CONTRIBUTIONS TO MANAGEMENT SCIENCE

Constanze Clarke

Automotive Production Systems and Standardisation

From Ford to the Case of Mercedes-Benz

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and Standardisation

Contributions to Management Science

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1 Introduction

In January 2000, Mercedes-Benz started to implement the Mercedes-Benz Production System (MPS) throughout its world-wide passenger car plants. This event is exemplary of a trend within the automotive industry: the creation and introduction of company-specific standardised production systems. It gradually emerged with the introduction of the Chrysler Operating System (COS) in the mid-1990s and represents a distinct step in the process towards implementing the universal principles of lean thinking as propagated by the MIT-study. For the academic field of industrial sociology and labour policy, the emergence of this trend seems to mark a new stage in the evolution of the debate about production systems in the automotive industry (Jürgens 2002:2), particularly as it seems to undermine the stand of the critics of the one-best way model (Boyer and Freyssenet 1995).

The introduction of company-level standardised production systems marks the starting point of the present study. At the core of it is a case study about the Mercedes Benz Production System (MPS). The goal of the study is to contribute to the debate about production systems by examining the social and economic implications of the role of standardisation in production systems: at the centre of this study are, on the one hand the analysis of the driving forces behind the evolution of company-specific standardised production systems; on the other, from the perspectives of control and power, the analysis of the effects of standardisation on the shop floor. Thus resulting, I will focus on three core questions.

First, what are the driving forces behind the changing forms and functions of standardisation and what role do institutions play in this process? Second, what impact does standardisation have on the evolution of production systems in the automotive industry? Third, derived from Adler and Cole's notion of the "learning bureaucracy" (Adler 1993:198, Adler and Cole 1993), how do standards influence the work of actors on the shop floor: do standards contribute to organisational learning processes or do they continue to serve as control tools intended to regulate the work of actors on the shop floor ?

The first two questions will be examined in two parts based on historically-genetic arguments, with the first part focusing on the rise of standardisation driven by the changing forms and functions of standardisation and the role of institutions in this process; the second part explores the role of standardisation in the evolution of production systems in the automotive industry.

The third question about the influence of standardisation on the work of actors on the shop floor in terms of learning and control will be examined on the basis of my own empirical research and surveys I conducted as part of the company-focused case study of the Mercedes-Benz Production System (MPS).

The introduction of standardised production systems in the automotive industry is part of a far more widespread trend witnessed today: the proliferation of standardisation. The underlying dynamics of this process, according to Power is the need that increasingly "performance must be constructed in such a way that it can be measured, audited and communicated to external agencies in a legitimate, rational form" (Power 1997:114). This process thus seems to signal a change in the driving forces of standardisation: first, in the changing form and function of standards and second, in the role institutions take as standard setters in this process. To examine the former, in my view, it is important to trace the evolution of standardisation from providing standards for the production of interchangeable parts, time and motion standards, recruitment selection standards, skills standards, training and pay standards and quality standards, to process standards today. Of particular importance is the expansion from product quality standards to process quality standards and subsequently, the analysis of the central role standards have for production systems.

Concerning the dynamics driving this evolution of standardisation, one has to consider what role standard setting institutions have played in this process and how it has changed in the course of time. Historically, primarily external institutions have used standards to achieve particular aims: to protect national products from minor quality imports, to raise quality awareness, and to improve the competitiveness of companies, to reinforce centralised structures within companies, and to ensure the harmonisation of processes throughout multi-plant global operations. The introduction of company-level production systems seems to mark a shift from the dominance of external institutions as standard setters, to the dominance of companies as standard setters.

This shift also signals a change in the form and function of standardisation and its impact on production systems. Historically, three distinct models for production systems have emerged: a Fordist-Taylorist model (mass production model), a model based on Volvoism and a Toyotism based model. Obviously, this represents a rather simplified, ideal-type of differentiation. However, these three models (and variations thereof) continue to dominate and influence the organisation on the shop floor and throughout companies, today. The introduction of standardised production systems though raises the question as to which of the three models has evolved as the major de facto standard model of production systems in the automotive industry. Related to this question of the dominant model of production systems is the effect the implementation of such a standardised production system has on the actors on the shop floor.

Standardisation has been surrounded by controversy and the current debate about standardisation and production system continues to reflect this. Standardisation is primarily associated with Taylorist standards. Based on time and motion studies, standards represent "one best way" of scientific principles of work. Standards are thus seen to primarily serve as regulatory control tools curbing the freedom of actors to individually organise their own work.

In contrast, Adler and Cole argue that the combination between standardisation and the continuous improvement process approach facilitates organisational learning: standards represent temporary best practice solutions which workers on the shop floor can refine. In doing so, their know-how and experience is tapped, incorporated into the standard, and thus shared throughout the organisation. Based on two surveys conducted as part of the case study of the Mercedes-Benz Production System, I will examine to what extent Adler and Cole's argument holds true and the effect of implementing a standardised company-specific production system does indeed facilitate organisational learning and the inclusion of the shop floor know-how and experience.

1.1 Theoretical perspective and literature

The remaining part of this introduction is divided into three parts and is intended to give an overview of the most relevant theoretical perspectives and literature of this study, the research methodology and approach used, and a chapter overview.

After placing the study in an academic context, in the first part, I shall introduce the major literature on standardisation and discuss the relevance of the theoretical perspectives raised in the labour process debate and the theory of institutionalisation. Rounding off this part is a presentation of the core literature on production systems and the relevance of organisational learning as theoretical perspective. In the second part I shall outline the research methodology and approach used. Concluding the introduction to the study, I will give a brief chapter outline.

As introduction to the literature and theoretical perspectives of this study, I will first indicate where the study is located from an academic perspective.

This interdisciplinary study is placed primarily within the spectrum of industrial sociology and production management. From the perspective of industrial sociology it follows in the footsteps of the debate about industrial systems and industrial societies rooted in the works of Durkheim (1893) and Weber (1924), and continues the tradition of examining the interaction between social and technical systems as initiated by the Hawthorn Studies and the notion of socio-technical systems related to the studies of the Tavistock Institute. More currently, it reflects the direction of the discussion about the social aspects within production as discussed by Jürgens (1989, 1993, 1997, 2002), Kern and Schumann (1994), Springer (1999).

The study is also placed within the theoretical spectrum of production management, as it focuses on the design and control of systems responsible for the productive use of raw materials, human resources, equipment and facilities in the development of a product (i.e. in this particular case, the production processes within the automotive industry). Viewing production operations and standards as part of a system, the study continues in the tradition of Bowman and Fetter (1957) and Buffa (1961).

1.1.1 Standardisation and the labour process debate

Standardisation has been a contested issue based on the seemingly irreconcilable arguments that on the one hand standards are needed to regulate issues such as emission standards, health and safety standards and food quality standards; on the other though, this regulatory character of standards curbs individuality and flexibility and is often associated with highly bureaucratic structures.

Concerning standards on the shop floor, standardisation has reached its climax during Taylorism and Fordism. Standards regulate the sequence of tasks the worker has to perform, and based on time and motion studies, a one-best way standard dictates the worker how to perform these tasks. As a result, the worker (subject) is separated from the work (object) which he no longer controls. The worker is thus reduced to a "self-serving cog in an industrial machine" (Badham and Jürgens 1998:36). Alienation occurs as standards divorce the object of work (the task) from the actors (subjects) on the shop floor: work is no longer meaningful but individual creativity is repressed for the sake of industrial productivity. As Worthy put it, by treating actors as "means" and as "categories of status and function rather than as individual," this resulted in the "consequence of destroying the meaning of work itself" (Worthy 1959:70). This type of work organisation is associated with the alienation image (Badham and Jürgens 1998:40) primarily derived from the theories of capitalism, critiques of institutionalised authoritarianism (Badham 1986, Clegg 1990), and primarily the labour process debate, as I shall now outline.

The labour process theory (initiated by the publication of Braverman's *Labour and Monopoly Capital*, 1974) historically traces the notion of control back to the rise of the factory system, when workers were no longer the masters of the processes on the shop floor. Instead, capitalists controlled the means and organisation of production. Standardisation played a key role in this process. First, the standardisation of parts eroded the function of the traditional craftsmen. The reproduction of identical parts no longer necessitated their skills. Thus, the production organisation became controlled by those who owned the means of production instead of those owning the skills and knowledge of production. This shift of control occurred parallel to the expansion of standardisation from product parts to the standardisation of work processes. Through Taylor's *Principles of Scientific Management*, the first publication which formalised the concept of one best way standards of work, time and motion standards, standardisation became institutionalised.

The significance of standardisation, particularly standards concerning the protection of workers health and their acquired rights, had been raised by union representatives before the rise of Taylorism. Of particular relevance, for example, was the fight for standard working hours (the *British Factory Act* 1833)[1], the fight for

[1] The Factory Act, 1833 was an attempt to establish a normal working day in a single department of industry, textile manufacture. The way in which it proposed to do this was the following: The working day was to start at 5.30 a.m. and cease at 8.30 p.m. A young person (aged thirteen to eighteen) might not be employed beyond any period of twelve

standards concerning breaks (driven by the textile industries in Britain and enshrined in the 1874 *British Factory Act* regulating a 30 minute break per day) and standards regulating the minimum age of workers (primarily to protect child labour, see the 1891 *British Factory Act* raising the minimum age at which a child can be set to work from ten to eleven). Many of these issues had been fought out in Britain, particularly in the textile industry, well before the rise of Taylorism. This also applies to standards concerning the regulation of health at work, such as for example standards regulating heating, lighting and air conditioning standards, the treatment of hazardous substances, physical strain caused by work, including an entire range of ergonomic standards for the prevention of work related illnesses as first formulated in his *Outline Of Ergonomics, Or, The Science Of Work Based Upon The Truths Drawn From The Science Of Nature* (Jastrzebowski, 1847).[2]

Concerning the role of unions in Taylorism, time and motion standards are of particular relevance. On the one hand, these standards ensure that a specific efficiency level is achieved (standard number of units produced), on the other though, they protected workers from the pressures existing on the shop floor, specifically from the threat of "speeding up" (increasing the speed of the mechanically controlled assembly line). Conflicts concerning "speed-up" represent a classical cause for strikes in the labour relations in the USA and became subsequently regulated by collective wage agreements.

In Germany, time and motion studies became regulated in the collective bargaining agreements between employers and unions (as reflected in the Steinkühler collective wage agreement of 1982, Jürgens, Malsch, Dohse, 1993) and are thus subject to integration of works council representatives (co-determination). In order to prepare these union representatives for their role in the decision making process, they underwent the Industrial Engineering training as offered by the REFA and hence learned the methods and work practices of the Industrial Engineers at first hand. The intention to control the standard setting function of the Industrial Engineers (time and motion standards) by both employers and worker representatives, was particularly evident in the industrial nations in the West. Thus the influence of the Industrial Engineer to control and improve speed and standards at work gradually declined. Instead, standardisation, time and motion, and ergonomic standards and became key subject to the conflicts and negotiations between unions and employers.

Therefore, during the 1980s, the entire functional area of Industrial Engineering, as discussed in *Breaking from Taylorism* (Jürgens, Malsch, Dohse, 1993), became subject to management reform. Subsequently, lean production represented a welcome opportunity for deregulation.

The position of the unions' policy on standardisation served to protect workers in their working environment. Standards form this perspective represent preventa-

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hours, less one and a half for meals; and a child (aged nine to thirteen) beyond any period of nine hours. From 8.30 p.m. to 5.30 a.m.; that is during the night; the employment of such persons was altogether prohibited.

2 Ergonomic standards became formally institutionalised much later with the founding of the British "Ergonomics Research Society" in 1949.

tive measure to ensure a safe working environment. Continuing to fight for the continue use of these standards, unions also assures the protection and defence of the acquired rights of workers. Insofar, this position is in juxtaposition to Adler and Coles view of standardisation, particularly as tool facilitating organisational learning (learning spiral). Thus, role of the unions in a discussion about the forms and functions of standardisation is certainly a key complement, which so far has received little research attention. However, is less concerned with my research interest of examining the influence of standardisation in terms of learning on the shop floor.

Exemplified by the case of the Mercedes-Benz Production system, I will examine this issue by focusing my analysis on the influence standardisation has on workers on the shop floor, particularly in terms of learning and the inclusion of tacit knowledge into standards.

1.2 Aspects of standardisation

1.2.1 The trend towards a standardisation of standards

Despite its controversial nature though, during the course of history, standardisation has gradually penetrated all areas of life, up to a point where they are finally ingrained in our social values and cultures. Today, at the brink of the new millennium, we witness a) a proliferation of standards and b) at the same time a standardisation of standards: be it the number of different standard paper sizes, the A4 size has become the standardised standard; be it the number of European currencies, the Euro has become the standard currency for Europe; be it the number of standards quality management systems developed, the ISO 9000 has become the standard of industry-wide quality management system.

In general, we observe that the number of standards regulating our lives, and social and working processes have increased. This extension of standardisation seemingly confirms a key notion raised in Habermas' early work about the rising dominance of the normative, instrumental world (Habermas 1968). This spread of standardisation "indicates its extreme pervasiveness in modern society" also according to Brunsson and Jacobsson (2000:7).

To take an analogy: it no longer depends on where you are around the world, the spread of the standard ingredients of, say, the Hamburger means that by adhering to this recipe, it no longer matters if a chef in Peking, Berlin, New York or Rio prepares this dish: its taste, at least in theory, should be the same. In other words, standardisation creates "global uniformity" (Brunsson and Jacobbson 2000:1). By adhering to standards, our international chefs ensure that their dishes taste as well as the original: the adherence of standards is therefore inherently linked to the assumption of ensuring the correct, good quality. But how can constant quality be achieved?

1.2.2 De facto and formal standards

In order to produce standard quality, a common document listing details of the content and form of standards is needed. The closest to such type of document is provided by the International Standards Organisation (ISO) which proposes the following attributes of standards:

- "A written document, accessible to the public
- A document established by a method drawing on consensus in the general interest
- A document intended for repetitive and common application
- A document approved by a recognised body
- A document which relies on the achievements of science, technology and experience
- A non-obligatory document by its very nature" (Hesser and Inklaar, 1998: 36-37)

The aspect of formalisation in this definition helps to distinguish between informal, unwritten, commonly used de facto standards on the one hand, and formal, written, normative standards. De facto standards evolve informally as more and more actors adopt them. Be it a product, process or even a particular social behaviour, once accepted as a common fact, it becomes a de facto standard. This is for example the case with Microsoft "Word" which has emerged as the standard, de facto word processing programme: only over a period of time and through widespread usage it evolved as a customary de facto standard. The second type, normative standards, are already created with the purpose to norm. Unlike de facto standards which exist, whether legally recognised or not, normative standards are legally binding, once they are part of contractual obligations.

This distinction between de facto and normative standards is also particularly relevant for production systems as it helps to differentiate between informal, commonly used practices as part of the shop floor knowledge (the tacit dimension), and formalised standards.

Both, de facto and normative standards though have one common denominator: they regulate. The regulating function of standards ensures co-ordination and co-operation (Brunsson and Jacobbson 2000:1). Mintzberg, for example, considers the "standardization of work processes, standardization of work output and standardization of work skills" as part of the five core mechanisms which serve to co-ordinate organisations (Mintzberg 1983:4). Thus, standards can be considered control instruments. An interpretation also confirmed by Brunsson and Jacobsson, who furthermore distinguish between the regulatory nature of standards, norms and directives. Whereas norms are defined as internalised, unreflected rules that we accept as self-evident part of our lives (for example norms of social behaviour and ethics), directives are mandatory, formalised and written rules (for example, the Civic Law).

1.2.3 Standard setters and institutionalisation

Brunsson and Jacobsson suggest that standards, too, provide rules, but unlike norms, are "explicit and they have an evident source" (Brunsson and Jacobsson 2000:13). As economic actors we thus know who issues the standards, whereas the source of social norms of behaviour are difficult to determine as they were not developed by institutions but instead evolved from generation to generation as part of our cultural heritage. The authors also stress the voluntary nature of standards as prerequisite that "standardisation presupposes an ability on the part of the adopter to act independently" (ibid.:6). The success of standards hence depends on the willingness of the economic actors to adapt them. Thus, standardisation can only be achieved if people are willing to accept a standard. The greater the number of people willing to adopt a standard, the stronger the degree of standardisation.

To differentiate between the different role actors have in the standardisation process, Verman (1973) developed a three dimensional model of standardisation. According to the author, standards cover a three dimensional standardisation space confined by three axis denoting subject, aspect and level of standardisation, as shown in the diagram below.

