised in a team-centred manner, organisational structures in the school context must be so designed that teamwork is both transparent and possible for the learners concerned. Due to the fact that learning and cooperation do not come about automatically, schools and instructors have to strive for and accept an experimentation stage. This enables the initiation of development processes that lead from the prevailing 'go-it-alone' mentality to cooperative forms of working and teaching. These forms have to be provided in a different context that the familiar, mono-disciplinary and systematic context, and conveyed to students using methods that stimulate motivation. This necessitates the formation of teams, interdisciplinary cooperation, and the performance of project work.

*3. Focus on business/work processes*

Unlike the situation in the traditional service organisation, in which separate functional entities (individuals or departments) were designated and responsible for the outputs from those entities, in teleservice all those involved in the processing of orders are responsible for achieving successful results and a high level of customer satisfaction. The responsibilities for a particular set of tasks is therefore overlapped by this shared responsibility for achieving the objective of an overall business process. For vocational education and training, what this means is that priority must be attached to knowledge of the interrelationships in the business and work process, and that all specialised knowledge is conveyed in relation to its particular context.

*4. Focus on customer orders*
The focus on customer orders is the term given to a didactic principle, according to which the occupational learning process is centred on real orders in the operational context. The objectives pursued are:

- to sensitise trainees for quality, customer-centred work,
- to enhance the sense of responsibility for one's occupational activity,
- to acquire knowledge and occupational competence in the overall context of a real or semi-real assignment.

*5. Focus on design*
Competence in design is expected of employees to an increasing extent. The prerequisite for conveying design competence is that learners be confronted, at an early stage in the action- and project-centred learning process, with the technological and operational scope for action and design that they are increasingly expected to exploit in a world where corporate organisation is continually developing.

Design-centred training does not reduce a particular learning task to a predefined specification for which solutions can only be confirmed as correct or wrong. Instead, design-centred learning involves open assignments of practical relevance in which it is possible to discuss what the most expedient solution would be. Only then is it possible, within the learning process, to weigh up different solutions, criteria for solutions and evaluation criteria against each other and to assess the results of the project in terms of their appropriateness. Realistic learning assignments within training therefore foster the design competence of learners.

## 3.2 Learning scenarios and arrangements

Against the background of the educational concepts discussed in the foregoing, we now describe some *application scenarios* and ideas for *teaching projects* that can serve as the basis for learning arrangements.

*Telediagnosis and tele-maintenance in the virtual electropneumatics laboratory*

A malfunction has arisen in a remote, electropneumatically controlled system. On the basis of a display path diagram, a group of learners is to diagnose this malfunction and draft proposals for eliminating it. In the first step, the students analyse the display path diagram and transfer their results to circuit status tables. A logic plan or electropneumatic circuit diagram is subsequently produced with the help of a computer and efforts made to locate the fault by simulation. Results are then swapped over the Internet with a different group of learners that also eliminate the fault in the real system. E-mails and audio conferences are used as support in order to ensure a continuous exchange of information between the learner groups.

*The virtual CNC workshop*

The NC program for a workpiece to be milled must be written on the PC and the milling procedure subsequently simulated. The software required is run either locally, from a host computer or downloaded over the Internet from another technical college so that it is locally available. The real milling process can be started and stopped telematically, and the production process is monitored using live video. In certain circumstances, the video camera with zoom function enables the learners to acquire even better insight into details of the machining process than is possible in a real workshop, because the location of the camera can usually be chosen for greater benefit than personal 'on site' access would permit.

*Distributed modelling*

With the help of a distributed modelling environment, technical college students perform an assignment in the field of control engineering. Firstly, a real system is constructed using components typically used in industry. A computer-based model is generated synchronously and made available over the Internet to other groups of learners. The latter then try to verify the model by means of simulation and discuss their results in a computer-aided conference. Various technologies such as WWW and VRML are used in order to describe to describe and visualise the model. The main focus in working on this assignment then consists in all groups of learners producing a solution that is subsequently implemented on the real system.

*Controlling a telerobot*

Remote control of a mobile telerobot causes problems in path finding, in locating objects and in circumventing obstacles. These problems are caused by the dynamics of the system, by transmission delays or by incorrect data and control algorithms. In order to solve these problems, it is necessary that learners be able to correctly program and configure a distributed regulation system comprising on on-board controller located in the respective robot. To do this, they have to design a control algorithm and implement it in the remote regulation unit. Practical testing of the control program is carried out on the real system, whereby the workroom is monitored by a video camera.

