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Summary

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SUMMARY

The TAB report focuses on the »future of industrial work« in the next five to ten years. This report methodologically draws on a broader understanding of industrial work encompassing »all the directly and indirectly value adding activities in industrial companies of the manufacturing sector contributing to the value added of the product«.

The aim of this future report is to identify and discuss where, currently and in the future, evolving changes in the frame conditions might lead to transformation processes of work in manufacturing companies necessitating parliamentary actions to be taken or monitoring activities. Thus, on the one hand, important development paths of industrial work evolving from changing demands increasing internationalisation and »inner tertiarisation« of the industrial work are analysed and described. Secondly, corresponding changes in the enterprises' organisation and their potential impact on the concept of industrial work are analysed. Thirdly, three key technologies of the future are to be discussed in terms of their potential relevance and impact on work: biotechnology, nanotechnology and the concept of Ambient Intelligence (AmI). We deliberately selected three key technologies which differ strongly in terms of their implementation in industry.

Selecting these *three future key technologies*, however, also implies that analyses of these technologies' potential impact on the future design of industrial work cannot be based on reliable empirical evidence yet. In all three research fields mentioned above, the examined studies and analyses strongly draw on experts' assessments ranging as far as »well-founded speculation«. This particularly applies to nanotechnology and AmI technologies, i.e. technologies whose industrial application is being expected rather far in the future. Nevertheless, this report aims at discussing the work-related impact an application of these technologies might have, whilst thereby attempting to foresee the potential design of industrial work in the future; an approach which in its applied consequence represents a novelty in research on this topic. However, due to a certain lack of empirical findings and reliable data in this field, some assessments and conclusions of this report will therefore have to be formulated in a rather soft and cautious way.

On the whole, this report *does by no means try* to exhaustively describe, discuss, or classify all the aspects relevant for the development of industrial work. The authors deliberately selected some developments experts, studies, and literature regard as important ones which are expected to increasingly influence the ac-

tivities and value adding processes of industrial companies in the future and which do thus constitute essential frame conditions for the further development of industrial work. Therefore, the selected approach of this report is rather an in-depth approach than one focussing on broadness of analysis. The following crucial findings on the future design of industrial work will be presented in the following.

INTERNATIONALIZATION

The analyses on *internationalization of production* and its future development have shown that this process is neither expected to come to a halt nor that a stable equilibrium between the global locations might evolve. Admittedly, German industrial companies seem to be rather advanced as regards internationalization of their business activities. Compared internationally, German companies' direct investments abroad are quite high. In terms of current production offshoring activities abroad Germany takes a midfield position compared to other European countries. Germany indeed does not rank top in terms of offshoring activities as the often heated public discussion on this topic might induce one to believe. However, the drivers of continuing internationalization remain strong: new markets evolve, former threshold countries with comparatively low labour costs develop industrial structures, or important key customers go abroad so that ever new stimuli to produce internationally evolve in new regions. On the other hand, new products and solutions at least partly demand new production processes which are mostly ramped up at the home location and as a result entail optimization potentials also at the home location. Summing up, all these findings indicate that the international generation of value adding processes will continue to be dynamically adapted to actual and changing demands, however, this does not necessarily have to be an irrevocable process directed abroad. This finding is confirmed by figures on direct investments of foreign companies in Germany and figures on backsourcing activities of German enterprises.

These findings mentioned above entail quite a number of consequences for a future-oriented design of industrial work. It is clearly conceivable that *co-ordinating tasks* as well as service and consulting activities at the German home location for the respective foreign location or the international network will continue to increase in importance. Even at the level of production workers this seems to lead to a continuous task enrichment in terms of an inclusion of quality securing and monitoring activities into the task portfolio of the workers. This particularly applies to specialists and executive staff. They have to find ways to tackle successfully with these growing demands. Different approaches such

as temporary on-site consulting, deployment, mentoring concepts at the German location, or co-ordination with the help of the central departments at the headquarters might help to meet these challenges. So far, large multinational enterprises, particularly, have successfully developed adequate solutions. But also small and medium sized enterprises (SMEs) with their flat hierarchies and without specially installed management functions will increasingly be called upon to internationalize their value adding processes and to manage it efficiently so that at the German location high value adding activities can evolve or be maintained. Here, research policy might be called to stimulate the c*onception and testing of innovative concepts for co-ordinating and controlling of transnational networks of SMEs*.