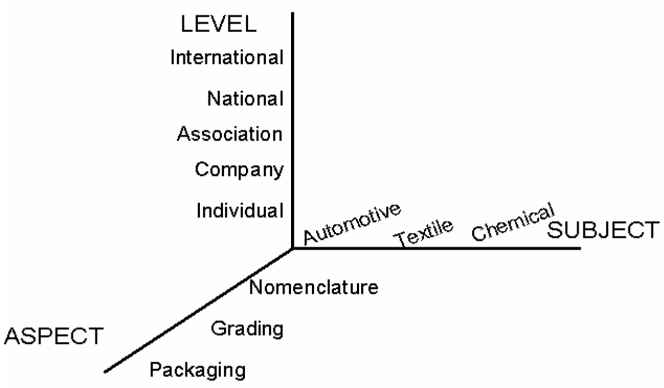

Fig. 1.1. Diagrammatic presentation of Verman's model of standardisation space (source Verman 1976:33)

Along the first axis, the subject of standardisation denotes the type of economic activity regulated by standards such as for example industrial sectors like the textile, chemical or automotive industries. The second axis clusters the various types of standards, for example standards of nomenclature, grading, packaging and labelling. The third axis, the level of standardisation defines the "operational level of a standard" (Verman 1973:34), or put simply "the domain to which a standard may be applicable" (ibid.). Verman suggests a 5-tier division of this domain a ranging from standards applicable to actors, company, the association, a national body and finally an international body.

From the perspective of institutionalisation this differentiation also helps to distinguish between the different levels of the agencies of institutionalisation, ranging from the individual actor developing his own standard working sequence as a routine, to international standardisation organisations like the ISO, setting international standards. These institutions represent building blocks which contribute to the permanency and stability of social and political structures. As such, institutionalisation refers to a process in which social restraints, obligations and circumstances become engrained in society as social rules of acting and behaving, i.e. they become institutionalised (Walgenbach, P., 2000:21). Standardisation serves as a means to efficiently produce predictable results (ibid.:18). The predictability of behaviour standards improves economic efficiency, particularly in form of transaction costs which occur as goods and services are transferred as a result of human action.

In order to curb transaction costs, organisations develop new governance structures. As Williamson deduces, "the modern corporation is mainly to be understood as the product of a series of organisational innovations that have had the purpose and effect of economising on transaction costs" (Williamson 1985:273). With their intention to improve the economic efficiency of processes within and between companies, standards represent organisational innovation and hence the process of the institutionalisation of standards contributes to the reduction of transaction costs. Companies create and introduce their own standards in addition to standards set by external institutions. This is for example the case with the introduction of production systems.

According to Mintzberg, the standard setters in typical "Machine Bureaucracies" (Mintzberg 1983), such as the automotive industry belongs, are located at the level of the technostructure. In his view, "control analysts of the technostructure serve to effect certain forms of standardisation in organisations" (ibid.:15). Distinguishing between the Industrial Engineers as work-study analysts, planning and control analysts and quality control engineers, Mintzberg's definition of the technostructure reflects that the role of standard setters is located in specific departments removed from the actual operative part of the organisation. This view somewhat points towards the continuation of a Taylorist division of labour whereby the standard setting, is strictly divorced from the direct physical work on the shop floor. The standard user is not integrated into the standard setting process and standardisation is a function and a responsibility institutionalised by a few, professional standard setters in the technostructure of the organisation. The opposite of this role of standard setters are highly decentralised "Professional Bureaucracies" in which standards "originate largely outside its own structure, in the self-governing associations its operators join with their colleagues from other Professional Bureaucracies" (ibid.:192). This division shows that the institutionalisation of standards is driven by a relatively limited number of highly skilled professionals working either in technostructure of the organisation or at external standard setting institutions. Insofar, organisation are seen to adapt to "their institutional context" (Meyer and Rowan 1991:48). They do so because they "are driven to incorporate practices and procedures defined by prevailing rationalised concepts of organisational work and institutionalised in society" (ibid.:41). However, as pointed out by van Burg, driven by the competitive mechanisms of the market, companies take an active approach toward institutionalisation of standards (van Burg 2001). Moreover, as Meyer and Rowan pointed out, they "actively seek charters from collective authorities and manage to institutionalise their goals and structures in the rules of such authorities" (Meyer, and Rowan 1991:49). This step involves that "their immediate relational networks" adapt the organisation's own structures and procedures. According to Fligstein, companies thus have "differential power to dictate the actions of others in any given field" (Fligstein 1991:314). The author adds that the co-operation within the industry and across competitive boundaries is achieved as "members benefit from the formation of stable rules governing legitimate actions in the field" (ibid.).

1.2.4 Globalisation: driving force for the institutionalisation of standards

One major driving force underlying the process of standardisation in the economy is that the introduction of standards results in a simplification and economisation of management functions, particularly as companies pursue globalisation strategies and set up international multi-plant organisations. The management of national, country-specific or plant-specific differences is eased as standardisation creates uniform processes and procedures.

In the case of Toyota, the development and adherence of company-specific standards throughout its international production facilities eased the transfer of Toyotas manufacturing principles from its Japanese production facilities to its international plants. Be it the plant layout, the JIT delivery system or the Kanban, standardised operating procedures help to harmonise the manufacturing processes of global operating companies (Hofmann 2000:5). Personnel rotations, changes in production location, and performance comparisons are harmonised, potentially making management more economically efficient.

As standards reduce the variety of practices, they harmonise operations, an effect which also contributes to cost reductions and greater economic efficiency. Organisational learning and the continuous improvement of processes play a key role within this process. If companies consider standards not as fixed but as temporary best solutions, encouraging staff to constantly refine and improve standards, standardisation contributes to creating a climate of organisational learning. As a result of this constant improvement, the simplification and harmonisation of processes, standardisation creates stable processes within multi-plant companies. The creation of robust processes is a key driving force behind standardisation, as it warrants quality consistency of products. Through standardisation, production processes are stabilised and become more robust, thus ensuring constant output and constant quality. This applies to both processes inside companies, but also at the interface between companies and their suppliers.

Deploying global sourcing strategies, companies increasingly rely on suppliers. The key considerations in this outsourcing process are to enable a smooth coordination of interface processes. To do so, companies and suppliers need to share common standards regulating production processes at these points. They also need common control systems, such as audit and certification systems, to check that these standards are adhered to.

1.2.5 Standardisation and certification systems

The introduction of standardised audit and certification systems, limits the risk underlying outsourcing and global sourcing. Standardisation thus acts as a liability assurance system, as companies select suppliers on the basis of their certification which signals that the supplier adheres to generally accepted standards.

Also, companies gain a competitive advantage once their company-specific solutions (be its products or technical specifications) is accepted as industry-wide standard (Brunsson and Jacobsson 2000:9). From the perspective of the economic theory of standardisation, this is explained by the increasing rates of return or Metcalfe's Law, which means that companies benefit by adopting more widespread standards, instead of opting to use highly individual standards. Although, van Burg cites the specific example of network externalities, the economic theory of standardisation may be transferred to the case of production systems in the automotive industry. As pointed out above, three major production system models and variations thereof continue to dominate the automotive industry. According to van Burg though, "a single winner is likely to emerge because as a network becomes larger and exponentially more beneficial, positive feedback mechanisms kick in, with the result that the leading network drives out smaller rivals" (Van Burg 2001:11). Once this winning model has emerged it represents the best-practice standard. Best practice standards are selected during a benchmarking process. According to Strassheim benchmarking is defined by a certain style of politics that legitimizes political decisions in terms of best practices" (Strassheim 2001:1) and for Naschold (1995) and Naschold and Bogumil (2000) benchmarking represents a tool which serves to counter the irrationality of political processes with the rationality of political planning. Applied to the context of production systems, through the seemingly neutral benchmarking process, best practice standards are identified and thus become legitimised as de facto standards. To control if standards are implemented by actors, the institutionalisation process relies on audits as control tools. According to Meyer and Rowan, "evaluation and inspection are public assertions of societal control which violate the assumption that everyone is acting with competence and in good faith" (Meyer and Rowan 1991:59) and, in accordance with the standards set by institutions.

The success of implementing standardised systems is checked by audits. In these audits the extent to how far standards are actually implemented is examined. However, what guarantees that the actors on the shop floor do actually follow these standards every day? Through the audit system examining and investigating the extent to which standards are being practiced, the work on the shop floor is controlled and regulated. According to Power (1997), the "increasingly prominent role of internal control systems" is linked to the concept of governance (Power 1997:41) which apart from determining the choice between centralised and decentralised structures, "is about regulating the relationship in complex systems" (Rhodes 1994:151). Thus control is pushed further into organisational structures, "inscribing it within systems which can be audited" (Power 1997:42).

Standardisation plays a key role in the evolution of production systems in the automotive industry as I shall outline in the next part.

1.3 Production systems

Concerning the term "production system", there is no consensus as to a commonly accepted definition (Jürgens, 1999). According to the Encyclopædia Britannica a production system is "any of the methods used in industry to create goods and services from various resources" (Britannica online 2002).

A comprehensive definition of production system is given by Bösenberg and Metzen (1992) acknowledging the inherent complexity of a production system by relating the term to intellectual, political and corporate laws, an approach which hence defines the term production system as a complex system concerning organisational structures with the human being at its centre. It elements consist of guidelines, principles of work, new organisational structures, strategies describing core business tasks, scientific methods and principles of industrial engineering as well as a number of pragmatic tools for all staff. (Bösenberg and Metzen 1992:7)

Boyer and Freyssenet suggest that underlying the development of production systems is a:

> "process of making the technical organisation and economic practices and systems of firms internally coherent and externally viable with the goal of reducing uncertainties related to the market and work, and able to reveal general principles applicable to a variety of geographical spaces and able to ensure a certain level of predictability in the firm's evolution over time, to the point of leading to a series of macroeconomic and societal configurations. " (Boyer and Freyssenet 1995:113)

Skinner (1985) provides a more tangible definition differentiating between the components of production system as the tools or "hardware", and organisational elements or "infrastructure" (Skinner 1985:95):

> "In designing a production system, what is being done essentially is to establish a set of manufacturing policies. Manufacturing policies are the means by which the basic structural elements of the system are made consistent and pulled together. Manufacturing policies can be thought of in two parts. The first part has to do with bricks and mortar and machinery. This is hardware or "fixed assets" – the number, capacity, and location of plants and the equipment and process technology. The second part has to do with the infrastructure (integration issue, production planning, scheduling and inventory control, work-force management and quality control). " (Skinner 1985:95)

Argued from a social tangent, production systems represent "a set of new practices and new forms of work and process organisation" (Jürgens 1995:298).

Whereas the Mercedes-Benz Production System (MPS) is defined as "an integrated model of how processes should be designed and sustained within the Mercedes-Benz manufacturing" (MPS 2000:5), Monden's definition of the company-specific Toyota Production system provides a goal-focused perspective stating that "the principle consideration of the Toyota production system is to reduce costs by completely eliminating waste." (Monden 1983:2). Jürgens, Malsch and Dohse (1989) are more specific and define the Toyota Production System as a link between systems of production control and work and social organisation. The thus resulting regulatory system of work, the authors refer to as 'Toyotismus'". (Jürgens, Malsch, Dohse 1989:44). They stress that Toyotism is based on the complementarities of a certain degree of self-regulation and a closed system of social integration and social control (ibid.). Insofar, the social organisation and above all the work organisation correspond with the process chain (Jansen and Jürgens, 1999:35). There are two key aspects denoting the function of production systems. On the one hand, production systems are set in context with overall goals resulting from the corporate strategy, the market and regulatory environment; on the other, production systems serve as structural patterns to order and organise organisational processes, including social processes (Jürgens 2002: 2). In other words, production systems provide the structural framework for regulations and standards concerning organisational and social processes. More figuratively, production systems are like an empty wardrobe with selves and coat hangers, in which shirts, trousers and other clothes can be grouped, hung and folded up. Thus, the production systems provide the framework and structural outline in which organisational rules are filed into.

Of key importance is the impact these structures have on social processes. This link is strongly reflected in the industrial sociology debate on the production systems, as I shall outline now.

1.3.1 The industrial sociology debate on production systems

Historically, three distinct production paradigms have emerged: a model based on Taylorism and Fordism, a human-centred reflective model based on Volvoism, a lean production model based on Toyotism. As pointed out above, obviously this differentiation is somewhat simplified, and in practice, a number of variations of these three models exist.

The first model emerged as the introduction of standardised parts signals a shift from the early "American System Of Manufactures" (Hounshell 1984, Nelson 1974, Skinner 1985) to the introduction of scientific principles of work by Taylor (Waring 1995), Rabinbach 1990). Taylorism supported and eased the introduction of Ford's system of mass production and subsequently the first production paradigm based on Taylorist and Fordist principles, evolved. Set by Industrial Engineers, standards are externally generated, are static and occupy a central place in this model. Time and motion studies, short and highly repetitive cycles characterise this model. The shop floor know-how is not incorporated into decisions concerning the work content, structure and process optimisations. As pointed out above, this give rise to the alienation image of work and thus a body of literature focusing on the effect of Taylorism and Fordism on social and human aspects of work (Asher and Edsforth 1995, Gartman 1986, Meyer III 1981) and has initiated the industrial sociology debate about the impact of production systems on the actors on the shop floor and social aspects of work during the first half of the twentieth century.

Following in the tradition of the human-relations school and the Hawthorn Studies, social science research focused on examining the social impact of Taylorism and Fordism on the actors on the shop floor. This debate was initiated by Georg Friedmann's book *Où Va Le Travail Humain?* (1950). In context to labour studies, the London Tavistock Institute developed a so-called socio-technical systems approach at the end of the 1950s (Trist 1956, 1959, later Emery 1969). This concept was established to stress the interrelation between man and machine and to develop systems which would reconcile both, economic efficiency and the social conditions of work. This concept radiated throughout Europe and led to the introduction of human-centred production systems such as envisaged by the programme on the "humanisation of work" (HdA) in the 1970s which was jointly supported by the German government and unions (Forschungsinstitut der Friedrich Ebert-Stiftung et. al. 1982; Badham and Naschold 1994).

The socio-technical systems approach led to the "Swedish Revolution" (Agurén and Edgren 1983) and subsequently to the development and introduction of the reflective production system at Volvo Uddevalla in the 1990s. It is characterised by deliberately rejecting the use of standards to regulate work. Volvoism gives the individual worker and teams the freedom to organise their work autonomously. Instead of the highly fragmented work based on Taylorist time and motion standards, teams determine the working speed and the work content is based on holistic tasks and long cycles (Ellegård 1995, 1997, Berggren 1992, Rehder 1992, and Medbo et. al. 1999, Jürgens, 1990, 2000, and Cattero, et. al. 1995).

The late 1980s saw the peak of the success of the Japanese automotive industry. Focusing primarily on an analysis of the automotive industry as the "locus classicus of the new model of production" (Jürgens 1999:5), exemplified by the Toyota Production System (TPS), the most widely publicised study was the Michigan Institute of Technology (MIT) study by Womack, Jones and Roos (1990). Previously, Jürgens, Dohse and Malsch (1985, 1989) had analysed Toyotism and Kenney and Florida (1993), along Dohes and his co-authors explore Toyotism as a "more advanced and exploitative version of fordism - a hyper-fordism" (Kenney and Florida 1993:123).

Toyotism continues in the tradition of the Taylorist-Fordist model, but is not a remake thereof because it introduces a range of new key concepts which clearly distinguish Toyotism: standards are internally generated and through the system of continuous improvement evolve dynamically; work content despite continuing to be based on highly repetitive tasks and short working cycles is team oriented. Processes such as just-in-time mechanisms determine, amongst others, the working speed (Fujimoto 1999, Monden 1993, Ohno 1993, and Jürgens and Nomura 1995, Jürgens 1993, 1994, 1995, Cusumano 1985, and Shimizu 1995).

The impact of Volvoism, the debate about the humanisation of work (HdA Programme) and the introduction of highly automated production processes (automisation), in Germany gave rise to the discussion about "new production concepts" (Kern and Schuman 1984). A key focus in this discussion was the technological impact on the work on the shop floor and the tendency of a "reprofessionalisation" of work as proclaimed by Kern and Schumann in their book *The End of the Division of Labour*, 1984. A second focus was on the introduction of team-based structures on the shop floor, which was initially met with scepticism from management as well as unions (Jürgens 1995:202ff) but as the studies of Gerst et al. (1999) have shown contribute positively towards worker satisfaction, in the meantime.

Among others, research by Durand (1999) has shown that there are considerable differences of the notion of Japanese-based teamwork within and between national contexts. These differences also apply in context to other elements of lean production focused systems, as pointed out in the study of Altman, Endo, Nomura and Yoshida (1998). The analysis of the differences arising from the adoption of production systems (particularly of lean production based systems) is subject of the research conducted by the *GERPISA* programme (Groupe d'études et de recherche sur l'industrie et les salariés de l'automobile). Its prime focus is on issues of adoption and transfer of production systems and the rise of hybrid forms of production systems. This is reflected in the publications of the *GERPISA* programme such by Boyer, Charron, Jürgens and Tolliday (1998), Boyer and Freyssenet, (1995), Abo (1994, 1999).

A key strand of literature thus evolving has been concerned particularly with the evolution of production systems, standardisation and organisational learning, also a key concern of this study, as I shall point out in the following part.