*Tele-configuration and programming an automation facility*

In the learning field entitled 'Designing and producing mechatronic systems', students must reconfigure and reprogram an automation system. Use is made of available materials and simulation software. In the final step, exercises are performed on a real system provided by a different learning location. Access to the real system is obtained by loading control programs and parameters into the system by means of data transmission. This procedure is monitored by a group of learners or an individual person 'on site', who then provides feedback on whether the exercise was a success or a failure.

Some of the *application scenarios* described above were specified in greater detail for training purposes and subsequently implemented as part of the RADIO project (see Section 5).

# 4 Media for teaching and learning

## 4.1 Requirements to be met by teaching and learning media

Based on the educational premisses outlined in the 'Learning concepts' section, the content of teaching and learning media for teleservice should be able to illustrate

- the interdisciplinary structure of mechatronic systems,
- the processual nature of mechatronic procedures,
- the systemic integration of mechatronic components in functional procedures and the structure of service technology,
- the behaviour and purpose of the technology deployed.

In order to develop occupational competence, media should support the learning process in such a way that the requisite scope arises for independent and comprehensive action and that the necessary proximity to reality is established.

## 4.2 Basic requirements for teleservice

In order to convey and acquire teleservice skills, it is essential to be furnished with an adequate basic supply of appropriate teaching and learning media. These including training materials such as learning programs (CBT), self-teaching materials and bibliographies. These training materials can be provided over the Internet or a training-related Intranet. In the RADIO project, the *BSCW*[12] (Basic Support for Cooperative Work) groupware system proved very useful. For practical exercises during lessons, communications systems and the relevant hardware and software are required. In general, the following communications technologies can be used:

1. *Asynchronous technologies:* WWW portals; News, discussion boards; e-mail

2. *Synchronous technologies:* chat; videoconferencing; application sharing; whiteboard; remote control software

## 4.3 Simulations and virtual laboratories

Computer-based simulations are an appropriate way of practising the use of equipment, machines, technical systems and other types of apparatus. Simulation

[12] The *BSCW System* is based on the concept of 'shared workspace'. The members of one workgroup set up these shared workspaces on a *BSCW* server and use them to organise and coordinate their various tasks. Such a shared workspace can contain different types of (electronic) objects, such as documents, tables, graphics, WWW pages or links to WWW pages. The members of the workgroup can transfer objects from their local computers to the workspace, or vice versa, for example to read or edit a document (http://bscw.gmd.de).

has proven to be a good technique, especially when the objective is to become familiar with and drill specific behavioural responses to malfunctions or emergencies in complex situations. The didactic importance of simulation is above all the reduced risk in the event of incorrect response, and the opportunity to experiment and practise without exposure to risk. The relevance of simulation from the training psychology perspective extends not only to cognitive, but also and very significantly to meta-cognitive skills, psychomotoric and affective training objectives. By combining simulator training and learning-by-doing on real-life systems, it is also possible to reduce the problems of transferral between virtual and real systems.