Closely related to this increasing importance of co-ordinating and consulting activities between the different locations is the also increasing demand to organise a well functioning knowledge transfer and a principle of »learning from each other« between the different locations. Here, also SMEs have started to initiate approaches and pilot solutions to meet these demands, for instance with the help of so called »boundary spanners« or by the establishment of small working groups. In this regard, also the maintenance and protection of know-how in the company, i.e. the »arming« against the looming danger of know-how loss through product piracy and process copying at the foreign location constitute relevant topics. Here, research policy might be called to develop *intelligent concepts particularly for the protection of process and organisational knowledge* which might help to prevent copying of manufacturing processes by local competitors abroad. Recently, the BMBF (Federal Ministry of Education and Research) has launched an initiative called »innovations against product piracy«. Here, it should be monitored attentively whether in this context also innovative organisational concepts are included in order to protect not only product know-how but also the process know-how effectively against attempts to copy it. Following the principle »products are easy to copy, processes quite not so« might be a promising strategy securing the generation of innovative and value adding tasks competitively at German locations also in the future.

As in our age of internationalisation of business activities international qualifications – particularly, intercultural competences and communication skills– are increasingly gaining importance and affecting all groups of employees, the question arises whether the existing concepts of education policy do already provide adequate solutions. Here, education policy might be called to *integrate* not only language skills but also *more far reaching intercultural abilities into the diverse training programmes*. In the future, not only students and high-school graduates will be increasingly confronted with this demand. It will apply to all trainings

targeted at industrial skilled work. Thus, existing curricula should be systematically analysed whether they already meet these demands of international qualification or not.

Finally, internationalisation of business activities and the partly already perceptible demands and dynamics of an »economy round the clock«, also imply an increasing *flexibilisation as well as an intensification* of industrial work, triggered off particularly by a rise in co-ordination, communication and harmonisation needs with locations in other countries. This development is to be critically monitored in the future. Currently there are signs that after a period of sheer euphoria about e-business work systems and the tendencies towards work intensification and enlargement (»Software developers enjoy working late nights although they are not forced to do so by their superiors«), tendencies which once had been positively connoted, a more critical attitude towards this kind of self-exploitation seems to spread. This kind of work load can lead to marked creativity and productivity losses with specialists and executive staff, developments no employer or company can wish for. Here, monitoring is necessary to keep an eye on indicators for further changes in work intensity and work duration.

INNER TERTIARISATION

The analyses on *tertiarisation of industrial work* have shown that in the companies of the manufacturing sector, i.e. in the secondary sector itself, a tendency towards more service providing work is discernible and that this development is to continue also in the future. This increase in service activities in the secondary sector is referred to as »inner tertiarisation«. This finding may be astonishing at first sight, as industry is known for increasingly outsourcing services which are not relevant for the core competences of the enterprise, such as canteens, vehicle fleets, security services or also IT and administrative tasks, to specialised companies of the service sector. Thus, manufacturing industries seem to simultaneously establish service activities, astonishingly enough this even overcompensates for the losses resulting from outsourcing activities. The analyses show that the *growth* particularly covers services with a direct link to the industrial product, so called *product-related services*. Lately, industrial companies have systematically introduced these product-related services to transform themselves from the manufacturer of goods to the offering of problem solutions for their customers. These hybrid product-service combinations help them to differentiate themselves from cost pressures and competitors.

The further increase and importance of product-related services foreseen by future studies and Delphi experts has manifold effects on the future of industrial work. Given the increasing importance of the share of turnover with services at the total value added, manufacturing industries will try very hard to offer and provide product-related services as professionally and as productively as possible. This might result in an increase in the number of independent service departments, leading to a reduction and reversal of the integration of manufacturing and service tasks with individual employees, nowadays applied in many companies. In the future, the demand for specialised service persons might be rising. Whether and how strongly this assumed disintegration of production and service tasks at the individual employee's level will actually come true and which *implications* this will have on the task spectrum of the individual worker should be *monitored systematically* in the next few years in order to timely develop and offer adequate education and training programmes.