1.3.2 Production systems, standardisation and the theory of organisational learning

In the literature on learning and knowledge, organisations are assessed by their ability to effectively disseminate and generate information. The management of information and knowledge have become important factors for measuring productive efficiency (Lippert, Jürgens and Drüke 1996:238). Picot (1990) claims that they represent additional evaluative factors, Stehr (1994) goes even as far as suggesting that they have replaced traditional factors determining productivity.

Learning and the dissemination of knowledge represent key reasons cited to explain the success of Japanese production management techniques and their production systems. Nonaka and Takeuchi (1995) propose that Japanese companies have become successful because of their skills and expertise at "organisational knowledge creation" (Nonaka and Takeuchi 1995:preface). According to the authors, this denotes "the capability of a company as a whole to create new knowledge, disseminate it throughout its organisation, and embody it in products, services and systems" (ibid.). They stressed the importance of the transfer of tacit knowledge into "articulable knowledge" (ibid.:33).

This concept of tacit knowledge had previously been developed by Polanyi (1983). At the core of his work, *The Tacit Dimension*, lies the assumption that all knowledge stems from experience. In Polanyi's words,"we know more than we can tell" (Polanyi 1983:4). Cognition is seen as interplay between explicit knowledge and implicit, tacit knowledge. However, Polanyi distinguishes between these two dimensions by suggesting that all knowledge derives from tacit knowing. As such it is logically superior to explicit knowledge and thus the anchor of explicit, inferential knowledge. Building upon these concepts, Nonaka deduces that the dynamic potential of Japanese companies and their continued market dominance is founded on their ability to create structures which facilitate this "externalisation" of "tacit knowledge into explicit concepts" (Nonaka and Takeuchi 1995:64). This knowledge then is shared throughout the entire organisation stimulating the generation of further knowledge.

I shall examine to what extent this concept of learning and the inclusion of the shop floor know-how challenges the view of standardisation in terms of controlling the work of actors on the shop floor. Focusing on the analysis of the role of standardisation in production systems, I shall juxtapose the arguments of the labour process debate with the arguments put forward in the discussion about learning organisations. Whereas the labour process debate considers the function of standards to control work, the theories of learning propose that standardisation offers an opportunity for workers to contribute their know-how and experience, thus tacit knowledge become transferred into organisational standards. These in turn are disseminated and shared throughout the company; a process which then drives organisational learning.

Following Fujimoto, this link between standardisation and learning is one factor which has also contributed that the TPS has become established as the de facto standard of production systems for the automotive industry. Defined by Fujimoto as Toyota's ability to "change the manufacturing system in a frequent and regular manner to improve functionality" (Fujimoto 1999:18), "routinised manufacturing capability, routinised learning capability and evolutionary learning capability" (ibid.:17) are key concepts promoted by the TPS.[3]

For the analysis of the link between standardisation and learning, I shall put focus on the role that routinised learning capability plays. According to Fujimoto it

[3] Routinised manufacturing capability, such as for example poka-yoke (foolproof prevention of defects), jidoka (automatic defect detection and machine stop) or andon (real-time feedback of production troubles) consist of "sets of routines that jointly enhance the accuracy of repetitive information transmission on the shop floor, through the production process to the products themselves" (Fujimoto 1999:17). Routinised evolutionary learning capability is seen as the ability "to cope with a complex historical process of capability building – or multi-path emergence – that is neither totally controllable nor predictable." (Fujimoto 1999:21) It hence defines organisational learning in terms of how effectively a company manages to learn from its "intended and unintended actions." (ibid.) Specifically, it concerns a company's preparedness for continuously challenging its own standards, for "reinterpreting, refining, and institutionalising those routines that have become established for whatever reasons. " (ibid.:23)

refers to "a set of organisational routines that affect the pace of continuous or repetitive performance improvements, as well as recoveries from system disruptions and deterioration" (ibid.). Thus, Fujimoto considers learning as part of an organisational routine. To distinguish between the different standards used to facilitate organisational learning, Fujimoto differentiates between three types of learning routines: routines for problem identification, routines for problem solving and routines for solution retention (ibid.:19). Whereas routines for problem identification consist of "stable practices that reveal and help visualise problems" (ibid.), routines for problem solving refer to the "ability to search, simulate and evaluate alternatives" (ibid.), and routines of solution retention concern the "ability to formalise and institutionalise new solutions in standard operating procedures, thereby providing stability for individuals who internalise solutions" (ibid.).

1.3.3 Standardisation between control and learning: Adler and Cole versus Berggren

The link between organisational routine and learning is also documented in the so-called "clash of images" (Jürgens and Badham 1998:43), a controversial discussion in the social science debate about the effect of standardisation of work on the shop floor, fought out between Adler and Cole (1993) and Berggren (1994). It documents the clash between the human-centred production approach and the lean production approach.

The premise is that historically, standardisation has often been associated with the 'bad' image of work: standards representing systematic constraints upon the creativity and freedom of the individual actor on the shop floor, as raised in the arguments of the labour process debate discussed above.

The controversy arises, as Adler and Cole (Adler 1993, Adler and Cole 1993) based on their research at the New United Motor Manufacturing Inc.(NUMMI) joint venture between Toyota and GM, challenge this view and instead propose that the standardisation of processes is a necessary prerequisite for the organisation of work, particularly for the continuous improvement process. Considering the TPS as "democratic Taylorism" (1992), Adler and Cole regard the NUMMI plant as a "learning bureaucracy" (Adler 1993:198) in which standardisation features as an "essential precondition for learning" (ibid.:104). Learning primarily occurs as procedures are "designed by the workers themselves in a continuous, successful effort to improve productivity, quality, skills" (ibid.:98). For the authors, this marks a break with the traditional role of the Industrial Engineer as standard setter because at NUMMI, the workers themselves are responsible for the standard setting process and "they learn techniques of work analysis, description and improvement (ibid.:102). Thus comparing NUMMI and Volvo Uddevalla, Adler and Cole conclude that the former represents the superior model. The argument being that the latter in which standardisation of processes has been replaced by a human centred approach where workers organise their work individually, fails to initiate learning processes which go beyond the working teams or the work shop.

From the perspective of the alienation critique of work, Berggren rejects these arguments and proposes a solution based on integrating Japanese production management and product design with American corporate strategies and European approaches in job design such as empowerment and reskilling (Berggren 1994:44).

As pointed out above, this study intends to examine to what extent Adler and Cole's claims apply in the case of the implementation of the Mercedes-Benz Production System (MPS).

1.4 Research methods and approach

In the following I shall outline the research approach and methods used in the study. The first part focuses on the initial research steps commencing with the literature and documentary review, the second part focuses on the case-study approach used.

1.4.1 Literature and documentary review

This research is based on a three year longitudinal study starting in October 1999. I conducted both documentary and empirical research. Concerning the former, I conducted research at the following libraries: the library of the University of Hohenheim, the library of Stuttgart, the library of the Free University of Berlin, the library at the Social Science Research Centre Berlin, the library and archive of the DIN in Berlin, the Berlin State Library, the Library of the State of Baden-Württemberg in Stuttgart, the Library of the University of Applied Sciences, Esslingen and the DaimlerChrysler library and Archive at the plant Untertürkheim.

Moreover, I drew on company-internal publications and documents of DaimlerChrysler. I thus reviewed all references available, including textbooks, academic papers, professional magazines and newspapers as well as DaimlerChrysler Television broadcasts, internal presentations, speeches given by board members and documents such as minutes and files tracing the evolution of the Mercedes-Benz production system. Emphasis was placed on the most recent material and the sources were critically reviewed. The review also showed what research methods and approaches had traditionally been used in this field (Creswell 1994). It also indicated that an examination of the forms and functions of standardisation in production systems analysed from an industrial sociology perspective represents a new academic contribution in the field (Leedy 1989).

As a result of the literature review, I developed the three research questions, the study addresses and developed a research approach which consists of a combination between a historically-genetic approach and an empirical approach, drawing on both quantitative and qualitative research methods.

Thus, the second chapter focusing on the evolution of the forms and functions of standardisation and the role of standard setters therein, has been written primarily with reference to secondary literature, including classic textbooks and academic articles but also publication by standard setting institutions (ISO, DIN and VDA, for example). In addition, information generated in more than twenty-six semi-structured conducted at standard setting institutions such as the DIN, has been incorporated.[4]

Similarly, the third chapter on the rise of production systems and the role of standardisation is based on a review of secondary literature incorporating textbooks, journal publications and around forty-one semi-structured and unstructured interviews with managers of automotive manufactures other than DaimlerChrysler and also of suppliers has been taken into account.[5] I conducted these interviews at conferences and during a number of plant visits and on the telephone (interview guidelines see appendix). I thus collected information from BMW (plant Munich), Porsche, Opel (Eisenach), VW (Gläserne Manufaktur Dresden); also from interviews with experts at the Deutsche Institut der Normierung (DIN) in Berlin, the chairman and representatives of the REFA Committee Automotive Manufacturing and with experts at Bertrandt, Bosch and Eberspächer.

The fourth and fifth chapters focus on the case study of the Mercedes-Benz Production System (MPS).

1.4.2 The case study approach

The case study is for the social scientist what laboratory experiments are for the natural scientist (Kasanen and Suomi 1987, Smith 1990). Yin (1989) defines a case study from a research perspective as "an empirical enquiry that investigates a contemporary phenomenon with its real life context, when the boundaries between phenomenon and the context are not clearly evident, and in which multiple sources of evidence are used" (Yin 1989:1, 1993).

I chose this method for two reasons. First, my research objective focuses on one specific incident: the implementation of the Mercedes Benz Production System (MPS). According to Bell (1993), the case study approach is particularly suitable for such research objectives concerned with an enquiry around one or a few specific instances or events. Second, I chose the case study approach because the central questions of this present study are concerned with establishing why and how the Mercedes-Benz Production System (MPS) was created and what effect it has once it is being implemented on the shop floor. Yin argues that case studies are particularly "valuable in answering who, why and how questions" (ibid.). This view is also supported by Schramm (1971) who envisages the function of the case study to illuminate decisions particularly why they are taken, how they are implemented and with what result.

However, one also has to point out the draw back of the case-study approach insofar as it introduces a certain bias, a tendency to draw on incomplete evidence (Yin 1989), and is said to lack rigour and objectivity (McCutcheon and Meredith

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[4] The goal was to conduct a minimum of twenty semi-structured interviews.

[5] The goal was to conduct a minimum of thirty such interviews.

1993). Moreover, nothing can be deduced from a single case study (Yin 1989). To counter these shortcomings, I thus integrated a range of empirically focused methodologies such as semi-structured interviews and two surveys into the case study. The result is a longitudinal panel study which draws on a broad content of statistical, sociological and psychological measures.

I followed Dalton's classic single case study approach with the intention of getting a detailed picture of how a standard production system is being created and implemented at one particular production centre at the DaimlerChrysler plant Untertürkeim. The single case study approach is thus used to "interpret this world and its problems from the inside" (Dalton 1959:1). It's strength is "to highlight a construct by showing its operation in an ongoing social context. The result becomes a much more coherent, credible, and memorable story" (Dyer and Wilkins 1991:616).

This case study is based on empirical evidence generated during a longitudinal study of almost three years (October 1999 to June 2002) which I conducted at the DaimlerChrysler AG, plant Untertürkheim.[6] In the role of observer as participant, I accompanied the institutionalisation process of the MPS, from the stages of actually writing it, until its introduction to top management, cascade training, to its actual implementation on the shop floor and its evaluation by the MPS audits.

The research parameters of this single case study are derived from the particular organisational structure and products produced at the Untertürkheim plant. The main product of the plan Untertürkeim is the power train unit used primarily in all Mercedes-Benz passenger cars. The three main components produced in the plant are the axle, the transmission and the engine, and variations thereof such as the V8 and V12 or diesel engines. These products are manufactured in so-called production centres. The case study focuses on examining the implementation of the MPS at the plant Untertürkeim and in particular, at one of the three production centres (denoted throughout the text as production centre Z).

1.4.3 Observational and survey research

For this purpose, I deployed two basic approaches: observational research (Silverman 1994) and survey research (Remenyi, Williams, Money and Swartz 1998). For the observational research, the primary research tools I deployed to generate this information were the following:

- More than twenty-four semi-structured interviews[7] (interview guidelines see appendix) conducted internally at DaimlerChrysler.
- Around fifty-two unstructured interviews (usually based on spontaneous interview opportunities arising at conferences or meetings at DaimlerChrysler).

[6] I was able to accumulate the information for the present study thanks to being deployed as a full-time doctoral researcher for the DaimlerChrysler AG during the entire research period.

[7] The goal was set to conduct at least 20 structured and 50 unstructured interviews and 30 passive observations.

- Approximately thirty-three passive observations (meetings, trainings, conferences) with role of researcher either type 3, observer as participant, or a hybrid role of the researcher as full member of the organisation (type 1) but with recognised status as an internal researcher (type 2 'going native').
- A three week long field study in summer 2001, collecting evidence concerning the effects of implementing the MPS as a fully employed student worker on the shop floor, without organisational members being aware of my research status and company affiliation.

For the survey research I designed a questionnaire and administered two surveys. This method allowed for the collection of a large quantity of data (Oppenheim 1966). With the thus collected numerical evidence and the application of the technique of statistical inference, the research objective was to record and examine changes in the actors' perception towards a range of issues during the implementation phase of the MPS. The topics covered for example, the actors' satisfaction with the level of communication, leadership, teamwork, quality, and their own work; but also their direct perception of the MPS and the extent to which they are involved in the standard setting process. I administered the first survey in November 2000, shortly after the start of the implementation of the MPS and the second survey exactly 12 months later in November 2001. The participants were drawn from a previous randomly selected identically structured population (n) at production centre Z and its three main production departments (sub-centres, A, B, and C).

1.5 Chapter outline

The study is structured in a straightforward way. In the next two chapters, my goal is to analyse the driving forces behind standardisation. To do so, in the second chapter I shall focus my investigation on the evolution of standardisation. For this purpose I focus on Germany, the USA, and Japan. The key aspects is the driving force behind the spread of standardisation and the role actors play within this process. For this purpose I divided the chapter into three parts.

In the first part I shall commence with an analysis of the driving forces underlying early institutionalisation of standards in Germany, particularly the role of the craftsmen and guilds in the establishment of early product standards during the pre-industrial era. My focus then shifts across the Atlantic to analyse what drove the development of standardised and interchangeable parts in early 19th century North America. By the end of the 1930s, quality standards were institutionalised.

Whereas in America and Germany, the history of quality management evolved from quality control to quality assurance, and was primarily the responsibility of separate quality management departments, the historical evolution of standardised quality management systems in Japan took another turn.

This resulted in the creation of their unique quality management approach, known today as the Total Quality Management (TQM) System, a system which envisages a holistic view of quality and hence represents by far no longer a quality management system but already a production system. This leads then into the second part of this chapter, presenting a detailed analysis of standard "quality management" system used across international industrial sectors.

National and governmental interests do play a role in this process, as standards are considered a means of educating the national industries thus ensuring their international competitiveness. During Fordism, the responsibility for the competitiveness of companies in terms of quality rested with internal centralised organisational units such as the Industrial Engineering and quality assurance departments. However, in the wake of the globalisation of production and sourcing structures, this responsibility has shifted from companies to external international institutions, such as the ISO.

In the third part, I will raise the question of the underlying reasons why companies adopt standardised "quality management" systems. A key part of this analysis is the role, audit systems have in this process. Intended to check if companies adhere to the standards, audits serve as control tools. The concluding part of this first chapter then examines the significance of certification systems and specifically quality audit processes on the evolution of standardisation and the forms of institutionalisation.

The third chapter covers the major production systems in the automotive industry and is divided into six parts.

I shall start off this historical analysis by looking at the role standards played at the transition from the craft production system to the system of mass production in America. Juxtaposing the role of the skilled craftsman with the factory worker, I will point out how significantly standardisation is for the shift from highly individualised skilled work to highly fragmented and repetitive work.

In the second part of this chapter the focus is on the role of standardisation in Taylorism. Acknowledging, that Taylor's *Principles of Scientific Management* do not represent a production system as such, I think it is nevertheless important to include it in the discussion particularly as it lay the foundation of the first production system of the automotive industry: Ford's system of mass production. Thus I shall analyse how Taylor's division of labour was introduced as a form of standard to organise work and how it functioned to split work between mental and physical tasks, resulting in highly fragmented tasks which Industrial Engineers, through time and motion studies, had previously scientifically engineered.