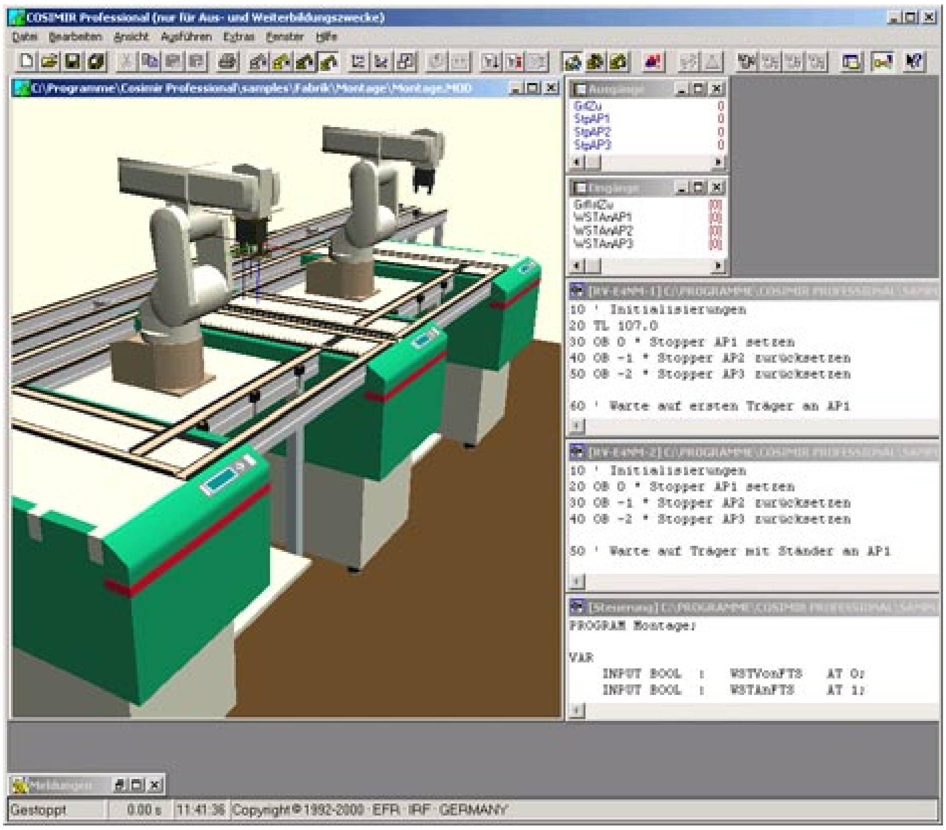


*Figure 1: Simulator*

In the higher education field, a number of pilot projects are being conducted that focus on remote, network-based use of robotic and machine-tool laboratories. In the joint 'Virtual Laboratory' project, for example, students can perform laboratory experiments over the Internet (VVL 1999). A real laboratory is provided at one site and is connected to several virtual laboratories at other sites. The virtual laboratory is a simulation of the real laboratory and enables learners to acquire experience and knowledge of process modelling, programming, monitoring and process management for virtual and real systems. The real, material laboratory can be remotely controlled using telematics methods, and can be used both locally and globally. The experiments are taken from various fields of mechanical engineering, robotics, image processing, automation engineering and computer science. The principal aim of the joint 'VVL' project is to reduce dependence on time and place during one's studies and to develop teaching and study materials for further education in the sciences, whereby joint utilisation of distributed resources is a key aspect. Results from the VVL project indicate that remote utilisation concepts can be transferred to training and skilling in the teleservice field.

In the RADIO project, teaching units were therefore planned and implemented that use forms of remote utilisation such as virtual laboratories. Two examples are described in Section 5.

### 4.4 The DERIVE learning environment – an example

Based on the so-called Mixed Reality concept[13] in the DERIVE[14] project, a learning environment is now under development that will help vocational schools and technical colleges in delivering mechatronics courses. The envisaged system enables participants to cooperate within complex real and virtual mechatronics systems that consist of parts which may be distributed all over the world. The learning environment includes a supportive web database with multimedia learning sequences providing theoretical background information, exercises and help in handling training assignments. Mechatronic hardware equipment can be connected to the virtual environment with a special sensor-actuator coupling called *hyper-bond* (Bruns 2000). Real electropneumatic circuits can be directly imported into the virtual world via image recognition facilities. The DERIVE learning environment integrates equipment seamlessly and supports full hardware-in-the-loop functionality, thus enabling real mechatronic systems to be created as subsystems of complex virtual systems.

Tele-cooperation functionality in the learning environment allows users to carry out training projects for teleservice, i.e. remote diagnosis and maintenance of mechatronic systems. This is confirmed by initial evaluation results.

[13] *Mixed Reality* is based on the real interactions between physical and virtual components.

[14] DERIVE (Distributed Real and Virtual Learning Environment for Mechatronics and Teleservice) receives support from the European IST Research Programme. In addition to the Work, Environment and Technology Research Centre (ARTEC) at the University of Bremen, the following partners are involved in the project: Festo Didactic GmbH & Co. (Denkendorf), Stockport College – College for Further and Higher Education (Great Britain), Escola Superior de Technologia e Gestao – Instituto Politecnico de Leiria (ESTG, Portugal), Schulzentrum des Sekundarbereichs II Im Holter Feld Bremen and the Institut für Arbeitspsychologie at the Eidgenössischen Technischen Hochschule Zürich (IFAP-ETHZ, Switzerland). Further information: www.derive.uni-bremen.de.