Additional qualification demands vary according to the kind of the product-related services. Knowledge-intensive pre-sales services as for instance engineering or consultancy for product design demand engineering qualifications, thus increasing the demand for university-educated staff. After-sales services such as maintenance, error diagnosis, start-up or repair call for rather broader qualifications including, besides qualification in engineering, also skills in the fields of electronics, in information and communication technologies and a basic knowledge in the field of economics. A close look at the *curricula and vocational training regulations for industrial jobs* reveals that services *still play a minor role in them*. Industrial job descriptions are for the most part rather technology-oriented, thus, simply adding specific service-related contents to the job descriptions and vocational training regulations will certainly not be sufficient. Therefore, experts propose proceeding in three steps for instance: During the primary vocational training the teaching of service competences is to be closely related to technical issues. Nearing the end of the training programme, customised for the target group, additional qualifications on customer-related services should be offered. Finally, adequate training concepts enabling the respective employees to further cultivate and shape their service competences on their own should be developed. Currently, the realisation of such training concepts seems to be rather a rare and often spontaneously motivated phenomenon than a methodical and systematic implementation process. Therefore, *considerations of education policy* as well as corresponding activities to further *monitor* the diffusion of suited concepts in industry should take the above presented demand patterns as a starting point for their activities.

An increasing inner tertiarisation of industrial work will also entail an increasing demand for *different working time models*. This particularly applies to so-called time-critical product-related services, as for instance hotline, repair, or maintenance services which often have to be rendered outside the regular working hours. Here, two groups of employees can be identified which need specific working time regulations. On the one hand, this applies to employees, who on-site the customer's location pursue services such as instant or emergency repair services, maintenance, customer complaint services, or training measures for the customer's employees, often in the evenings or at weekends, their working time sovereignty being thus extremely dependent upon the customer's problem. The corresponding working time regulations necessarily must have a high degree of flexibility and self-determination, thus being outside direct time control possibilities on the side of the employer (»trust based working time«). This, however, entails a *rising danger of self-exploitation and a permanent mingling of work and leisure time* which can negatively affect or impede the availability and planning of leisure time and thus the compatibility of working and family life. The second group of employees is increasingly asked to be permanently available and to provide a kind of »stand-by function«, for instance in the case of a hotline or a »service around the clock«. Here, working time sovereignty of the employees is rather being reduced and *concepts of a capacity-oriented flexible working time* (KAPOVAZ) where in the individual work contract a provision is included according to which the employee's working time will be dependent on operational demands will further increase. Both developments should be attentively and systematically monitored in the future, paying special attention to their impact on the health and the capacity to work of the respective employees.

MARKET ORIENTATION

Analyses *on market and customer orientation of industrial work* show that market-oriented forms of decentralisation at company level, as for instance the division of formerly centralised departments or the division of production units into customer or product-related production segments are already utilised by about 50 per cent of the companies. However, when compared to other European countries, German companies still show a large unexploited potential for a broader and more intensive utilisation of these principles. The following pattern evolves: As regards the utilisation of advanced production and information technologies such as industrial robots, tele service or systems for production planning and controlling, German companies take a leading position in comparison with other European countries. However, as regards the utilisation of innovative organisational concepts, German companies tend to lag behind.

It also shows that decentralisation concepts at company level are not always consistently supported by corresponding decentralized approaches of work organisation as for instance team work concepts. Thus, it is obvious that no reliable correlation between the utilisation of market-oriented decentralisation concepts at company level and an increasing task enrichment of employees in production can be verified. *Task enrichment and market-oriented company organisation seem to follow separate paths as yet.*