In the third part of this chapter I will examine how Ford applied the principles of Taylorism in his system of mass production. Regarding the role of standardisation in Fordism, I differentiate between technical and process standards, work standards and social standards. Much is known about Ford as the inventor of the moving assembly line in the automotive industry. However, Ford not only set this new de facto process standard, but also continued to refine systems of standardised jigs and gauges. Moreover he also introduced new products which became standard components of cars such as transmissions. Despite the significance of these technical, process and work standards, I will stress the extension of standards from the shop floor to the social realm of the workers as a key development of the function and role of standards within production systems. The example of the standard pay (the 5$ Day) for standard work and the standardised selection criteria of workers eligible to receive this wage show just how far standardisation had penetrated the social realm during Fordism. Together with Taylor's division of labour and the job fragmentation, this extension of standardisation into the private sphere of the workers contributed to the alienation of the worker from his work. As pointed out above, this lay the foundation of the image of alienation of work.

The chapter continues by showing how Fordist principles were disseminated in Japan. Toyota first adopted mass production principles but then continued to develop and refine them until they created their own company-specific production system, the Toyota Production System.

I will focus on the forms and function of standards in the TPS. Two key aspects of standardisation within the TPS are selected: standardised operations and the kanban system. Underlying the standardisation process at Toyota, is the system of continuous improvement of standards, organisational learning takes place as workers learn from each other and exchange their shop floor know-how. The analysis of the TPS will be closed by examining the transfer of the TPS outside its national Japanese environment.

In the fifth part, the role and function of standards in the Volvo production system at Uddevalla will be analysed. Unlike the highly standardised TPS, the production system of Volvo Uddevalla explicitly does not intend to standardise processes, operations or methods. As its name "reflective production system" already points out, its intention is to create a human centred production system in which workers have the freedom to organise and perform their own work according to their individual skill level and their own methods of work. In a sense then, Volvo declares the reflective production system to represent their standard way of organising production, although its actual intention explicitly rejects the notion of standardising processes, methods and operations.

In the final part of this chapter the analysis of the role of standardisation in production systems focuses on the current trend to introduce company-level standardised production systems and the question to what extent the Toyota Production System has evolved as the de facto standard model for automotive manufacturers.

The third chapter focuses on the case study of the Mercedes-Benz Production System. For the purpose of examining the institutionalisation of a production system and the particular form and function of the standards therein, and also on the link between the effect of standardisation on the actors on the shop floor in terms of learning and control, this case study is based on an analysis of the implementation of the MPS at the DaimlerChrysler plant Untertürkheim and at one of its production centres.

This chapter covers three main aspects: the evolution of the MPS and its institutionalisation, its structure, content and relation to other already existing standardised systems. The first part presents the production organisation of Daimler Benz and Chrysler before their merger in 1998.

In the second part, an analysis of the institutionalisation of the MPS is given by looking first at the organisational structures supporting the implementation of the MPS. In a second step the role the MPS audit plays within the implementation process will be examined. In view of the regulatory nature of audits, based on my own observations, both the role of the auditor and the auditees on the shop floor are analysed and a set of audit-strategies auditees adopted is presented.

In the third part of this chapter I shall focus in depth on the content of the MPS. First an overview of the MPS and its structure is given. In a second step, the MPS is compared with already established methods proposed by the REFA. The question also arises, as to what extent the MPS is modelled upon the TPS. To investigate this question, a comparison between the TPS and the MPS is drawn.

Apart from analysing the driving force underlying the standardisation process, the second goal of this study is to examine what effect standardisation has on the work of the actors on the shop floor: how far standardised production systems contribute to the image of alienation? As pointed already out in the methodological discussion above, this question was operationalised into an empirical survey and the results are presented in this fourth chapter.

The purpose of this survey was to collect the opinion of actors on the shop floor during the implementation process of the MPS to thus examine changes in their perception towards the level of communication, leadership, teamwork, quality, and their own work; but also their direct perception of the MPS and the extent to which they are involved in the standard setting process. Within one year, I conducted two identical surveys from a previously randomly selected identically structured population (n) at one production centre (centre Z) and its three departments (A, B, and C). The findings reflecting the changes in opinion of the actors on the shop floor between the two measuring points are at the core of this chapter. The findings are divided into overall centre Z results and individual sub-centre results. In addition, the chapter contains a presentation of the relevant statistical methods deployed and a presentation of the questionnaire design.

In the final chapter, the major conclusions which can be drawn from the preceding discussion and implications for the research question posed, will be presented. What are the implications behind the current process of the standardisation of production systems? Focusing on the forms and functions of standardisation in production systems, the role of institutions therein and the effect of standardisation on the shop floor in terms of learning and control, the conclusions of this study are presented. I will also point out future research implications and questions arising from this present study and the conclusions it draws.

2 The evolution of standardisation

2.1 Introduction

Standards and the specific forms of standardisation play a key role for the development and the function of production systems. The intention of this chapter is twofold. First, to examine the changing forms and functions of standardisation from an historical perspective and to assess how this process is related to the rise of production systems in the automotive industry. Second, to assess the driving forces of standardisation: why do standards evolve and who is responsible for setting standards. In other words what are the underlying dynamics of the process of standardisation and what role do standard setting institutions play therein.

The changing forms and functions of standards have influenced the evolution of production systems significantly: standards hold a core function in production systems. This function of standardisation within production systems is not unproblematic. The term "standardisation" is not value-free but is associated with a particular form and function of standardisation focusing primarily on its function to regulate time and motion as an extremely static process standard of work (Jürgens 2002:3).

The historical evolution of the forms and functions of standardisation shows that standardisation has played a far more varied role: the introduction of standardised parts and tools facilitated the American system of mass production, during Fordism, standardisation was extended to skills, training and even social standards, such as the housing and living standards Ford's workers had to conform to in order to qualify for the infamous $5 day wage. Together with Taylorist time and motion standards, this era marked the height of standardisation. Subsequently, with the quality problems arising from mass production, the forms and functions of standardisation changed to providing quality standards. This shift also marked a gradual change in the evolution of production systems away from mass production systems towards lean, process-oriented production systems which emerged during the early 1990s and were influenced by the Total Quality Management (TQM) idea and EFQM-models. With their holistic view of quality, TQM-based systems go beyond the focus of standards contained in traditional quality management systems such as the ISO 9000. They already represent production systems in their own right because the standards they contain no longer focus on regulating time and motions at the micro level of the shop floor but are intended to design and regulate (production) processes and outcomes. This historical overview shows that a key form and function of standardisation has been to assure the quality of products and processes, this significance is being accounted for as the evolution of standards for quality represents the key focus of the following discussion.

Of particular interest in this process is the issue of institutionalisation, specifically the role institutions play in the standard setting process. From an historical perspective, during the craft production period, guilds set skill standards. During Fordism, internal organisational units such as the Industrial Engineering departments represented the central standard setting institutions within companies. With the rise of quality standards, this responsibility shifted from companies to external standard setting organisations, such as the ISO and the DIN. As the standard setting function became located outside companies, the problem of how to control that standards are correctly applied arose. This led to the rise of certification and audit systems, and represents yet another stage in the changing form and function of standards. Also, as the case of the Mercedes-Benz production system will show, the concept of a standardised audit has been adopted for the control of the implementation of the Mercedes-Benz production system. From a social science perspective, audits function to reaffirm order and according to Power, the rapid rise and the significance attached to audits has lead to the concept of *The Audit Society'*(Power 1997).

The present chapter covers the following parts. In the first part, the historical analysis follows a time line tracing the evolution of standardisation exemplified by the rise of quality management systems from the pre-industrial times to the present day. Commencing with early examples of quality standards in Germany, to the role of standards affecting the quality of product, processes and work in the system of mass production in American, up to the birth of quality control standards. The spread of quality standards from quality control to quality assurance is traced following the developments in America, Japan and Germany which are the leading nations within this process.

Drawing a parallel between the institutionalisation of quality standards and production systems, in the second part of this chapter I shall examine the role of the major standard setters providing quality standards for the automotive industries in Germany and the USA. I will also look at the influence actors from the automotive industry have on the standard setting process.

To examine in detail the forms and functions of standards in quality management systems and the influence of Japanese quality management techniques, in the third part of this chapter I shall analyse the structure and content the ISO 9000, the VDA 6.X series, the QS 9000 and the EFQM. One part of this discussion is devoted to an examination of the role and function of audit systems.

Derived from this analysis, in the final part of this chapter I will present a cost-benefit analysis of standardisation and critically appreciate the introduction of standardised quality management systems.

2.2 Germany: the historical roots of quality standards

Before the onset of the Industrial Revolution in Germany, the quality of a product was associated with craftsmanship. Using stamps or marks, craftsmen provided the earliest "manufacturing guarantee for quality" (Lerner 1995:211). These marks also established the craftsmen's responsibility for their work (Juran 1995:615). Hence, up to the Middle Ages, the control over the quality of a product rested in the hands of the craftsmen. Regarding the quality goal, they were in "a state of self-control" of how to achieve it and how to "readjust the process in the event of non-conformance to the quality goal" (ibid.:618). This self-control prevailed and quality was considered as a skill which transcended through the apprenticeship in a craft (Juran 1995:554). Moreover, as craftsmen predominantly sold their goods locally, quality could be directly traced back to its origin and thus "the craftsman had a large personal stake in meeting his customers' needs for quality" (ibid.:544).

With the centralisation of power, the decline of the village and the rise of the cities, the role of the craftsmen was strengthened and new organisational structures were introduced (Ketting 1999:20). With the progress in technology and trade, but also out of fiscal interests and driven by the craftsmen themselves, quality awareness became a dominant concern. Craftsmen founded guilds. These guilds were responsible for issuing measures to limit competition, they provided training for novices and above all by setting regulations concerning working processes and the types of raw materials to be used, the guilds regulated the quality assurance of their trade or craft. (ibid.:21).

Regarding the foundations of the quality assurance system in Germany, the textile industry in particular was one of the forerunners. *The Codex Diplomaticus Brandenburgensis*, a document dating back to the early thirteenth century in which the city of Berlin granted Frankfurt/Oder the right to control cloth manufacturers, explicitly stressed the importance that only previously controlled and checked material of the highest quality was to be sold (Lerner 1995:217). Inspectors, so called co-supervisors, the forerunners of today's quality auditors, were official experts and assessed the quality of the garment (Ketting 1999:21). At the beginning of the nineteenth century, competition particularly in the textile sector intensified as materials from Britain, France and the Netherlands entered the German market. The system of controlling the quality of garments, "once voluntarily established by their predecessors to preserve the good reputation of the trade, now became a strict law that was imposed on them during the early modern times by the town council and the patricians, after they had fought for participation of the trades in the administration of the cities and lost" (Lerner 1995:227). This system became institutionalised as the so-called cloth show. Master craftsmen proposed by the corporation of weavers were elected by the town council and thus "sworn in quality inspectors were put in office" (ibid.). Together with a number of city council members, their task was to examine the entire manufacturing process:

"This supervision started at the loom, where warps were inspected. After the cloth was taken off the loom, it was sheared and fuelled. Now the products were inspected again, to see whether they met the standard measurements for length and width. All flaws in the weave were marked with a linen hook. Only flawless products were considered perfect. According to the number of linen hooks, the imperfect cloth was divided into several groups. Faulty products were cut up and could only be sold in pieces, not as a whole, on the local market. The cloth then had to be moistened and after the drying it had to be pulled back into shape and folded according to the norm" (Lerner 1995:228ff.).

Despite being removed from today's systems of quality management and control, this early example nevertheless reflects the three particular aspects, common to all efforts to ensure the quality of products.

First, the quality of a product is seen as competitive advantage, distinguishing one product and its maker. Be it the craftsman pledging for the quality of his cloth or an automotive manufacturer today producing a first class product, quality was and is used for marketing and is therefore part of both, the image of the product and the manufacturer.

Second, quality is not an inherent characteristic of a product, but is visually displayed by signs or marks. In other words, a sign or mark is used to indicate a particular level of quality. Whereas at the beginning, craftsmen marked their products with symbols, today adherence to specific quality standards is signalled with officially standardised symbols.[1]

Third, quality assurance was initially part of the skills of a craftsman: craftsmanship stood for high quality. However, with the rise of guilds and trade associations, the quality was removed from the realm of production and placed into the hands of inspectors. Thus, quality control was no longer considered as part of the craftsman's job. Instead, inspectors checked the quality of products. This inspection of quality then necessitated a system of standards which would regulate how, what and when inspections were to be conducted. Indeed, these are the roots of today's complex quality audit systems.

Turning back to the historical evolution of standardisation, the Enlightenment spread the ideas of the French Revolution. A key concept was Liberalism, which intended to put an end to "antiquated customs, and liberating individuals and the economy from old chains, „cutting off old tails" (Lerner 1995:236). As a result, the previously "imposed systems of quality control" (ibid.) in Germany became liberalised, too, as young merchants imported the ideas of the Enlightenment from France and Great Britain (it was a custom for young German entrepreneurs and merchants to do internships in French or British companies or to go on study trips abroad).

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[1] The DIN label for example denotes the adherence of products or processes to DIN standards, the CE symbol signals that toys reflect European safety standards and do not contain chemicals harmful for children, and the DVE/GS label indicates that electrical products obey safety standards.

At the same time, inventions like the steam engine revolutionised the transportation systems in Europe. This allowed markets to expand beyond their national boarders, leading to an increase in product variety and diversity, but subsequently also to differences in quality levels (ibid.:237). At the same time, the establishment of the second German Reich in 1871, created a unified economic trading zone (DIN 1992:92). After the political turmoil which had prevailed since the French Revolution, this caused a political stability and paved the way for reinstating "principles of order in the communities" (Lerner 1995:240).

The World Exhibitions in Paris (1867), Vienna (1873) and Philadelphia (1876) spread the reputation of German products beyond national boarders and German products soon "challenged the previous British dominance of the European market" (ibid.). This sparked a fierce competition between the two nations regarding the quality, price and delivery reliability of their goods. In order to curb the influx of German and other international goods, in 1887, the British government introduced the British Merchandise Marks Act, regulating that all foreign products should be labelled according to their country of origin (ibid.). According to Lerner, the mark "Made in Germany" under which German products were now offered on the world market, soon proved to be an excellent advertisement (ibid.).

Moreover, the consequences of this law then allowed consumers to compare products, and like in the pre-industrial era, the choice of product according to superior quality was made according to the *caveat emptor* principle (Juran 1995:604). Subsequently, craftsmen reinstated former traditions such as the apprenticeship training system, certification marks and the professional title of "master craftsman" (Lerner 1995:240). Moreover, these attempts were supported by two laws. In 1874, the *Statute to Protect Marks* protecting the interest and rights of third parties and consumers was issued in Germany and the protectionist policies led to the ratification of the *Statute to Protect Trade Marks* by the German Reichstag in 1894. In order to protect German products, the prerogative of issuing marks, once administered by craftsmen, became an institutionalised standard centrally regulated by the *Patent Office of the Empire*. As in the case of quality control, quality assurance was displaced from the individual to the realm of the legally enforced power. In general terms, the quality function shifted from the company-internal sphere of responsibility to the company-external, quality official or institution. This was underscored by transferring the right to issue marks of quality from the level of the individual craftsman to the level of governmental institution (Patent offices).

The early history of quality and quality standards in Germany shows that quality had been associated with the skills of craftsman and quality control was an inherent part of their job. Both economic success and reputation but also job pride were linked to product quality. However, the quality of German products was threatened as foreign goods entered the German market. Quality standards had to be introduced to protect home consumers and products from foreign substitutes of inferior quality. Common quality standards for goods such as cloth were developed and guild inspectors, the forerunners of the modern day quality auditors, inspected and rated the quality of products. Moreover, quality as key attribute of products became enshrined through legal acts. Quality thus became increasingly a subject of standardisation as it passed from the responsibility of the craftsman, to the guild quality inspectors and subsequently became institutionalised in the legal provisions for product quality, such as trade marks and consumer protection laws.

2.3 The USA: interchangeable parts and mass production

Parallel to this process towards institutionalising quality standards in Germany, in America, the evolution of standards and standardised quality systems arose from another need: war.

As early as 1800, Eli Whitney submitted the first standardised rifles to the US government and thus put his mark on the history of standardisation as "the father of mass production for war purposes" (Dunn 1946). According to Hounshell though, Whitney merely "espoused the two principle ideas (…) interchangeability and mechanization, but never (…) understood, much less developed, its basic principles let alone its complex subtleties (…) Whitney was a publicist of mechanized, interchangeable parts manufacture, not a creator" (Hounshell 1984:31). Instead, Hounshell associates the advent of mass production with the development towards interchangeable parts, driven by the work of Simeon North's development of standard gauges and milling machines (1816) (ibid.:29) and the first set of interchangeable rifles produced in 1827 by John Hall (ibid.:41).