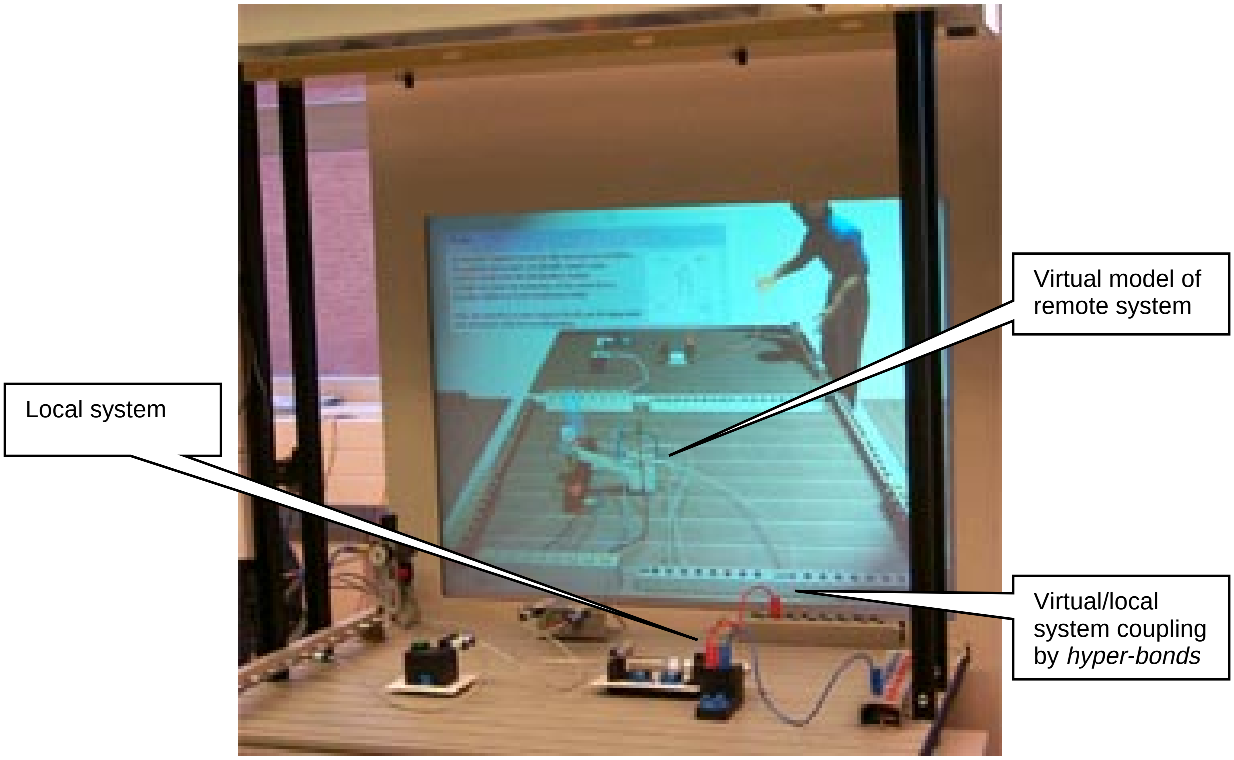


*Figure 2: The DERIVE Learning Environment*

# 5 Sample teaching units and lessons

## 5.1 Teleservice and tele-cooperation

The teaching unit entitled ‘Teleservice and Tele-cooperation’ was planned and carried out in a Bremen technical college by trainee technical college teachers from the University of Bremen[15], in conjunction with the RADIO project and an undergraduate course at the university. The lessons were given as part of the vocational training and education on mechatronics technicians (in their second year of training). The lessons primarily addressed aspects of teleservice. The topic of the unit was ‘Teleservice and Tele-cooperation’. The teaching project has not been fully documented and evaluated as yet, so the lesson plans are described below in the form of keywords only.

### *Learning content and objectives of the unit*

The following contents and objectives were to be presented and attained on the basis of action-oriented learning:

*General learning objective:*

Acquisition of technical and communicative competencies in connection with occupationally relevant media.

*Particular learning objectives and content:*

- Electropneumatic variables, how they are interrelated and how they can be visualised
- Controlling operational processes with the help of information technology
- Analysing, evaluating, documenting and reflecting on workflows and their outputs
- Programming simple movements and control functions
- Using in-company communications systems (teleservice)
- Teamwork / communication / presentations
- Customer-manufacturer relations

### *Teaching methods*

The objective of the unit is to be achieved by simulating a teleservice scenario in which the students can playfully explore their skills in taking action and making decisions in a variety of roles (including those of teleservice experts and skilled workers). In group discussions, the students are to exchange and evaluate the experience they acquire.

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[15] Rainer Pundt, Jörg Tuppak (2001): Materialien zur Unterrichtseinheit ‘Teleservice’. Bremen

### *Media*

- Computers (networked) with appropriate software (Microsoft NetMeeting, programming software for PLC)
- Headsets/ web cameras/ loudspeakers
- Beamers (for presentation of results)
- 2 digital cameras, video camera with tripod
- Overhead projector
- Noticeboard, media kit