Our future studies, however, indicate that an increasing knowledge-based production and institutionalised opportunities for the employees to acquire and practice new competencies during working hours are regarded as one of the most important preconditions for a future competitive production. This form of competence acquisition with the employer providing the necessary resources is expected to be widely spread by the year 2013. The future studies mentioned above also indicate that a flexibilisation of work will more strongly than even today be determined by the demands and needs of the companies and their market environment. Thus, an »internal form of intrapreneur« who flexibly applies his/her abilities in different areas and networks within the organisation is regarded as quite crucial for the manufacturing industry's competitiveness. The majority of the surveyed experts in a Delphi study expects this to have come true by the year 2014. On the other hand, however, the surveyed experts doubt that companies might offer customized working conditions enabling a *»work life balance«*. Here labour and economic politics together with stakeholders, trade unions and management are called to introduce *new approaches for sustainable working conditions* reconciling the flexibility demands of the companies with the employees' wish for flexibly organising their private life.

Team work

As the analyses of new forms of work organisation, using the example of team work, have shown, two thirds of the companies of the German manufacturing sector have introduced team work, at least nominally. Compared to other European countries, German industry lags behind. This picture becomes even bleaker when analysing in more detail how many companies have introduced team work not only in some or other form but as autonomous team work with a homogeneous qualification profile. Such advanced forms of team work are currently utilised by a mere fifth of German industrial companies, whereas only 3 per cent have comprehensively implemented this form of team work in their companies.

Thus it comes as no surprise that the utilisation of team work does seem to only have a rather limited impact on task enrichment of production workers. As re-

gards the assignment of quality securing tasks to individual production workers, team work seems to exercise rather limited stimulus whilst labour division seems to prevail also in team work settings. If further responsibilities are transferred into the teams, individual specialists within these teams seem to be responsible for these tasks, thus the division between planning and operating functions at the level of individual persons still seems to prevail. *The impact of team work onto the task enrichment of individual workers continues to be very limited*.

The impact the introduction and utilisation of team work has on the qualification profile of the employees, too, is rather limited. Hopes that the introduction of a team-based work organisation might entail a marked *re-qualification* of the employees in the manufacturing sectors of industrial companies thus *can hardly be fulfilled*. This might be partly due to the fact that the qualification profiles existing in the companies rather present a qualification overhang which can now be better exploited by means of the new work structures.

A look into the future with the help of Delphi studies shows that the majority of the surveyed production experts regard self-dependent teams as important or very important for the future competitiveness of German industry. It is thus expected that self-dependent teams at workshop level will be widely spread by the year 2012. As regards the *task enrichment and qualification* of employees, however, no radical trend reversal which might not be absorbed and converted by the proven reformation of the training programmes can be discerned. The content-related and functional design of team work might gain new dynamics if it was recognised as an important individual element in the course of introducing so called »holistic production systems« and would thus be further promoted. Should standardisation and consistency endeavours with regard to other organisational elements of holistic production systems necessitate the promotion of further advanced forms of team work with enlarged task and qualification profiles for all the members of the group, here a new development quality might evolve. Given the resulting impact on the competencies and qualification demands of industrial work, education, economic and research policy should attentively observe which direction concepts of holistic production systems take in the future, not only in large enterprises but also in numerous small and medium sized enterprises.

BIOTECHNOLOGY

In all industrialised countries *biotechnology* is regarded as an important future technology and is often also labelled one of the »key technologies of the 21st

century«. Due to its growing technological maturity and the expected impact on future competitiveness of the economic sectors influenced by this technology, biotechnology plays a central part in innovation politics. As biotechnology is a cross-sectoral technology it is ascribed huge potential in a large number of industrial applications, branches, and activities. Among the three technologies analysed in this report, biotechnology represents the technology being the most advanced one in terms of commercialisation. Thus, the implications these technologies have on industrial work become rather evident in the case of biotechnology.

Remarkably enough, there is an unexpectedly large gap between the potential for industrial application ascribed to biotechnology on the one hand and the existing knowledge about biotechnology's impact on industrial work on the other hand: For this report we only found scarce empirical material allowing for well-founded assessment of the potential impact on industrial work. Work science and work sociology have not yet sufficiently considered neither biotechnology nor nanotechnology. This might be due to the comparatively early development stadium biotechnology finds itself still in, as well as methodological reasons rendering difficult an analysis of this topic as companies active in the field of biotechnology do not (yet) constitute a clear-cut and separable »sector« which could be mapped in the established statistics.