The standardisation of parts or components, gauges and machines initiated in the arms industry, soon spread to other industrial sectors. Parallel to the evolution of standard gauges and parts, in 1864, W. Sellers had created the Sellers Thread, a standard for screw threads which became an American national standard in 1868 and basis of the Metric Thread adopted by the ISO in 1957. According to Baba et. al., "the standardization of screw threads dealt with only the basic standard of a thread. In order to have effective interchangeability, tolerance standards and gauge standards were also required" (Baba and Yoshiki 1997:47). The development of a gauge system subsequently enabled "interchangeable manufacturing" (ibid.:42). As parts became standardised, so did the quality of them: the reasoning was that standardised mass produced products consisting of standardised parts would also ensure a constant, standard quality: thus quality would become reproducible. (Ketting 1999:23). However, according to Baba and Yoshiki, during the craft production period, manufacturing was "relying on the experience and tacit knowledge of skilled technician, (…) with the introduction of interchangeable manufacturing, fitting can be done by an unskilled worker using limit gauges" (Baba and Yoshiki 1997:40). On the one hand, quality of products thus improved, on the other, the role of the skilled craftsmen became less important (ibid.:41).

This shift from skilled to unskilled work had been propagated previously by Adam Smith in *The Wealth of Nations* (1776) and was also reflected in the publication of Charles Babbage's *The Economy of Machinery and Manufactures* (1833). Both called for a division of labour and a reduction in job content. This would increase the repetitiveness of work which the authors considered necessary because "the constant repetition of the same process necessarily produces in the workman a degree of excellence and rapidity in his particular department, which is never possessed by a person obliged to execute many different processes" (Babbage 1833:172-3). According to Braverman, "Babbage's principle eventually becomes the underlying force governing all forms of work in a capitalist society, no matter in what setting or at what hierarchical level" (Bravermann 1974:57). It became enshrined and formalised as scientific standards of work proposed by Taylor towards the end of the nineteenth century (ibid.:61).

Taylorism led to the systematic and simplified organisation of work (Ketting 199:24) and a sharp decline in quality caused by the low qualification level of workers in production. (ibid.). Moreover, Taylor's credo to split work into planning elements (mental work) and execution of work (physical work), quality in America became a concern of independent "central inspection departments" (Juran 1995:555). As quality departments became responsible for the checking and controlling of the quality of products, the responsibility for producing quality shifted away from the workers on the shop floor to the quality inspectors. Thus quality was a matter to be inspected, and not to be produced (Ketting 1999:24). The reconciliation of Taylorism and mass production techniques with quality management was not possible because quality awareness was not seen to be the responsibility of the worker on the shop floor. (Schaafsma and Willemze 1954:3). According to Ketting, this resulted from the fact that over time staff gradually thought that the responsibility for quality rested in the structural unit of the quality department within the organisation and hence outside the direct realm of the work on the shopfloor. (Ketting 1999:24),

Moreover, Juran observes that "each functional department in the company carried out its assigned function and then handed off the result to the next function in the sequence" (Juran 1995:561): a system termed "throwing it over the wall" (ibid.). With it, the responsibility for quality, too, was passed on down the line. Thus quality control was located at the end of the production process, at the end of the assembly line, where the inspectors of the quality management department, sorted the products into defect and acceptable products. This led to an enormous increase in the amount of indirect labour. Taking the example of Hawthorn Works of the Western Electric Company, in 1928, the company consisted of workforce of 40.000, of which alone 5.200 were quality inspectors. In other words, more than 20% of the workforce inspected the quality of products produced by 80% of the workforce.[2] This example shows that the responsibility for quality and quality awareness was lacking. Instead quality control was seen as a final filter to extract defect parts.

In addition to this decreasing quality awareness, in the wake of the results published by the Hoover report of 1921, the efficiency of the system of mass production was questioned. The Committee on Elimination of Wastage in Industry reported that the American industries were running only at 50% of their maximum economic capacity. The committee's main recommendation was that the "industry should utilize more effectively the principles of standardization" (Dickson

2 By coincidence the reversal of the Pareto Principle.

1947:10). This initiated a nation wide government programme run by the Simplified Practice Division of the US States Department of Commerce. The purpose of this programme was to explore the potential of standardisation to simplify products.[3] Thus standardisation became a national endeavour and results showed that by simplifying products and processes, waste reductions ranging from 24% to 98% were made (Spriegel and Landsburgh 1955:8.1ff). However, another main reason for the waste of resources was that machines and tools were unable to produce products of constant quality particularly with regard to conforming to measurement standards. Moreover, the most common defects did not necessarily represent the root cause of the problem, hence it became necessary to classify and statistically evaluate errors. (Ketting 1999:25).

To improve this, a statistical tool to control and analyse production processes was developed. In 1926 a team of engineers of the Bell Telephone Laboratories started experimenting with statistical control tools to improve the quality of telephone products at the Hawthorn Works of the Western Electric Company. (Juran 1995:556ff, Ketting 1999:25).

Interestingly, at the same time, Roethlisberger and Dickson (1944) examined the social and human aspects of work within the system of scientific management at the Hawthorn Works of the Western Electric Company. Their findings, stressed that "the indirect effects of technical innovation must be assessed not only in terms of fatigue and monotony but also in terms of their social consequences to the worker as a member of a social organisation" (Roethlisberger and Dickson 1944:546). Their work lay the foundation of the human relations perspective on work, treating organisations as social systems responsible for balancing both the company's external economic position and its internal organisation consisting of the reconciliation between technical and human organisation (ibid.:552ff.). Particularly with regard to the extent of standardisation and scientific principles of work, the authors are critical as "much of this advance has gone in the name of efficiency and rationalisation. Nothing comparable to this advance has gone on in the development of skills and techniques for securing co-operation that is, for getting individuals and groups of individuals working together effectively and with satisfaction to themselves" (ibid.).

This critical view also applies with regard to the work of the Bell Engineers as their proposed early quality assurance systems were rooted in scientific methods using "probability theory to put sampling inspection on a scientific basis, and a demerits plan for evaluating outgoing quality of telephone products" (Juran 1995:556). Thus, quality management was considered an intellectual discipline in the field of mathematical statistics removed from the shop floor. The same applies also to the publication of the W.A. Shewhart's work *Economic Control of Quality*

[3] After the World War II, the Hoover report initiated British activities to conduct similar surveys measuring and comparing the degree of standardisation in the UK and the US. The results were published by the Lemon Committee and the Anglo-American Council on Productivity in 1948. For details refer to Verman 1973:9ff. and Dickson 1949.

of Manufactured Product in 1931 which marked the birth of the Statistic Process Control (SPC).

Initially, Shewhart control charts and other statistical processes were only applied by US companies (Juran 1995:557). Only America's involvement as supplier to the Allies in World War II, "brought the urgency of national and international standardization even more pointedly to the forefront" and standardisation "emerged as a technique of simplification for the conservation of national resources and enhancement of productive capacity" (Verman 1973:9).

Moreover, the differences between weapon and supply management between the Allies pointed at the significance of having common standards and resulted in an influx of academic activity in the areas of operations research for materials management, value analysis and various statistical methods such as linear programming to insure the harmonisation of standards regulating the material flow. Notably, the Bell System sampling methods, or Acceptable Quality Level (AQL), were applied to the quality inspection of military goods in 1942.[4]

After the war, the War Production Board set up training programmes in order to spread the application of Statistical Quality Control (SQC) methods throughout the American civil industry. The American Society for Quality Control (ASQC) was thus set up in 1946. This initiated a wave of developing new statistical quality control tools and resulted in several changes. For example, a new job category emerged, that of the quality specialist, in companies referred to as quality control engineer. Quality assurance and control were formally institutionalised as organisational units such as the statistical quality control or quality control engineering departments.

Since the 1950s, technical innovation became an increasingly important factor for the standardisation of quality control. Particularly through the introduction of numerically controlled (NC) tools, quality assurance in the form of mechanical or automated quality control checks was introduced. According to Ketting, this allowed for the first time to erode any potential manually caused errors, thus reducing the impact of human errors and thus facilitating quality to be produced, (Ketting 1999:26).

Continuing the development of numerical control of machines, by the 1970s, the NC machines were replaced by Computer Numeric Controlled (CNC) machines which allowed for a direct process control, a quality control inside the machine (ibid.) Whereas technological advancement regarding machines improved the control of parts, the rapid development of technologies for the military and space industry, necessitated the development of quality assurance models. The National Aeronautics and Space Administration (NASA) contributed to the development of error analysis and recognition methods such as the Failure Mode Effects Analysis (FMEA) model, first introduced in the 1960s but only twenty-five years

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[4] Their improved version was introduced in 1963 as military standards 105 (MIL-STD-105) and reached a legal status by being referenced in contracts with military suppliers, and found its way 1973 into the DIN 40 080 and in 1974 the ISO 2859 standard. For details refer to Juran 1995:558 and Ketting 1999:25.

later adopted by Ford as the Q101 (ibid.:27). Significantly, only upon being adopted by Ford as the Q101 quality guideline, was this tool introduced in the automotive industry in 1985 (ibid.).

Parallel to the spread of quality standards, consumerism and business consultancy services spread (Juran 1995:564). Consumer test services such as the American Consumer Report founded in 1969, started providing independent research and comparison on the quality of goods. Moreover, bodies like the Underwriter's Laboratories, an independent, non-profit product safety testing and certification organisation commenced issuing standards for materials, it tests the manufacturers' compliance with those, and awards marks for quality compliance, so called "listing the products" (ibid.). Regarding products in the pharmaceutical, foods and food additives sector, quality became regulated by government certification through federal law. For customer complaints, ombudsmen in companies were made available or the American Better Business Bureaus (BBB) set up data banks which started recording the number of complaints lodged against a particular entity.[5] Since the founding of the first BBB in 1912, the BBB system particularly, has proven that the majority of marketplace problems can be solved fairly through the use of voluntary self-regulation and consumer education.

During the 1960s and 1970s managers increasingly sought the help of management consultants to provide for solutions regarding the management of quality. However, these solutions were piecemeal approaches such as isolated strategies for "incentives for quality", "automated inspection and tests" and "awareness training" for staff and management (ibid.:584). According to Juran, companies lacked a comprehensive "plan of action that addressed their major quality problems" (ibid.). The 1980s saw the comprehensive reintroduction of up-to-date versions of the original statistical process controls (SPC), such as publicised in the video cassette titled *If Japan Can, Why Can't We?* (ibid.:585). It implied that Japanese success was exclusively based on the use of statistical methods to control quality. However, merely taking the dust off old quality control measures was insufficient as companies first had to define their particular quality goals and strategies, before considering in detail the tools how to achieve them (ibid.).

All in all, post-war strategies of American quality management, particularly during the 1980s, can be summed up as lessons learned in "what not to do" (ibid.:586). The situation changed with the publication of studies analysing the competitive advantage of Japanese manufacturers. Companies in the West suddenly became aware that their competitive advantage as quality leaders had long shrunk and that Japanese efforts, to improve and manage quality had been undertaken at a revolutionary rate. In other words, by the end of the 1980s, Juran's prediction of 1967 had become reality:

> "The Japanese are headed for world quality leadership and will attain it in the next two decades because no one else is moving there at the same pace. " (Juran, 1967:583)

[5] For more details on the issue of consumer protection see Juran 1995:563.

2.4 The rise of quality management in Japan

Whereas the USA laid the foundation of standards quality management systems, it was the Japanese who perfected them. Most importantly though, the history of quality management in Japan shows how quality standards contributed to the evolution of production management systems.

Similar to America, Japanese quality assurance before World War II was predominately focused on applying statistical quality tools (SQC), foremostly implemented by Ishida at the Tokyo Electric Company (ibid.:519ff.), and the application of standardised "tools, cutting and forging techniques" (Baba and Yoshiki 1997:42) imported by Tatuse Ikeda from Pratt & Whitney Co. to Sonoike Manufacturing Co. in the 1920s (ibid.).

During the occupation era, quality improvement became an immediate necessity particularly in the area of telephone communications, where the breakdown of telephone lines and services hampered the communication at the Allied General Headquarters (GHQ). Thus the Civil Communications Sections (CCS) of the Allies requested the American telephone company AT&T to send engineers to Japan to improve the quality of communication services: the door for an international exchange on quality issues between Japan and the West was opened. Notably under Sarasohn, in 1949 the CCS held management training seminars about quality improvements for the Japanese electrical industry. The content of these seminars stressed that quality was a top management issue and not only one for the quality departments and that Japanese companies were lacking sufficient quality, cost and technical control measures. Nonaka sums up the effect of these early seminars as being "helpful in encouraging the top-level managers to get down to the business of rebuilding their companies in the aftermath of war" (Nonaka 1995:529).

In addition, according to Baba and Yoshiki, "the use of gauges spread through the Japanese industry because the US occupation army purchased large quantities of parts that had to meet their specifications" (Baba and Yoshiki 1997:51). Any parts failing to do so were rejected by the Americans. This approach was unknown in Japan, as manufacturers accepted minor quality and compensated such parts with a lower price (ibid.). In order to meet the US quality prerequisites, Japanese manufacturers had to purchase gauges facilitating standardisation of "not only the size of the parts but also the angle, parallelism, and distance between holes" (ibid.:50). An approach which until then had been resisted as Japanese manufacturers relied on the "craftsmanship on the shop floor (…) based on rigorously trained technicians brought up under the apprentice system" (ibid.:44).

Moreover, the GHQ urged the Japanese industry to set up democratically run institutions to regulate industrial standardisation. Until then, this had been a government prerogative. In order to meet the precondition for joining the ISO, Japan set up the Japan Management Association (JMA) in 1942, The Japan Standards Association (JSA) in 1945 and The Union of Japanese Scientists and Engineers (JUSE) in 1946. Moreover, unlike Germany and the US, Japanese standards became mandatory with the introduction of the Industrial Standardisation Law 1949. This instigated the creation of the "JIS" mark, the "sign of endorsement by the government that the JIS standard was met" (ibid.:50). Moreover, "the law states the responsible government minister must examine various aspects of production by an applicant to see whether the firm has satisfactory facilities to maintain the JIS quality standard. The applicants had to receive inspections on production and inspection facilities and methods of quality control" (ibid.). In addition to the official labelling of quality, as competitive incentive, the Excellent Factories Implementation of Industrial Standardization Awards was initiated in 1951.

Historically then, in Japan standardisation and quality control were legally enforced by institutions. In addition, the achievement of quality was considered a competitive advantage and the participation in the award competition underscored this effect, as did the Deming Prize first issued also in 1951. Two more events anchored quality management into the awareness and mind of the actors in Japanese post-war industry.

In 1950 and 1951, Dr. W. Edward Deming, trained in physics and mathematics and advisor for sampling at the US Bureau of the Consensus, gave lectures about the application of Statistical Quality Control (SQC) at the Union of Japanese Scientists and Engineers (JUSE). Dr. Shigeru Mizuno, participant of the Deming lectures recalled that "the lectures had a great historical significance for the history of quality control in Japan" (Mizuno 1984:351). The core focus was the relevance and applicability of statistical sampling and control charts to the quality control process. According to Koyanagi:

> "The control chart is a tool for obtaining the most economical manufacturing methods. Look for the trouble and its explanation and try to remove the cause every time a point goes out of control." (Koyanagi 1950:40)

First, this quote stresses the link between quality and costs. Second, the quality control process is a structured process starting with an analysis of the problem (Nonaka 1995:545). Third, with this statement Deming, underscored that quality control is a constant process of improvement. Deming's lectures provided an impetus on Japanese quality standards of production such as striving for continuous improvement and the structured problem analysis.

Interestingly, according to Fujimoto, "the Japanese automobile industry did not play an active role when the role of total quality control emerged in the 1950s. After both Nissan and Toyota dispatched their staff to seminars on the U.S.-born method of Statistical Quality Control (SQC) in 1949, and then adopted it, both companies began emphasising capability of inspection, but the concept of company-wide quality management was not prevalent" (Fujimoto 1999:71). Instead, in the case of Toyota, the influence of Deming's lectures sparked initiatives to adopt and develop their own tools of quality control, according to Monden then "more traditional methods of quality control have been replaced by self-inspection of all units (…) this approach to quality control is called *Jidoka* or *Autonomation*" (Monden 1993:222). This shows that with regard to setting standards the local industry "selectively applied foreign examples to Japanese circumstances" (Baba and Yoshiki 1997:50).

The need for the development of quality tools was taken up by the lectures of Juran in 1954. Whereas, Deming had raised the significance of the tools of quality control, Juran "stressed that control charts, while necessary, were far from sufficient, and that use needed to be made of the managerial tools, requiring the understanding and co-operation of top and middle management" (Nonaka 1995:540). According to Juran, management's responsibility for quality covers the areas of policy making, planning, control and measurement and review. Thus, Juran offered a structure for the implementation of quality control. According to Nonaka he "provided a structured approach to managing for quality and to quality improvement" (ibid.:547). After Juran's visit, the JUSE set up courses for middle-management spreading the key points of Juran's lectures. Indeed the course was extended to train workers and foremen via 15 minute daily slots on the radio later to be published by the national broadcasting association as an accompanying text which sold 85.000 copies. Quality control became a concern of management and worker alike. In addition to extending the training for quality, journals, such as *Total Quality Control* or *Quality Control for the Foreman*, continued to raise quality awareness (ibid.:544ff.).