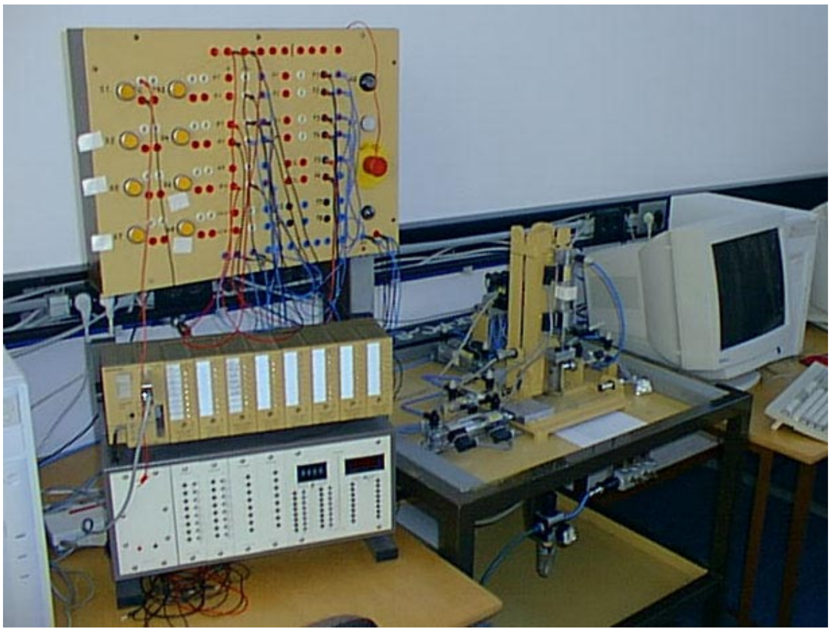

*Figure 3: Mechatronic system for teleservice learning tasks*

### *Organisation of groups and rooms*

The lesson is given in two adjacent classrooms for automation engineering that are linked in a local network (LAN)[16].

[16] Class composition: 23 trainee mechatronics technicians, 2nd year of training (all male), of which 17 are from secondary modern school, 4 with *Abitur* and 2 from lower secondary school. The class is split into two double groups for the laboratory exercises (Group 1 and 2 = 12 students, Group 3 and 4 = 11 students). The students have only minimal prior knowledge of teleservice.

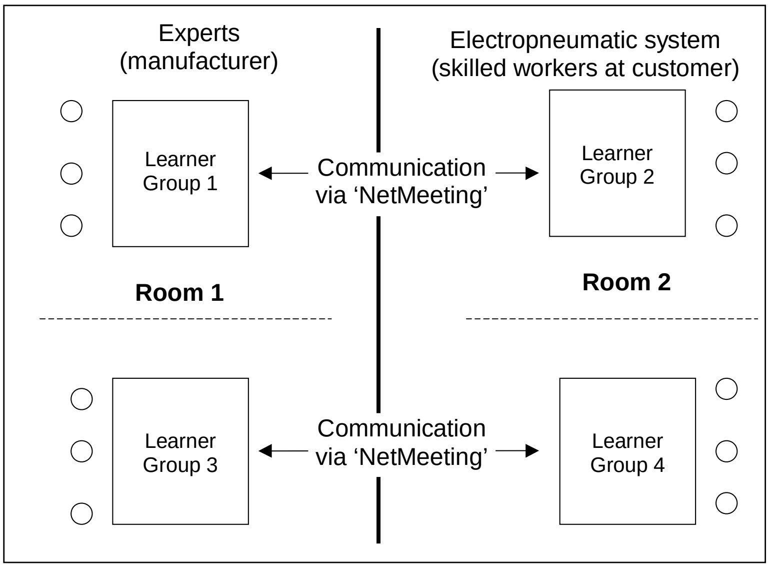


*Figure 4: Organisation of groups and rooms*

***Sequence of lesson***

The following overview shows the sequence of activities within the lesson:

| Phases | Learning activities |
|---|---|
| *Phase I*<br>*Introduction and entry into topic* | Presentation of the content and organisation of the teaching unit<br><br>Presentation of evaluation results from previously distributed questionnaire, with possible changes content of teaching unit<br><br>Teleservice – what, how, who, why?<br><br>Practical example: short presentation of real applications, distribute handout about communication and teleservice/tele-cooperation |
| *Phase II*<br>*Execution* | *General block (laboratory)*<br><br>Becoming acquainted with, conducting and describing basic communicative processes when interacting with the PC, on the basis of described scenarios; in groups (max. 3 students in each)<br><br>Saving results |
| | *Practical block (laboratory)*<br><br>Function modification in an PLC-controlled electropneumatic system using teleservice – as well as ongoing documentation of the experience gained; groupwork with brief exchange of experience afterwards |
| *Phase III*<br>*Reflection* | Presentation and analysis of the problems that arose for each group in the general and practical blocks, and various problem-solving strategies<br><br>Subsequent evaluation in plenary session |

*Figure 5: Students in action*

## 5.2 Troubleshooting with the help of teleservice systems

The teaching unit entitled ‘Fault-finding Using Teleservice Systems’ was prepared and tested in a Bremen technical college as part of the training course for mechatronics technicians[17]. The objective of this unit was to develop ways of using a telemedia learning environment and to subject these approaches to practical tests in the specific teaching situation.