The analyses also show that the expected »revolutionary« changes through biotechnology are not yet discernible, at least not to the assumed extent, when looking at a period of several years. Rather, incremental changes can be observed. Dramatic changes in terms of an »upturn« do rather evolve in the course of decades. Thus they can only be identified in a far reaching retrospective analysis or demand foresight analysis covering some decades; this procedure, however, will entail a certain degree of uncertainty. Nevertheless, »bio-based economy« or the shift of value adding processes to earlier steps of the value chain, as for instance in plant breeding, are areas showing potential to substitute established industries and thus might entail structural change. There is a fundamental demand for prospective assessments of the extent, direction, time horizon, and affected regions of the probable structural change.

As regards the industrial application of biotechnology it might also be necessary to *harmonize* the *professional qualifications* – predominantly oriented towards the employment of highly skilled academic persons in research and development and persons trained at technical colleges in traditional work fields –with the *actual demand in the companies*. Here, sector, production, market and application-oriented specialised knowledge and experiences acquired on the job, to-

gether with language skills and »soft skills« in interdisciplinary and international team work are required; qualifications which will become ever more important than they are already today. Therefore, we are confronted with the challenge to develop extensive *concepts for vocational and further training* covering all the formal qualification levels.

Already in the mid of the 1970s, there has been a discussion of new health hazards biotechnology and especially genetic engineering might pose at the work place and how these dangers might be effectively countered and restricted. In the following decades corresponding safety measures have been developed, regulated by law and thus put into practice so that biotechnology has already reached a state of statutorily regulation nanotechnology is currently striving to achieve. However, in the field of biotechnology with the emerging importance of *synthetic biology*, possibly also with the rise of *nanobiotechnology*, new fields emerge which might hold an *increased endangering potential for human health*. So far our knowledge of these dangers does not yet allow conclusive assessment of the actual endangering potential. Here, further research is needed to generate the knowledge basis for risk assessment and thus to develop preventive and safety measures.

Potential applications of biotechnology such as for instance identifying one's disposition for certain illnesses with the help of gene tests or the *further development of means to »improve« human capabilities (enhancement)* have quite a different impact quality on the health of employees. Whereas the issue of gene tests has been intensively analysed and discussed there is, however, consensus that regulations of the frame conditions under which gene tests in connection with employment might be legal is absolutely necessary. The opportunities for enhancement through biotechnology in work surroundings have not yet been discussed as they still are rather in a stage of research and development. Here, a *monitoring* of this development might be useful.

Finally, the aspect of *alienation* and the resulting possible impacts which can occur with tasks in biotechnology should also be taken into consideration: Biotechnology utilises and exploits the abilities of living organisms respectively their elements for its technical purposes. Thereby the living organisms or their elements become objects which might no longer be perceived as living organisms by the employees but primarily as resources and material for fulfilling technical purposes. This (mis)-perception might be reinforced if these objects can no longer be perceived by human senses but only indirectly by means of data and values or technical applications. Thus, interventions and manipulations of these organisms or their utilisation which might appear rational and »normal« to peo-

ple employed in biotechnology, might very well be judged as hardly acceptable, too far-reaching or immoral by people not employed in biotechnology. A case in point might be the gene modification of animals or the utilisation of human embryos for the generation of embryonic stem cells. To prevent severe controversies it is necessary to extensively analyse and research ethical, social and legal aspects and implications and to stimulate and conduct social debates on the desirability and aims of such biotechnological modifications and interventions into the integrity of living organisms. Furthermore, the *integration of these topics into academic education* might be a worthwhile option.

NANOTECHNOLOGY

Nanotechnology still finds itself in a transitional phase between basic research and industrial application. There is no »nanoindustry« in the proper sense, but rather two types of companies, i.e. young technology enterprises which exclusively deal with nanotechnology and larger enterprises which have integrated nanotechnology into their technology portfolio during the last few years.

Consequently, nanotechnology has received rather little attention in genuine work research. With a view to the key function nanotechnology plays it might seem a good idea to consider more strongly the impact nanotechnology has on human work. From today's point of view, particularly challenges for education and research politics as well as for work safety do arise.