Summarising this part, Japan played a key role in the history of quality management. The outsider role and the pressure of the Allies forced Japan to find better quality solutions than America. This was particularly aided by the input of both Deming and Juran sparking off a national awareness of the significance of quality. And true to this input, the Japanese continued to refine quality standards and became self-sufficient in their management of quality. Moreover, the continuous striving for higher quality contributed to the Japanese dominance, particularly in the automotive sector. According to Ketting, this led to the system of Kaizen consisting of the traditional Japanese approach and Deming's quality philosophy which can be thus traced back to the 1950s (Ketting 1999:25). More specifically then, quality control "emerged through the confluence" of "the American systemic approach and the Japanese way of organising production" (Baba and Yoshiki 1997:53). The latter being characterised by a process of learning by doing derived from combining shop floor knowledge with an inherent urge for continuous improvement and flexibility.

2.5 Quality management in Germany

The quality management in Germany during the twentieth century from then on evolved in four distinct stages (Hesser and Inklaar 1992:161). Commencing with the spread of mass production around 1920, quality inspections focused on the quality inspection of incoming goods, goods in process and final inspection and test. With the spread of Shewhart's statistical control charts, scientific tools and sampling methods became standardised (ibid.:162). Moreover, with the expansion of the methods and improved technical solutions, quality inspection became part of process related areas or became even integrate within practical processes. Ketting 1999:26). This led to a greater focus on the principles governing cause and effect of potential errors necessitating a more precise preparation and planning of quality control (ibid.). Ultimately, this led to a shift toward the management of quality.

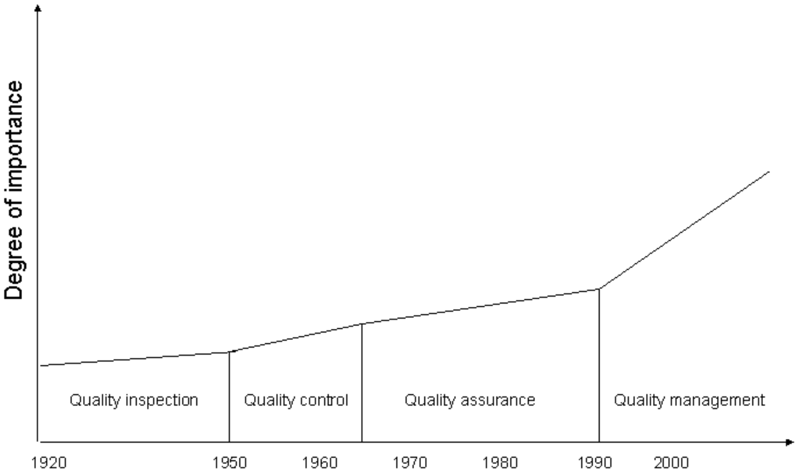

Fig. 2.1. Overview: evolution of quality management based on models by Hesser and Inklaar, and Junghans.(Hesser and Inklaar 1992:Appendix Fig. 7.1, Masing 1999:5)[6]

According to Ketting, during the first half of the twentieth century (commencing during the end of the 1930s, and after the end of the World War II), the focus of quality control departments shifted from a purely quality control focus toward to a distinctly production focused quality control, thus stressing the importance of quality awareness. This shift from quality inspection to quality control also coincided with foundation of independent national standard setting bodies responsible for regulating norms and standards such as the Committee for Norms for Mechanical Engineering and the German Standards Committee in 1926.

After World War II, quality control was considered no longer a matter associated with testing and rework but efforts focused on quality prevention. However, until 1965, these standards were predominantly concerned with technology and methods (Seghezzi 1998:909). The stress of quality control was on the final control, the precise definition of quality testing parameters and general orientation towards product quality (König und Hofele 1993:11). Together with the impact of American military standards, in the 1960s, the task of quality management shifted from a purely reactive quality control to a system of systematic, preventative quality planning and quality assurance (Ketting 1999:26). Quality control evolved into quality assurance and the focus on developing preventative measures to assure

6 see also Hesser, W., A. Inklaar, 1998:Appendix and Masing, W. (ed.) 1999:5

quality in technical and planning areas (König und Hofele 1993:11). Furthermore, a process orientation of quality management was already evident, insofar as quality tests for products were perceived to be no longer adequate. The challenge was on controlling the entire value chain from supplier right down to the customer ' (Seghezzi 1998:909). With this extension beyond internal quality assurance, companies increasingly perceived the need to provide resources for quality management. This shift is visualised in Masing's model of the relation between product and process quality.

The model links the functions of quality management systems and production systems, as it points out the link between work regulations and task performance as major inputs determining process quality, as shown below:

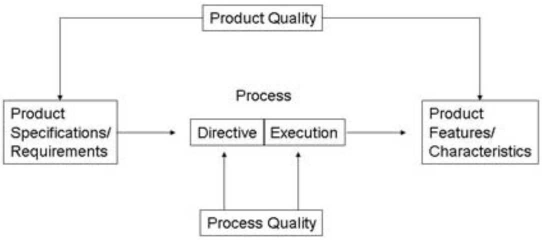

Fig. 2.2. Masing model of product and process quality (Masing 1999:9)

The quality of the product is reflected in both: customer expectations and demands in relation to the product and product specific characteristics (specifications), whereby the former provides the input into the production and quality process, the latter representing the result of it. Regulations determining how tasks are to be conducted are derived from the particular needs the product has to fulfil and are subsequently executed (Masing 1999:9). Both work regulations and task performance are in turn subject to the quality control of the entire process. Tasks are performed according to precise regulation, thus quality becomes regulated, accountable and controllable (ibid.). Work regulations and work performance are controlled and checked in terms of their contribution to the overall quality of the product. According to Masing then, based on the quality expectation of customers, process quality determines product quality (ibid.). A formalised framework for the evaluation of both product quality and process quality was therefore necessary and led to the introduction of the ISO 9000 quality management standards, discussed in due course.

Summarising this first part of the chapter, as seen in the case of Germany, during the pre-industrial era, quality had been part of the responsibilities of craftsmen and quality awareness was ingrained in the cultural consciousness of craftsmen and workers. However, through the introduction of specific quality controls, the responsibility for controlling quality shifted from craftsmen into the hands of guilds, professional trade organisations or town councils.

The origins of standardised quality management systems are in America. At the brink of industrialisation, during the early nineteenth century, in America the function of standardisation was to ensure the production of replaceable parts for the military. Thus standardisation spread from jigs, gauges to parts and work itself. With the advent of mass production, product quality suffered thus necessitating the development of standardised quality control tools. These were at first based on statistical methods, but gradually the rise of new technologies integrated mechanical quality control tools into machines and processes. The history of quality standards thus spread from quality inspection, to quality control, to quality assurance until today, quality management systems aim to ensure stable quality of products and processes.

Deming and Juran exported western standard quality control tools to Japan. Combining statistical quality standards with an awareness to constantly improve quality standards, the quality function changed. Instead of detecting quality errors in finished products, standards were developed to pre-empt any potential error to occur during the process: quality control evolved into quality assurance. Moreover, the Japanese integrated the American systematic approach towards quality control and assurance into their own production organisation. In my opinion this marked an important step: instead of merely assuring quality, by subjecting quality to the process of constant improvement, quality management became an integral part within the overall organisation of Japanese production systems. In the case of the Toyota Production System, for example, this is evident as quality assurance is considered a major sub-goal of the production system. Furthermore, workers are encouraged to continuously improve processes and standards not only to reduce waste, but also to improve the quality of the product (Monden 1993:3). Quality management has thus become a fixed ingredient of Japanese production systems.

Acknowledging the role of Deming and Juran as individuals contributing to the evolution of quality management, the history of standardisation and quality management is incomplete without looking at the key institutions which were founded along the historical path helping to institutionalise, formalise and develop standardisation. The purpose of the following part is therefore to take a closer look at their role in this process.

2.6 The historical rise of standard setting institutions

The second part of this chapter presents an overview of the role and function of the main standard setting institutions in Germany, the USA, Europe and internationally. I shall start by comparing the responsibilities of national standard setting bodies in Germany and the USA and what role professional associations of the automotive industry play in the national standard setting process. In the next step I will consider the international level of standard setters, primarily focusing on the function of the International Standards Organisation (ISO).

2.6.1 National standards setting bodies (NSBs)

National standards organisations (NSBs) are responsible for the co-ordination of company and industry level standards and their reconciliation with international standards (Verman 1973:104). Moreover, the „development of standards and technical rules by institutions given authority to do so by both the private and public sectors, is an essential element of the technological and economic infrastructure of a nation, and greatly influences its competitive ability and the strategies of companies“ (DIN 2000:6).

These national standard setters consist of either organisations, institutions, instituts, associations or societies. In non-centrally run states they are independent non-governmental bodies. For example, as National Standards Bodies (NSBs), the Deutsches Institut der Normierung (DIN) and the ANSI (American National Standards Institute) are members of the International Standards Organisation (ISO) but are responsible for their particular "national orbit" (Verman 1973:105). The DIN is privately run, its standards are voluntary and it published by far the greatest number of standards, current figures published in the annual report of the DIN (2002) show that since its beginning, the DIN has published 26.000 standards, 2.000 alone between 2001 and 2002 (source: DIN 22.01.02)[7]. Moreover, it conducts research and publishes periodicals on the issue of standardisation and also offers a standards certification scheme.

The DIN and the ANSI have traditionally been issuing technical standards. However, with the spread of quality standards, they have increasingly been responsible for issuing national standards on quality management systems such as the DIN:ISO series. To understand this development, a closer look at the history of both standards setting bodies is useful.

2.6.1.1 Deutsches Institut der Normierung (DIN)

In 1895 the *Verband deutscher Elektrotechniker* was founded to regulate energy safety measures. The first German standards then consisted of norms regulating material properties, classifications and testing processes of raw materials such as iron and steel (DIN 1992:94). However, this early attempt of setting electrical standards remained exemplary. In December 1916, driven by the need to simplify arms during the war, the *Königliches Fabrikationsbüro für Infantrie und Artillerie (Fabo I & Fabo A)* was set up in an old gym in Berlin Spandau. The production process of weapons involved a number of companies. However, standardised measures for construction parts such as screws, wedges, rivets, screws and gears were not standardised (ibid.:96). Indeed, the variety of existing systems on the shop floor proved to be a nuisance (ibid.). It was therefore the task of the Fabo to provide national standards harmonising these norms (ibid.). The benefits of the rationalisation of parts resulting from the standardisation activities of the Fabo soon

[7] A large number, compared to a total of 14.650 standards issued of the American counterpart of the DIN, the American National Standards Institute by 1999.

convinced other manufacturers. In order to provide standards improving war time production, together with representatives of the Fabo, the Association of German Engineers, and the German industry, the *Normalienausschuss des deutschen Maschinenbaus* was founded in May 1917 (ibid.:98). Recognising a need for standardisation after the war, in December 1917 the German Standards Institute Deutsches Institut der Normierung (DIN) was set up. The first standards, DIN Norms 1–5, regulating drawings for taper pins, standard diameters, paper sizes and technical drawings were issued in spring the following year (ibid.:99).

During the reconstruction period after World War II, the DIN standards became enforced law, particularly in areas where the Allied bombing had destroyed complete infrastructures. For example, in October 1945, the Berlin magistrates made DIN standards mandatory for the city such as standards for windows, piping systems, plumbing tools, heatings and baths were introduced (ibid.:114).

Today, the role of the DIN is "the principal regulatory body for technical rules" in Germany (ibid.:8). It represents Germany at the European Committee of Normation (CEN) and the International Standardisation Organisation (ISO). Based on the DIN 820, the task of the DIN is to provide standards insofar that they concern a harmonisation of material and immaterial objects as common goods (DIN Norm 820 1994:1).

According to the DIN, the object of their work is to research and propose standards aiming to relieve German law giving bodies, particularly with focus on providing standards for the safety of people and objects and the environmental protection in all areas. The work of the DIN provides structures and order and supports the smooth exchange of information (ibid.). Standardisation is thus seen to promote the rationalisation and quality assurance within the private realm as well as within the industrial, technological, science and administrative sectors (ibid.). In 2001 the work of the DIN was conducted in 83 Standards Committees, Technical Committees of Standards Committees (working groups of Standards Committees) 4.182 working groups, advised by 24.963 external experts and supported by a total DIN staff of 702 (DIN annual report/joint report of the president and director of the DIN 2001), brought together from a diverse background of representatives of "the manufacturing industries and commerce, consumers, interested parties within the trades, service companies, science and research, technical supervisor bodies, employers, trade unions, public agencies" (DIN 1992:8).

DIN standards are first and foremost considered to represent voluntary recommendations to ensure a reliable technical performance (ibid.:11). All standards are considered common property and are thus accessible for the general public (DIN Norm 820 1994:2). Their core aim is to harmonise standards for the needs of the general public (ibid.). Moreover, standards are to be revised every five years according to the DIN the regular updates serve to ensure that standards reflect the current know-how of science, technology and the economic developments. (ibid.:3). Considering the rapid changes particularly in the field of information technology, a five year period is rather long and it is doubtful if standards thus reflect the up-to-date level of advancement. To account for these rapid technological changes, the DIN has set up special project groups (Projekte zur Entwicklungsbegleitenden Normung, EBN), which keep a constant update of the evolution of new key technologies (for example, laser technology, robotics, telecommunication and artificial intelligence) and develop standards alongside their evolution (DIN 1992:74).

Once the need for a standard is recognised, it is drafted and its ratification is based on a consensus decision keeping in mind that standards are introduced if they are absolutely necessary. Standardisation is not an end in itself (Petrick and Riehlen 1999:77, Kortzfleisch 1967:333). However, the question regarding what is necessary, shows that there are actually no limits to what may be standardised within the technical discipline.

Finally, the DIN considers its work also in an international context, thus proposing that German standards are not insular solutions but have to function in an international context. Regarding the increasing globalisation of the German industry, this principle is particularly relevant. Indeed, already during the 1920s, the importance of an international harmonisation of standards was recognised as an essential prerequisite for the trade between countries particularly regarding the standardization of products, quality standards and quality tests. The DIN is therefore representing Germany at the International Standards Organisation (ISO).

So far then, the DIN has been seen to provide general quality management standards. The question though is, to what extent do standards incorporate the specific needs of the automotive industry and what influence do actors of professional automotive institutions have on national standards?

The interests of the automotive industry at the national standard setting level is represented by the committee for the automotive industry ("Fachkreis der Kraftfahrzeugindustrie", FAKRA) of the DIN. Its origins date back to the roots of the DIN, insofar as World War I necessitated the development of standards for replaceable parts such as tires, wheels and spark plugs. Blue FAKRA handbook first issued a collection of standards which had been suggested by experts from the automotive industry and finalised by the FAKRA (DIN Normenpraxis 2002:1). Based on the link between industry experts and standard setting institutions, the automotive manufacturers directly contribute their expert knowledge to the standardisation process.

After World War II, the work of the FAKRA focused on developing standards in four main areas: for measures, vehicle safety, technical equipment, construction and testing (ibid.:1). The assurance of international compatibility particularly with regard to mechanical parts, brake systems and electrical equipment was as important as developing standards regarding the testing of noise and emissions. The FAKRA then provides standards regarding product specifications at the functional level of standardisation and that it operates in association with the German Association of Automotive Manufacturerss (Verein Deutscher Automobilhersteller, VDA). As umbrella organization of the German automotive sector, the VDA itself is a mediator between political institutions and the automotive industry, the VDA considers itself as service provider of statistical data on the automotive industry, registration figures, data and surveys on the German automotive industry rather than as a bureaucratic organisation. Unlike the FAKRA, the VDA functions as the representative body of the German automotive industry, and thus does not issue standards.[8] However, through its co-operation with the FAKRA, the VDA provides a direct channel for the automotive industry to take part in the process of setting standards and specifications for the automotive industry.[9]

Regarding the international dimension, the FAKRA represents the DIN in specialist automotive committees of both the ISO and the CEN. Regarding the former, the FAKRA represents the German automotive industry in the technical committee (TC) of the ISO, (ISO/TC 22 responsible for international standards for road vehicles, and ISO/TC 104 and 204).

At European level, the FAKRA represents Germany at the Comité Européen de Normalisation (CEN). "Although the standardization culture of the automobile industry is mainly linked to ISO, there are applications, which are, for specific niche markets or legislative environment reasons, developed within European standardization" (CEN 2002:1), this applies, for example, concerning the development of standards for electrically propelled vehicles or fuel cell cars. To develop standards for these new technologies in the automotive industry, the CEN has set up specific technical committees which the FAKRA attends (CEN/TC 301, 278 and 119).

To sum up this part, the DIN represents the major national standard setting body in Germany. The interests of the automotive industry, as well as other industries, are represented in specifically set up committees. Thus professional bodies co-operate with national standard setting bodies, as is the case between the FAKRA and the VDA. Regarding the responsibilities, the FAKRA sets standards for products or technical specifications of the automotive industry. It also liaises with international counterparts at both European and international level. This shows that the automotive industry in Germany is integrated into the national and international standard setting process.