### Contact with users and manufacturers of teleservice systems

To obtain an overview of the current state of development of teleservice systems, contacts were established during the planning phase with manufacturers and users of teleservice systems. One of those contacts was with the ‘AlgoVision’ company in Bremen (www.algovision.de). In the field of tele-cooperation, the latter company has launched on the market a hardware/software product with the following functions: (1) File transfer (2) image transmission, (3) remote control of cameras, (4) application sharing, (5) chat and (6) linking automation software.

During a product presentation lasting several hours, the system way used to start up and control a small electropneumatic system from a remote computer using a stored program control (PLC). In addition to application sharing, video monitoring of the electropneumatic system by video and audio communication between experts (at the remote computer) and system operators (at local computers) were also possible.

### Experience with the teleservice system made by AlgoVision[18]

*1. Installation of the AlgoVision system:* The test of this system, each end comprising a card with hardware compression, ISDN interface, a camera and a headset, was carried out on two computers. An ISDN PABX system was used to connect the two computers. Communication over ISDN for the teleservice workspace seemed to make more sense than communicating over the Internet. Depending on whether channels are bundled, ISDN connections guarantee a particular transmission speed and are more reliable on the whole. No problems were encountered while installing the software. However, it was necessary to adapt the school’s PABX system to accommodate the teleservice system.

*2. First steps with the AlgoVision system:* The product tested was the ‘Vision & Life’ hardware/software package produced by AlgoVision (Version 4.1). Once the connection had been established between two computers, the audio volume could be adjusted and the video pictures positioned (own and other end’s pictures). The

[17] The lesson was planned, delivered and documented by Hermann Gathmann and Hendrik Müller-Seidel, two technical college teachers.

[18] We are grateful to ‘AlgoVision’ for providing, at no charge, a system for testing and teaching purposes.

automatic answer function can be set by clicking on a button. A still picture can be created, printed and transferred by clicking on the mouse. Transmission quality is significantly improved by bundling channels. Before a program installed on one computer can be shared by two connected computers (application sharing), the program in question must be cleared for sharing. Both participants can then control the program by double-clicking on the mouse.

*3. Testing the system in a small teaching scenario:* One local and one ‘remote’ computer were connected by ISDN. The local computer was connected by means of a Programmable Logic Controller (PLC) to a small modular production system (MPS).

Using a PLC editor (WinSPS), a small control program was generated on the ‘local’ computer and transferred to the PLC. After starting the program, the behaviour of the system was tracked by students over the teleservice connection, as well as in video and sound from the remote computer. It was possible to make corrections and additions to the PLC program over the same connection, and to implement these changes successfully.

In a further experiment, the students had knowledge of electro pneumatics, but not experience with an PLC. The system to be tested did not operate properly and had to be repaired. During the troubleshooting phase, the students were able to exclude any fault in the electro pneumatic section and suspected a fault in the control program. They established a teleservice connection to an ‘expert’ (another student), and discovered with his help that one part of the program did indeed contain a ‘bug’. The expert was able to provide fast and effective help in operating the manual programming device, because he was able to follow the keyboard input and the monitor display from the camera images. After making the corrections, the program was reinstalled and the system worked properly again.

The experience thus gained with the teleservice system were very positive on the whole. Installation the system was easy, and there were no problems operating the program. The quality of the video images could be adjusted to a certain extent. Transmission was over two channels, not quite wobble-free and was significantly delayed, but was satisfactory on the whole. If tougher requirements are to be met, then transmission quality can be greatly improved by bundling several channels. In summary, one can say that the students were greatly motivated by using a typical industrial-standard teleservice system and took an active part in the lesson.