When compared to the impact biotechnology has on industrial workquite a few similarities between the two technologies can be stated. Thus, despite all necessary caution against any kind of conclusion by analogies, the experiences gained in biotechnology might be used to a certain extent as orientation for future activities in the field of nanotechnology. Well used and proven means and measures of biotechnology might be adapted, weaknesses and deficits which have emerged in biotechnology might be taken into consideration in the case of nanotechnology early on thus enabling timely, preventive and adequate course of action.

Basic research, applied research and development in the field of nanotechnology will increasingly have to be interdisciplinary and this will have quite an impact on the design of training, qualification and promotion measures for this field. To initiate an innovation and productivity push, new organisational structures and training programmes, which are not rigidly restricted to disciplinary borders, but consider the multi or interdisciplinary character of nanotechnology, will have to be established. As in the case of other dynamic and knowledge

intensive technologies it is essential to focus already in the professional training programmes on *applicability* thus not only taking into consideration the demands and requirements of large enterprises but also those of SMEs in Germany.

From the perspective of industrial application of nanotechnology it becomes clear that most companies do not primarily seek declared »nano scientists or nano engineers« but are rather seeking more broadly qualified natural scientists, graduated engineers and computer scientists with »interface« competencies and a certain basic knowledge of nanotechnology. In the meantime, there is some consensus that first of all a basic study period in one of the traditional disciplines such as physics, chemistry or engineering should be conducted before students should focus on nanotechnology. Nowadays, universities and technical colleges do admittedly offer a broad range of these studies, however, there is still a lack of *comparability of contents and degrees*, particularly at European level discernible. Thus, there is still a *marked scope for design* and organisation and *need for co-ordination*.

Experts agree that early on in the course of the academic training, co-operation with industry should take place. For academics being trained today, an academic career (in universities and research institutions or in laboratories of large enterprises) still represents the traditional career path. Especially in the case of mere application sectors there are signs that academic training in the field of nanotechnology does not meet the actual demands of small and medium sized enterprises (SMEs). Here, measures have to be taken to enable and ensure an efficient and *timely transfer of scientific results bearing product and market relevance* and, above all, the *exchange of personnel between science and industry*. The co-operation projects of the 6th European Framework Programme, the initiatives by the Federal Ministry of Education and Research (BMBF) as well as the planned activities (7th Framework Programme and high-tech strategy of the federal government) clearly show that these problems have been identified and measures are being taken to solve them. An assessment of these activities in due time will then show whether the aim of marketable knowledge acquisition and inter-institutional personnel transfer »by heads« has been achieved with the existing instruments, or whether there might be a need for a re-adjustment or even a radically new redirection of these activities.

Medium qualifications, i.e. skilled workers and technicians in industrial companies are urgently in need of adequate qualification programmes. Here, it is by no means sufficient to meet the demand for knowledge and abilities in the field of nanotechnology merely by implementing new courses in vocational training. Rather, *associations and industrial and commercial chambers* should be stim-

ulated to *establish qualification programmes for further training measures of skilled workers in the field of nanotechnology*.

As regards *occupational safety and health* almost all studies stress that it is absolutely necessary to examine the noxiousness of nano materials and the potential exposures at the workplace and to introduce adequate safety measures. All over Europe, there is still a marked lack of knowledge of decisive factors. This knowledge gap should be closed by studies on the following questions:

> How toxic are nano particles of different – well known substances included – substances? Do nano particles interact with cell structures?
> Which nano particles of which size are noxious, which relation is there between dose and impact?
> Which particles do react similarly, can nano particles be classified into risk classes?
> Which work places and which workers are indeed affected by an exposure to nano materials, to which kind of, to which degree and to which length of exposure are workers subject to?
> Development of extensive internationally standardised methods of measurement, particularly for reactive surfaces of particles in the air and at the work place.

Recently, the German authorities in charge (Federal Environment Agency, Federal Institute for Risk Assessment, Federal Institute for Occupational Safety and Health) have taken up these questions. Their activities should be harmonized and co-ordinated with the respective institutions within the European Union. The results relevant for industrial work would then have to be classified in terms of their impact on adaption of work safety measures, and, if necessary, measures for improving work safety would have to be discussed and passed in the responsible boards and committees.