2.6.1.2 The American National Standards Institute (ANSI)

Like its German counterpart, the American National Standards Institute (ANSI) (founded in 1918) is a private, non-profit organisation providing the official forum for the development of "consensus agreements on technical, political and policy issues" (ANSI 2002b:2). The role of the American standards institution is influenced by the historical development of standardisation. As discussed above, quality standards originated within Europe. This strong tradition continues as the dominance of the standard setting institutions is still located within Europe: there are influential National Standards Setting Bodies (NSBs), like the DIN in Berlin, the European standard setting institute (CEN) in Brussels, and the International Standards Institute (ISO) in Geneva. The ANSI particularly fears this European in-

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8 The standard setting function of the VDA is limited to its Quality Management Centre (QMC), a division of the VDA set up in 1997, responsible for setting a issuing the VDA 6.X series of automotive standards, a topic which will be examined in detail below.

9 The VDA represents Germany at European level at the Association des Constructeurs Européens d'Automobiles (European Automobile Manufacturers Association) in Brussels.

fluence. Indeed, the European standard setting bodies are considered to pursue a strategy of "aggressively and successfully promoting its technology practices to other nations around the world through its own standards processes and through its national representation" (ANSI 2002a.:3). The participation of the ANSI at international standard setting level is then not only a matter of representation but an attempt to counteract the European dominance over the setting of international standards.

Regarding the function of the ANSI in America, it is important to point out that it neither issues standards nor tests or evaluates products or services itself. Instead, the ANSI "accredits qualified organisations to develop standards" (ANSI 2002b:6) and hence is more of an accreditation agency, than a standard setting institution. Part of this agency function of the ANSI is to regularly audit its accredited organisations. Currently, there are 250 accredited ANSI entities, but the total membership of the ANSI consists of around 1000 national and international companies, 30 government agencies, and more than 270 professional, educational, technical, trade, labour and consumer organisations (ibid.:21). Thus the work of the ANSI is limited to providing administrative support and serves as an "oversight body to the standards development and conformity programs and processes" (ibid.:6). In other words, instead of issuing standards, the ANSI provides standards on how to set standards and "designs processes for generating standards" (Knieps 1995:290) thus standardising the standard setting process. This allows each industrial sector to develop standards through a predefined standardised process. If accepted, the ANSI issues this industry standard as an American National Standard (ANS).

In the case of the automotive industry, standards are for example developed by the counterpart of the VDA, the Alliance of Automobile Manufacturers (AAM) founded in 1999.[10] It consists of all international automotive manufactures with manufacturing sites in the USA, including for example the BMW Group, DaimlerChrysler Corporation and Toyota Motor North America. Thus the "Alliance member companies have approximately 600.000 employees in the United States, with more than 250 facilities in 35 states. Alliance members represent more than 90 percent of U.S. vehicle sales" (AAM 2002:1). The standards set at this industry level are "so well developed that the standards issued by most industry associations are generally considered (…) as standards of national importance and used as such" (Verman 1973:99). Thus, development of national standards takes place at industrial level "under the auspices of the ANSI and in accordance with the latter's formal procedure" (ibid.).

The advantage of this sectoral focus is that standards are created from within the industry, thus embodying the specific expertise and experience in the particular industry. The understanding that "no single standardization system can satisfy

[10] Unlike the close connection between the VDA and its QMC standard setting body, there is a less formal link between the AAM and the Automotive Industry Action Group (AIAG), responsible for issuing the QS9000 standards (the US equivalent of the German VDA 6.1 standards issued by the VDA/QMC). For a detailed discussion of the AIAG's work and the QS 9000 refer to the second part of this chapter.

all needs" (ANSI 2002a:6) ensures that standards are appropriate to the actual problems of the industry sector thus providing for consensus decisions upon which the voluntary American system of standardisation is based. As with German standards, upon adopting or legally referencing ANSI standards, these in turn become mandatory. Moreover, like their German counterpart, in co-operation with the ANSI, standard developers and the US government are encouraged to set up education programmes particularly for promoting the "benefits of strategic standardization" (ANSI 2002b.:20).

Overall then, the difference between the DIN and the ANSI, is that the DIN is actively involved in the standards setting process, the ANSI provides the administrative framework for the implementation of standards but delegates the development of quality standard to accredited organisations. The advantage this approach ensures is that standards provide the most appropriate solution for the specific needs to each industrial sector. The interesting question resulting is, how can these different approaches be reconciled on an international level? To assess this question a closer look at the ISO provides useful input.

2.6.2 Institutionalisation of international standards – the International Standards Organization (ISO)

At the turn of the century, the discovery and wide-spread assimilation of electricity led to the creation of the International Electrotechnical Commission (IEC), considered the "premier international authority" (Verman 1973:151) setting standards for the electrical and electronics industries. However, attempts at creating one world-wide standard setting institution took almost another twenty years. In 1921, Belgium, Canada, the Netherlands, Norway, Switzerland, UK and USA agreed on exchanging information regarding their respective national standards. In 1926 the formal foundation for the International Federation of the National Standardizing Association (ISA) was laid by 14 countries including Germany, the USA and Japan. Between 1942 and 1947, the activities of the ISA were temporarily taken up by the United Nations Standards Coordinating Committee (NSCC). In October 1946, the constitution and rules of the International Organisation for Standardization were ratified by all members of the NSCC and the ISO started its activities in 1947. Aiming to harmonise already existing international standard setting bodies, as stated above, the International Electrotechnical Commission (IEC) was integrated into the ISO. Incorporated as the ISO's Electrical Division, the IEC nevertheless retained its independent status and identity. The function of the ISO is to draft international standards based on the individual contributions by its national members. In other words:

> "The existence of non-harmonized standards for similar technologies in different countries or regions can contribute to so-called "technical barriers to trade". Export-minded industries have long sensed the need to agree on world standards to help rationalise the international trading process. This was the origin of the establishment of ISO." (ISO 2002a:2)

However, parallel to the growing number of nations taking part in the ISO activities, the subject of standardisation was extended from providing functional standards to providing performance standards. Notably, the widespread use of the ISO 9000 series of standards proposing the specific criteria necessary for the management of quality, has reflected this development.

During the 1980s, the need to provide standards for global quality management systems became evident and the answer was seen in the introduction of the ISO 9000, a set of international quality management standards, issued for the first time in 1987.

The role of the ISO has mirrored the evolution of standardised quality systems. Whereas at first, the focus was on integrating technical standards into international standards, the responsibility of the ISO has increasingly shifted towards providing international standards for managing the quality of processes. The development of the ISO 9000 series has been a milestone for the ISO in this respect. To analyse this further, in the following section I shall examine the rise of international and national standards for quality management: the ISO 9000 series, the ISO/TS 16949, the VDA 6.X series, the QS 9000 and the European Federation of Quality Management Model (the EFQM model).

2.7 The institutionalisation of international standards for quality systems

This overview shows the evolution of quality management standards issued since the introduction of the first set of ISO 9000 standards in 1987. It is interesting to see that upon the introduction of the ISO in 1987, other quality management systems mushroomed first at European level, then at the level of automotive associations, commencing with the VDA in Germany and followed by the QS9000 in the USA. Moreover, this overview also shows that at neither level, the standards once introduced are fixed, as all standard quality management systems are subject to regular updates. Thus, standard setters perceive that standards represent only the temporary best solution which, according to the dynamic environment they intend to regulate and have to be adapted accordingly.

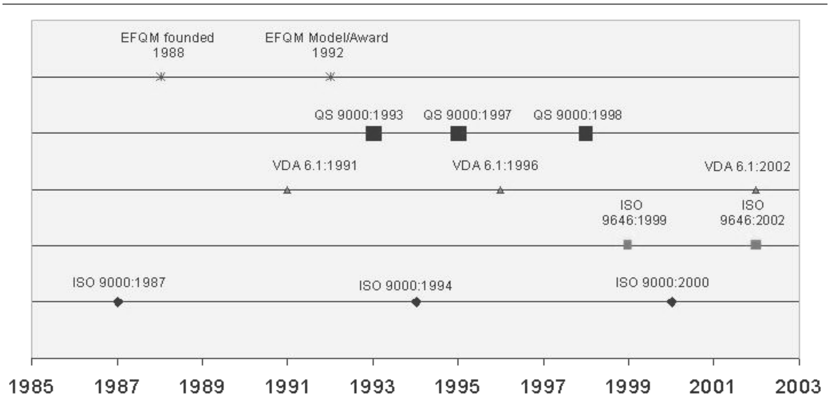

Fig. 2.3. Overview of the evolution of quality standards for the automotive industry from 1987 – 2002

To point out advantages of international standards but also their shortcomings I shall first focus on the evolution of the ISO from its origins to its current ISO 9000:2000 series. I will also examine and compare the ISO 9000 with the specific quality management systems used in the automotive industry (VDA 6.X series and the QS 9000) and to examine the implications arising from the introduction of TQM-based holistic quality management systems such as the EFQM-model. Concluding this part, I will give critical appreciation of the quality management standards presented.

2.7.1 Historical evolution of the ISO 9000

The origins of the ISO 9000 date back to the 1950s when, based on the criterion of the Acceptable Quality Level (AQL), the US government introduced the military standards 105 (MilStandard 105) for purchases of military goods conducted during World War II (Hesser and Inklaar 1998:162). In 1963, this standard was used by the NATO and became known as the US MIL-Q 9858. Based on the US MIL-Q 9858, during the early Thatcher years, the British arms industry adopted this NATO standard. As British National Standard 5750 (BNS 5750) it was adapted for a non-military context. Walgenbach concludes that the positive experiences made with standardised and contrlled elements of quality management systems used within the military sector of the NATO, led to the transfer of this system to the civil and industrial sectors (Walgenbach 2000:122). At the same time though, since the 1970s other national bodies had also started to introduce quality standards. This led to a "fragmentation of rules for quality systems" of business players (Hesser and Inklaar 1998:162). The difficulties of companies to reconcile these, different, often contradictory standards, raised the necessity to "standardise uniform models for the elements of quality systems" (ibid.) and both customers and governments demanded the transparency and documentation of quality systems. (Seghezzi 1999:103). Encouraged by the British, in 1987, the ISO used the BNS 5750 as a "prototype" for the ISO 9000 series (Hancké and Casper 2000:175). Particularly the British urged for the creation of an international standard to counterbalance the dominance of the label "Made in Germany", according to Klotz, during the Thatcherism, the ISO 9000 international standard series was particularly promoted by Great Britain and emerged as counter pole to the up to then prevailing quality brand "Made in Germany" (Klotz 1996:48). Published by the DIN-News in 1985, Premier Minister Margaret Thatcher, on the occasion of the inauguration of the new building for the British Standards Institute, noted that the Ministry of Trade and Industry supported by the British Standards Institute, promotes a national marketing campaign for quality (…). One aspect of this campaign is to convince top managers of the competitive advantages of quality assurance systems. (Thatcher 1985:232)

The purpose of the ISO was neither to create, nor to acknowledge the existence of a "one-best" quality management system: one universally applicable quality management system does not exist, thus one cannot standardise quality systems (DIN 1994:5). Instead the ISO attempted to harmonise the elements which constitute a quality management. According to Walgenbach then, it is not the quality management itself which was to be standardised by the DIN EN ISO 9000 series, but its structure and collection and presentation of evidence (Walgenbach 2000:2). Seghezzi goes as far as suggesting that the ISO 9000 is a standard model which sets the framework of what should be made transparent, but not this should be done (Seghezzi 1999:104).

The perception of the German industry towards the creation of a standardised quality management system was reluctant. During the mid-70s, in the wake of extending the tasks of quality assurance beyond its initial focus on production, German quality engineers had attempted to introduce standards for the documentation of quality assurance systems (Walgenbach 2001:7). These aimed at institutionalising the label and image of "Made in Germany" into a formalised set of standards (Hesser and Inklaar 1998:162). However, these early attempts were met with scepticism, as the quality behind the label "Made in Germany" was seen to originate from a degree of organisational freedom and the proposed standards were feared to infringe organisational freedom leading the standardisation of management (Walgenbach 2001:7).

This attitude prevailed, as the first drafts of the ISO 9000 were discussed. Particularly the following paragraph of the DIN ISO draft was criticised as it was considered to point towards an increased regulation of work (DIN 1985: Gliederungspunkt 4.1.2.2, Anmerkung 2):[11]

[11] This statement is also reminiscent of the Taylorist division between mental and physical work.

Walgenbach summarises this criticism insofar that a highly formalised system was imposed upon manufacturers which leads to inflexibility (Walgenbach 2000:164). In short, quality would be a matter of administration, no longer part of the production process (ibid.).

Furthermore, regarding the particular structure of the Germany workforce primarily consisting of highly skilled workers, "monitoring the product quality was an integral part of the workers' tasks" (Hancké and Casper 2000:181). An inherent job responsibility which the German industry thought could not be regulated by national standards (Seghezzi 1999:106ff.). Needless to state that the German stand was challenged as the ISO 9000 was officially ratified in 1987. According to Walgenbach and also Boehling (1991), Germany, as active member of the ISO and the EU commission, yielded to its implementation with a degree of forced acceptance (Walgenbach 2000:211). But how was the final submission to ISO 9000 quality standards perceived from the perspective of the automotive industry?

To appreciate the role of the automotive industry in this context, it is first of all important to understand what the ISO 9000 actually intends to regulate. For this purpose, I shall give a systems overview.

2.7.2 ISO 9000 – a standardised quality management system

The ISO 9000 standards were drafted independently from particular national practices but instead focused on providing standards for "a variety of commercial settings" (Hancké and Casper 2000:176). Thus, "requirements for quality management systems are generic and applicable to organisations in any industry or economic sector regardless of the offered product category" (DIN 2000a:9). It is noteworthy to point out that the suppliers were the first to implement the ISO 9000 series followed by final assemblers (Hancké and Casper 2000:182).

ISO 9000 standards are based on the assumption that successful companies need to be directed and controlled "in a systematic and transparent manner" (DIN ISO 2000a:6). Success is seen in terms of customer satisfaction. The implementation and maintenance of a quality management system which strives for „continually improving performance while addressing the needs of all interested parties“ (ibid.) is therefore considered one success factor. In other words, the ISO 9000 series "provides rules for a management system that *produces* quality" (Hancké and Casper 2000:178) and "contains the principles for the definition and introduction of quality systems as well as for their demonstration to third parties" (Hesser and Inklaar 1998:171).

Looking at its structure, the term ISO 9000 is a heading for a "coherent set of quality management standards" (DIN 2000a:6) and consists of a family of three series of "prescriptive technical norms" (Hancké and Casper 2000:176). According to Seghezzi, the ISO 9001 focuses on providing standards for quality assurance (Seghezzi 1999:105). In other words, it "specifies requirements for a quality management system" (DIN 2000a:6). It contains 20 quality assurance methods, related to the production, installation, servicing and design activities of a company.[12]

The ISO 9002 contains 18 methods. It focuses on providing standards for the quality steering, aiming to regulate processes and to prevent the production of faulty parts (Seghezzi 1999:105). The ISO 9003 with 12 quality elements is the least comprehensive and primarily offers standards for the packaging and distribution industries, mainly providing standards for quality inspection and tests (ibid.). The ISO 9004 "provides guidelines that consider both the effectiveness and efficiency of the quality management system" (DIN 2000a:6).

I shall now take a closer look at the ISO 9000 and ISO 9001.[13] The first part of the ISO 9000 headed "Fundamentals of quality management", sets the parameters for quality management standards in three sections: an introduction including general systems overview and eight quality management principles; scope or applicability of the ISO 9000 series and finally, the fundamentals of quality management systems (ibid.:8).

In the general introduction the purpose of the ISO 9000 standards is defined "to assist organisations, of all types and sizes, to implement and operate effective quality management systems" (ibid.:6). In addition it contains eight quality management principles. These give an account of the necessary aspects involved in quality management: "customer focus, leadership, involvement of people, process approach, system approach to management, continual improvement, factual approach to decision making and mutual beneficial supplier relationship" (ibid.:7). For example, the involvement of people is defined as "people at all levels are the essence of an organization and their full involvement enables their abilities to be used for the organization's benefit" (ibid.). The process approach is defined as "the systematic identification and management of processes employed within the organisation and particularly the interactions between such processes is referred to as the process approach" (ibid.:10). The crucial question is though, how can the ISO 9000 ensure that this process approach is adhered to and the people implement and apply the ISO standards correctly?

The answer is provided in section 2.8 which sets out that the adherence of ISO 9000 standards is to be checked by audits whereby a comprehensive audit is made every three years and interim audits are conducted every six months. The audit itself is regulated by standards set out under the ISO 9000 and its goal is to check on the effectiveness, adherence or deviation of ISO 9000 standards (Antoni 2001:142). According to the ISO 9000 each company filing for certification has to provide documentary evidence of the adherence of ISO 9000 standards. This evidence is presented in the so-called ISO 9000 Handbook. The main focus of the ISO 9000 audit is to check if this document contains the written evidence confirming the application of quality standards. Details about the ISO 9000 audit are pro-

[12] For a detailed comparison between the ISO 9000 series, refer to the comparative matrix of Seghezzi 1999:110.