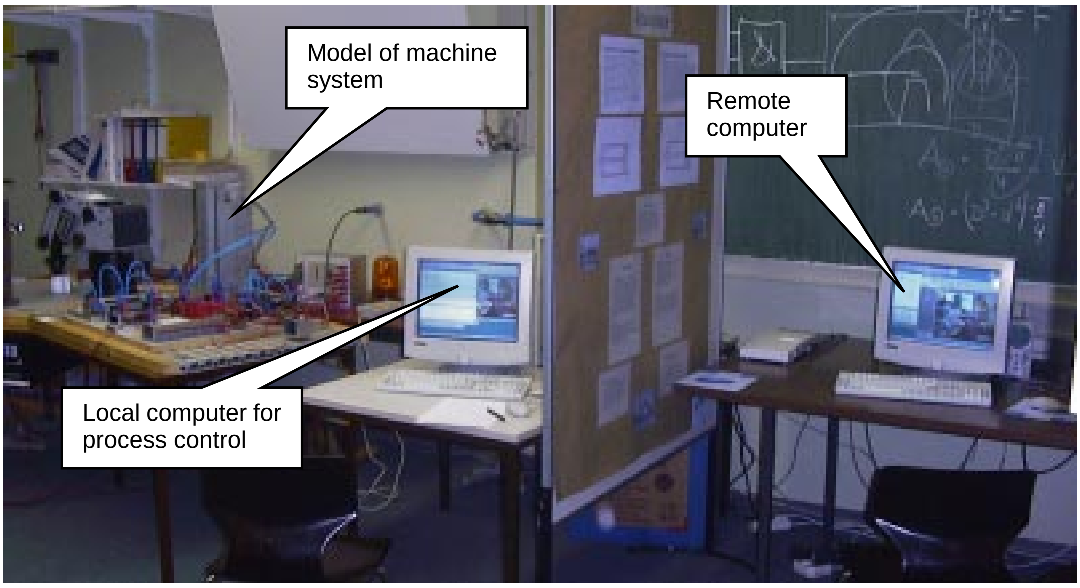


*Figure 6: Using the AlgoVision system I*

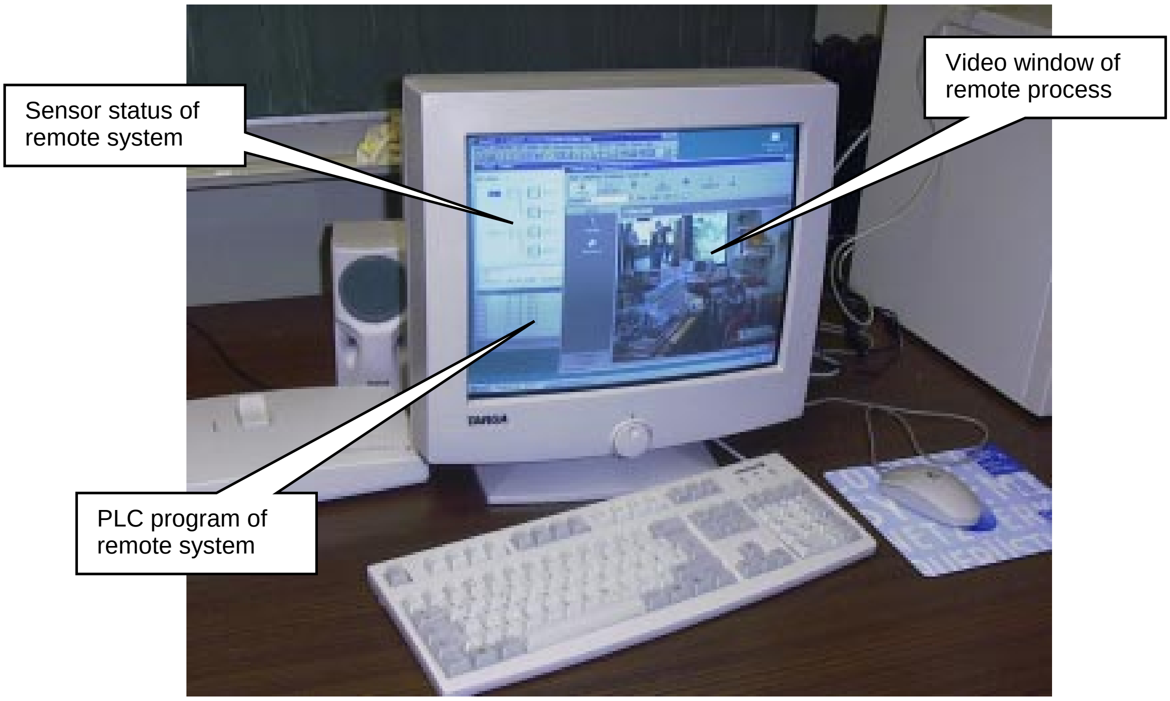


*Figure 7: Using the AlgoVision system II*

## 5.3 Summary

In both training units, unsupervised and autonomous learning played a key role. The open learning situation enabled training to be interesting and variable. The central focus was on the acquisition of functional and extra-functional skills, such acquisition being significantly supported in such open forms of learning through the use of *real* telecommunications and teleservice systems. Improving the visual clarity of complex interrelationships by using real systems was a predominant element of the learning process. The new media had a consistently motivating impact on the students. The action-centred lessons exhibited a definite improvement in student activities and the independent approach taken by students. These forms of learning, new to the students, enabled playful and risk-free experimentation.