AMBIENT INTELLIGENCE (AMI)

Compared to the technological key fields biotechnology and nanotechnology the vision of »*Ambient Intelligence*« (AmI) in the value adding process still is rather remote from concrete application and utilisation in German industry. The majority of AmI technologies which are mapped in the prevalent future scenarios still belong to basic research. Thus, statements on future implications of this technology line necessarily will be rather vague. Despite these fundamental restrictions as regards AmI applications in industrial manufacturing, even from

today's point of view some development lines relevant for the future design of industrial work do emerge:

In industrial manufacturing, AmI applications do fit into the trends towards rationalisation and flexibilisation which have been observed for decades; they help to accelerate these trends and do partly intensify their impact on company-internal processes. Already today it can be clearly seen that the introduction of RFID systems, which are regarded as having paved the way for AmI, is primarily aimed at increasing cost efficiency as well as the variability of production processes. Thus AmI will not lead to a radical transformation of industrial manufacturing, it is rather embedded into long term trends.

AmI applications' impacts on *task profiles and qualification demands* will probably be characterised by *contrary trends*. On the one hand, one might suppose that certain tasks in industrial manufacturing will experience a qualitative enrichment and enlargement which are related to the improved (information technological) integration of different steps in the value adding chain. Due to the growing complexity of manufacturing processes resulting from the demands for a flexible and »individualised« manufacturing, the employees concerned will be asked to increasingly plan and to take decisions autonomously. Besides an increased demand for context knowledge of the whole production process also social skills will become more important as in the course of the increasing joining together of formerly separated functions interaction with different employee groups will increase in importance. On the other hand, there are also signs that AmI applications will offer broader *opportunities for automation of simple control, monitoring and other manual tasks*. Although at the moment there are no reliable prognoses on quantitative employment effects possible, it is nevertheless feasible that with the introduction of AmI technologies in industrial manufacturing particularly simple tasks with low qualificational requirements will be substituted.

It might be safe to assume that for the majority of the remaining employees in industrial manufacturing the trends towards *densification of work*, enlargement of working time corridors and the loss of time sovereignty will continue with the introduction of AmI.

Given the yet low level of application maturity of AmI, formulating detailed recommendations for actions and measures to be taken, e.g. with a view to education and research politics might seem premature at this point. However, given the development of AmI which still might seem rather sketchy and blurred in some aspects, this does nevertheless call for an *intensive monitoring of this*

technology field. Work science, for instance has not yet started to analyse the impact of AmI on industrial work. In this context, also the evolving tendencies in terms of problematic effects on work and society triggered off by the intensified economic dynamics should be monitored attentively. The debates on rationalisation, automation and the future of work which have been triggered off by the introduction of micro electronics and information processing, as for instance under the heading Computer Integrated Manufacturing (CIM) in industry several years ago should thus be continued, intensified and redirected towards a new focus, particularly for the AmI age.

OVERALL IMPLICATIONS FOR INDUSTRIAL WORK

When analysing the implications for industrial work across the examined drivers for change, it is particularly striking that all the developments in terms of future formal qualificational requirements of German industrial companies point out a rather alarming »double dilemma«. On the one hand, simple and less know-how intensive tasks which can be carried out by *less qualified employees* will be *even less demanded* by the manufacturing industry *in the future*. On the other hand, it is quite obvious that *the increasing demand for academics and graduates from technical colleges* will increasingly become more difficult to meet. The first is due to the developments described in the following:

> As a result of the increasing *internationalisation* of value adding in industrial companies, simple tasks for less qualified employees will be executed to a higher extent than already today, either in a comparatively highly automated and thus less personnel intensive way still in Germany or – especially in the case of mature products and processes – in countries with lower labour costs.
> As a result of the *inner tertiarisation*, all the findings indicate that product-related services of industry, contrary to many other kinds of services, are dependent on highly qualified personnel. With the companies being increasingly oriented towards the offering of product-related services, the share of employees with a degree from university, college or technical school rises whereas semi- and unskilled workers are less in demand.
> *Market-oriented organisational structures* of companies do not (yet) involve a reduction in the share of semi- and unskilled workers in these companies. In-depth analyses of the Delphi survey »Manufacturing Visions«, however, clearly indicate that a broad utilisation of knowledge-intensive production systems with a share of less than 10 per cent unskilled or less skilled workers in total employment is regarded as realistic in the future.
> The impact of *team work* on the qualification profile of the employees, howe-

ver, seems to be rather limited. Nevertheless, the utilisation of team work has a significantly negative impact on the share of semi- and unskilled workers in total employment, however, in terms of scope this effect seems to be rather weak.

> Due to the inherent knowledge intensity and the great importance of research and development, *biotechnology and nanotechnology* in industrial work require highly qualified personnel, particularly adequately trained academic personnel and technical assistance trained and educated successfully in the training programmes of the German dual system. Thus it is not to be expected that positive employment effects for less or unskilled workers might evolve in this field.

> As a result of the introduction of industrial *Ambient Intelligence (AmI) applications* there are signs indicating that further and enlarged technical opportunities for the automation of simple control, monitoring and other manual tasks might evolve which might lead to a substitution of simple tasks with low qualification requirements.

Summing up, the developments described above give rise to the fear that German *industry so far being an important supplier of also simple tasks will cease to offer these jobs for less qualified employees* and will thus compensate less for the labour market of lowly qualified personnel than it has done so far. Hence, the question arises how in co-operation with trade unions and tariff parties adequate *approaches towards demand-oriented qualification programmes for less qualified personnel* taking into account the concrete demands of industry can be further promoted. On the other hand, it should also be systematically analysed and monitored whether in the future, besides the manufacturing industry, other sectors such as for instance specific services or SMEs (handicraft companies for instance) might develop a *higher absorptive capacity for less qualified employees* and under which conditions and with which concepts this might be stimulated.

The other side of the double dilemma shows when having a comprehensive look at the future demands for highly qualified personnel. Already today it can be clearly seen that the *increasing demand* for university and technical college graduates will become more difficult to meet as the lack of graduates and skilled employees, particularly in the case of engineering, natural and economic sciences will be aggravated further by the demographic change. This bottleneck situation will be further aggravated by the following developments.

> In the future, the competition for excellent heads, particularly for highly qualified specialists and managers with an *engineering or business studies profile* will, even more strongly than already today, be conducted *internationally* and across different locations. SMEs particularly suffering from a lower potential »attractiveness as an employer« compared to large companies and their re-

stricted possibilities to pay attractive salaries, will increasingly be confronted with severe recruiting problems. There is also a marked and significantly positive correlation between the increasing *inner tertiarisation*, the *market-oriented structures of organisations* and the demand for university and technical college graduates from engineering and business studies, for instance in the fields of consulting, service, research, development or construction.

> Due to their high knowledge intensity and the large importance of research and development, industrial applications of biotechnology and nanotechnology as well as to some extent applications of *Ambient Intelligence (AmI)* require highly qualified personnel, particularly academic personnel from natural and engineering sciences as well as adequately trained technical assistance with a training from technical colleges or the German dual training system. Already in a mid term perspective of about five to ten years, in biotechnology enterprises the demand for qualified personnel will increase and change in qualitative terms as a result of the expected growth and the stated expansion plans. As regards the industrial application of nanotechnology and AmI concepts, further lags in time ranging from about five to ten years will be feasible.

With a view to the developments described above, education, economic and labour market politics are called to confront and *counter consistently* the shortage *of academics with an engineering, natural and economic sciences background* evolving in the mid term. All means to prevent or reduce the conceivable bottlenecks are to be taken into account and put into effect, either by creating more attractive frameworks and conditions for studying, measures for recruiting skilled employees from abroad or generally increasing the attractiveness of challenging jobs in industry. By active communication and corresponding concerted measures, industry and politics must succeed in inspiring more young people to choose industry relevant courses of study in the future, particularly in the field of engineering, natural sciences and economic and business studies.

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