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# 7 Appendix

## Questionnaire: Teleservice in operation/within the enterprise

- Survey questions for companies that operate teleservices -

1. How do you communicate with plant operators when technical problems occur at the customer's end?

2. What tools, aids and methods do your service technicians use on site when they cannot solve a technical problem on their own and therefore have to collaborate with head office?

3. What information and/or data are exchanged in such a case?

4. In your view, what importance does teleservice have for your company?

5. In what areas is teleservice particularly important (distinguish, for example, between plant commissioning, inspection/monitoring, diagnosis, process support, maintenance, repair)?

6. To what extent, in your estimation, can teleservice-related tasks be performed appropriately by skilled workers?

7. What competencies (differentiated according to specialist, methodological, social and personal competence) do you expect from skilled workers in the teleservice field?

8. What training should a teleservice technician have received? What occupations does it make sense to deploy in teleservice?

## Training profile: Mechatronics technicians

**1. Name of occupation:** Mechatronics technicians

**2. Duration of training:** 3½ years

Training is provided both in-company and at technical college

**3. Field of work:**

Mechatronics technicians work in the assembly and maintenance of complex machines, plants and systems, in the field of plant construction and mechanical engineering, and in the companies that purchase and operate such mechatronic systems.

Mechatronics technicians perform their activities without supervision at a variety of locations, primarily on construction sites, in workshops or in the service field, in compliance with the relevant regulations and safety rules and on the basis of documents and directives. They often work in teams. They coordinate their work with upstream and downstream departments.

Mechatronics technicians are skilled electronics workers within the scope of accident prevention regulations.

**4. Occupational skills:**

Mechatronics technicians

- plan and control work procedures, check and assess work results and operate quality management systems,
- process mechanical parts and assemble modules and components to form mechatronic systems,
- install electrical modules and components,
- measure and test electrical variables,
- install and test hardware and software components,
- construct electrical, pneumatic and hydraulic control systems and test them,
- program mechatronic systems,
- assemble and disassemble machines, systems and plants, as well as transport and make them safe,
- check and adjust the functions of mechatronic systems,
- commission mechatronic systems and operate them,
- transfer mechatronic systems to customers and instruct the latter in their use,
- perform maintenance and repair work on mechatronic systems
- they work with English-language documents and can also communicate in English.

## Fields of learning: Mechatronics technician as a trained occupation

| | | Approximate time in hours | | |
|---|---|---|---|---|
| No. | **Field of learning** | 1. year | 2. year | 3./4. year |
| 1 | Analysing functional interrelationships | 40 | | |
| 2 | Making mechanical sub-systems | 80 | | |
| 3 | Installing electrical production equipment in compliance with safety engineering aspects | 100 | | |
| 4 | Investigating the flows of energy and information in electrical, pneumatic and hydraulic modules | 60 | | |
| 5 | Communicating with the help of information technology systems | 40 | | |
| 6 | Planning and organising work procedures | | 40 | |
| 7 | Implementing simple mechatronic systems | | 100 | |
| 8 | Designing and producing mechatronic systems | | 140 | |
| 9 | Investigating information flow in complex mechatronic systems | | | 80 |
| 10 | Planning assembly and disassembly | | | 40 |
| 11 | Commissioning, troubleshooting and maintenance | | | 160 |
| 12 | Preventive maintenance | | | 80 |
| 13 | Transfer of mechatronic systems to the customer | | | 60 |
| | Totals | 320 | 280 | 420 |

**Overview: Contacts with companies, training institutions, etc.**

- 31.01.2000 Visit to *AlgoVision* Systems GmbH, Bremen (Internet: www.algovision.de). Main focus: Presentation of the 'NewMedia280 system' for data, image and voice transmission.
- Participation on the final workshop of the *TeLec* (multimedia teleservice) project
- 13.03.200 Visit to the Bremen branch of Siemens AG
- 27.03.2000 Visit to *LSW* Maschinenfabrik GmbH, Bremen (user of products made by AlgoVision GmbH)
- 15.05 2000 Visit to Delmenhorst Technical College (visit to a solar energy laboratory with measurement data capturing and process simulation, use of products made by Siemens AG )
- 10. / 11. 07.2000 Continuing training event at *Technotransfer* GmbH in Erfurt
- 12. / 13.10.2000 Participation at the VDI event entitled 'Wireless-controlled communication', in Düsseldorf
- Visit to the *'Didakta 2000* education fair'