[13] The choice of these two parts of the ISO was made as are also the most common basis of certification in the automotive industry (Paradis and Small 1996).

vided by the ISO 19011. With regard to the audit administration, the ISO itself does not assess or audit quality systems these tasks are delegated to accredited audit organisations, in the case of Germany, to the quality inspection section of the Technischer Überwachungs Verein (TÜV). According to Walgenbach, independent certification companies conduct the ISO audit, because evidence of the matching of written standards and their actual practical application is to be provided by an independent third party (Walgenbach 2000:378).

To resume so far, the ISO 9000 provides a document intended to be used by companies across industrial sectors. Its core intention is to provide a set of guidelines on how to manage quality. The ISO 9000 identifies eight core areas which quality management has to focus on: customer, leadership, people, processes, continual decision making and suppliers. However, instead of providing a stringently formulated set of standards, the ISO 9000 is rather vague, a point I will come back to. To ensure that these standards do nevertheless reflect the best possible recommendations, the ISO 9000 is regularly updated.

Despite its 1994 update, the ISO 9000 continued to be based on a "proliferation of standards" (ISO 2000b:2), and therefore a leaner system of standards was called for. Reacting to this concern, the ISO thus revised the ISO 9000 series and issued the revised ISO 9000:2000 version. The diagram below shows the transition of the ISO 9000:1994 series into the latest 2000 edition:

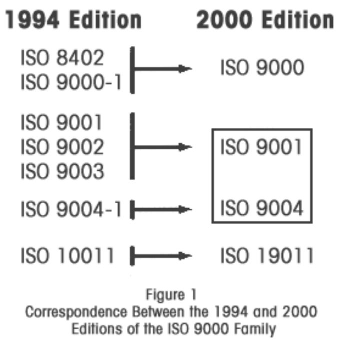

Fig. 2.4. The integration of the 1994 edition of the ISO 9000 series into the latest ISO 9000:2000 edition

Commencing with the structural changes, the updated version now consists of "four primary standards supported by a considerably reduced number of supporting documents" (ibid.). The fundamentals, definitions and quality vocabulary was continued as ISO 9000:2000, the three ISO series 9001, 9002 and 9003 were consolidated into one standard. The updated versions of ISO 9001 and ISO 9004 standards were developed as a "consistent pair" whereby the former provides the necessary requirements, and the latter "is intended to lead beyond the ISO 9001 to enhance satisfaction for interested parties" (ibid.). In other words, quality has been extended from the focus within organisations to providing quality standards to enhance customer satisfaction. Regarding the changes in content, according to Hesser and Inklaar, "the new ISO 9001 is intended to support process-oriented QM systems and incorporate continuous improvement of the QM system as an additional demand" (Hesser and Inklaar 1998:193).

2.7.3 The evolution of the ISO technical standard (TS) 16949

In order to provide specific guidance of the application of ISO 9000 standards for the automotive industry, the ISO/TS 16949:1999 (ISO/TS 16949 thereafter) was introduced in 1999. This set of standards was proposed by the International Automotive Task Force (IATF), a working team consisting of representatives of both the automotive industry including the consolidated former Big Three, Ford, GM and DaimlerChrysler, PSA, Renault SA and Volkswagen, and professional associations notably amongst others the Automotive Industry Action Group (AIAG) for the USA and the VDA – Quality Management Centre (VDA-QMC) for Germany. The purpose of founding the IAFT was to develop an international consensus regarding the provision of standards for quality management systems initially for its actual members but also open for any business active in the automotive sector. The IAFT is also responsible for developing audit guidelines and training programmes for the ISO/TS 16949.

Regarding the development of the actual standards, the ISO/TS 16949 consists of a criteria catalogue (VDA-QMC 2002:2) harmonising the quality management standards issued by its constituent member nations, such as the QS 9000 for the USA and the VDA 6.X series for Germany with the ISO 9000. This catalogue represents the prerequisites posed on the quality management systems of suppliers within the automotive industry (ibid.). Albeit the ISO/TS 16949 provides an international set of standards, it does not replace individual national standards such as the VDA 6.X series or the QS 9000. Instead, it offers an additional option for suppliers to be certified according to internationally acknowledged quality systems standards (ibid.). So how do the VDA and the QS 9000 differ compared to the ISO? Moreover, do they provide a more suitable set of quality standards for the automotive industry?

2.7.4 VDA 6.X series

Upon introduction of the ISO 9000 in 1987, the DIN adapted these international standards in their official catalogue of norms. However, recognising the necessity to integrate and adapt the general ISO 9000 standards to the particular context and environment of the automotive industry, a VDA working group, responsible for the standardization of technical norms, set forth to "consolidate the most useful standards from each of these series into a common quality management system package" (Hancké and Casper 1996:16) which could be used throughout the German automotive industry. Keeping in mind the particular needs of the industry, the committee adapted the ISO standards adding necessary standards such as, for example, the use of statistical process controls for mass producers delivering on a JIT basis. This effort by the VDA helped manufacturers and suppliers to save time, money and effort and contributed to a harmonisation of standards within the automotive industry. The VDA quality management series VDA 6.X series was introduced in 1991.

Since August 1, 1997, these VDA quality standards are administered by the VDA Quality Management Centre (herein referred to as QMC). Being able to draw from 400 freelance staff from the automotive industry organised in 21 committees, the QMC is responsible for the continuous update and translation of standards set by the ISO to the specific context of the German automotive industry. Since September 1997, BMW, DaimlerChrysler and Volkswagen demand their European Original Equipment Manufacturers (OEMs) to be certified according to VDA 6.1 (VDA 2002). Looking at the structure, the VDA 6.X standards series is divided into the following six parts:

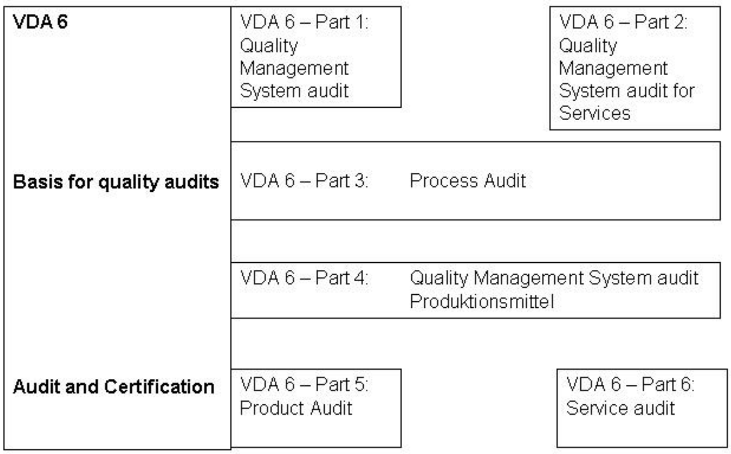

Fig. 2.5. Overview VDA 6.X audit series. Source: VDA 6.1, 1998:7

Concerning the automotive industry, manufacturers primarily file for certification according to the VDA 6.1 systems audit and I shall therefore specifically focus on this part of the VDA series (towards the end of the chapter, I will examine the implications that arise from using audits generally as control and verification tools).

The fulfilment of the VDA criteria is checked by means of an audit. According to the VDA, the auditor evaluates the degree and effectiveness of quality management measures. The auditor thus assesses the written evidence of the fulfilment of quality standards (Quality Management Handbook, process descriptions, job profiles, work sheet, etc). Moreover, the practical use of these documents is also assessed. (VDA 2000:20)

To evaluate the fulfilment of standards, the auditors use a rating scale ranging from 0 to 10 points with levels at 0, 4, 6, 8 and 10 points. Each score is verbally differentiated between zero points (No effidence) to 10 points ("Quality Management System is comprehensively defined and implemented") (VDA 6.1 2000:21) . The degree of fulfilment of each quality management element is thus calculated and the result ranked according to following table.

Table 2.1. Evaluation of Clients / Suppliers (Second party audit). Source: VDA 6.1 2000:23

Total degree of fulfilment (in %)	Evaluation of the Quality Management	Level
90 – 100	Fulfilled	A
80 – 90	Mostly fulfilled	AB
60 – 80	To some degree fulfilled	B
Below 60	Not fulfilled	C

Certification for three years is only issued for companies reaching a level of 90% and above (ibid.:25). In interviews I conducted, quality managers at the Mercedes-Benz plant Untertürkheim at centre Z stated that in their quality management department, the VDA 6.1 series represents by far the most important audit. The key role of the audit is underscored as it was developed by 27 companies from the German automotive industry.

The VDA 6.1 is divided into two parts. Each part is in turn split into standards defining a) management responsibilities, and b) standards defining product and processes. In an introduction, each QM-element is briefly introduced and visual references to particularly significant influences on the stability of processes and product are made.

Each set consists of the question and a definition (ibid.:38). Taking the example of the first section of the VDA 6.1, covering the management of the company, paragraph 01 Management Responsibility first relates the paragraph to its equivalent section in the ISO 9000 series and continues to define the general parameters of the audit questions. For example, the responsibility of management to develop a quality management policy for the organisation and the need of a commitment for its implementation; the setting of quality goals in accordance with the quality management system and to role of quality as management function (VDA 6.1 2000:39).

After this general introduction, specific questions regarding the management of quality in the company are posed, as above they are also referenced with the respective or equivalent sections in the ISO 9000. For example, question 01.1 Has the management set out a quality policy and has its content been communicated? Question 01.2 Have quality targets been set as part of corporate planning and are these being controlled? Question 01.3 has the continuous improvement process been integrated into the quality policy? (ibid.)

In this particular example, the first two questions can be traced back to the ISO 9000 series, whereas the last one has no equivalent and reflects the specific quality criteria developed for the automotive industry and in detail audits specifically the reduction of non-value adding activities (for example rework and repairs), the simplification of processes and optimisation of production methods, and the reduction of waste (ibid.:43). Insofar then the VDA 6.X series provides a much more industry specific tool for quality management.

2.7.5 QS 9000

Issued by the Automotive Industry Action Group (AIAG), the American counterpart of the VDA, the equivalent of the German VDA 6.X series is the American QS 9000. Whereas the VDA represents the entire German automotive sector, the AIAG is dominated by its founding members, the Big Three US automakers, Ford, GM and Chrysler and thus reflects their particular quality management needs. The QS 9000 is an example of how company internal quality management standards found their way into national standards for quality management. The origins of the QS 9000 date back to a report about the Japanese competitiveness issued by Arthur Andersen in 1980 whereupon the AIAG was founded in 1982 to provide an „open forum where members co-operate in developing and promoting solutions that enhance the prosperity of the American automotive industry" (AIAG 2002:purpose statement). Even before the issuance of the ISO 9000 standards, the AIAG issued its first industry standards for quality certification in 1986. In 1993, the Supplier Quality Requirement Task Force distributed the first set of quality requirements termed QS 9000, aiming to "harmonize the fundamental supplier quality manuals and assessment tools" (AIAG 1998:1). Both the VDA 6.X series and the QS 9000 were developed from the ISO 9000 series and offer thus a comparable system of quality management standards.

The QS 9000 is divided into three sections. The first section reiterates the standards of the ISO 9000 series plus specific quality demands. Focusing on the specific needs of the automotive producers, the second part consists of the 20 ISO 9001:1994 methods. In addition there are 3 sections describing quality standards which regulate the release of production parts, continuous improvement processes and manufacturing capabilities. Part final part contains special cases of client specific quality demands of the Big Three (Loos 1998:19).

Since 1997 the Big Three demand the certification of their suppliers according to QS 9000. This prerequisite was extended to the entire DaimlerChrysler Corporation after the official merger and the company now conducts all three major quality system audits: VDA 6.1, QS 9000 and ISO/TS19646 (Valade 1999:1).

2.7.6 The key differences between the ISO 9000, VDA 6.1 and QS 9000

Both, the QS 9000 and the VDA 6.1. go beyond the standards set by the ISO 9000 series. A detailed analysis of the differences of each set of standards is beyond the scope of this present study. Suffice to examine three particular examples reflecting on the divergent perspectives of the three systems.

Regarding management's responsibility for the quality system, the QS 9000 requests additional documentation of organisational interfaces. Both the VDA 6.1. and the QS 9000 stress the need for continuous improvements regarding the management of the quality system, particularly concerning the control function of management.

It is furthermore interesting to see that both the QS 9000 and the VDA 6.1 stress the importance of customer orientation as part of the management's responsibility for quality management. The focus on the customer within the quality management systems is also evident in standards regulating the dissemination and collection of data which according to QS 9000 and VDA 6.1 should include information about customers. Additionally, standards regulating quality management training, particularly in the QS 9000 demand that training provides insight into customer specific needs. Thus, QS 9000 and VDA 6.1 additionally focus on providing standards which link quality with customer satisfaction.

Moreover, there are differences regarding the regulation and the labelling and tracing of products. Particularly the VDA 6.1 demands are more detailed and more stringent than the QS 9000 and the ISO 9000.

For standards regulating the treatment of faulty parts, the QS 9000 adds standards for labelling defective parts, whereas the VDA 6.1 proposes additional standards regulating re-work and a system for recognising recurring errors. In other words, the VDA 6.1 is more concerned with the treatment and prevention of errors whereas the QS 9000 focuses on the visualisation of errors. The QS 9000 goes beyond standards of the ISO 9000, by including standards for problem solving techniques and the examination of returned parts. In contrast, the VDA 6.1 sets out far more stringent measures for analysing the actual root causes of errors, error risks and repetitive errors. In other words, whereas QS 9000 sets out standards for a problem solving techniques (error detection), the VDA 6.1 focuses on setting standards which aim at eliminating the root cause of the errors (error prevention).

Despite refining the ISO 9000 standards, the QS 9000 and the VDA 6.1, in my opinion, all three quality management systems lack the holistic view of quality encompassing the entire organisation. Recognising this, in addition to ISO 9000 based standard quality management systems, the total quality management perspective was institutionalised through the in the European Foundation of Quality Management (EFQM) model. In the following part I shall analyse the function of this model, particularly the degree to which it institutionalised the Japanese quality management principles discussed above.

2.7.7 Towards a holistic view of quality – from ISO 9000 to the Total Quality Management System (TQM) of the European Foundation of Quality Management (EFQM).

As seen above, the ISO 9000 provided a first attempt to set standards for controlling the entire process chains, however, at the same time, spreading from Japan and publicised by the MIT study, a holistic quality perspective, the Total Quality Management (TQM) approach (also known through Peters and Waterman (1984) as Excellence Model) - in Japan known as company-wide quality control - challenged the prevailing view of quality management. A change in understanding led to the perception that quality is a responsibility and task of all staff (Ketting 1999:29). The sustained quality satisfaction of the customer is a company-wide task of all members of staff. Moreover, customer satisfaction and the integration of the tacit knowledge of staff into a continuous system of improving quality and performance standards are key aspects characterising TQM (Seghezzi 1999:112). In order to achieve these goals, TQM draws on four aspects. First, management responsibilities and role model function (Juran 1995:650) stressing that quality is a mind set (Borgwards 1987:577). Second, the quality management system is enshrined in the official quality policy of the company. Third, quality tools such as FMEA analysis are deployed. Fourth, quality standards are subject to a continuous improvement process (Frehr 1999:35).

These four aspects of TQM aim to help companies achieving quality of products, a company-wide quality awareness and quality of skills performed. In other words the four pillars of TQM support a holistic view of quality within the company (ibid.). The function of management, for example is to continuously promote the TQM process and managements' attitude and behaviour is oriented on a setting an example by living the continuous improvement of quality within daily routines (ibid.:38). Moreover, management is responsible for allocating appropriate funds to support the continuous TQM process, to offer training opportunities, to incorporate necessary TQM measures in budgets and to control the TQM process by instigating regular TQM audits.

In order to institutionalise quality management as a "habit of improvement" (Juran 1995:650), aiming to improve the competitive position of the European industry, major European managers founded the European Foundation for Quality Management (EFQM). This foundation aims at providing companies with additional quality standards which are based on the TQM model and go beyond the ISO 9000 demands.

Recognising that "the battle for quality is one of the prerequisites for the success of your company and for our competitive success" (Delors 1998) presidents of 14 major European companies, including Volkswagen and Fiat, founded the EFQM in 1988 to provide a "European framework for quality improvements" (EFQM 2000:1 and Malorny 1999:203). Based on a standardised framework for self-assessment, the EFQM Excellence Model was developed by 1991. It serves as a judgement tool for companies entering the European Quality Award and thereupon has been introduced as an organisational self-assessment tool throughout European businesses. As a non-prescriptive framework, the EFQM Model is divided into nine categories, five of which relate to what the company does ("Enablers") and four focus on the achievements of the company ("Results") (Seghezzi 1999:113). The implementation of each category is evaluated according to a scoring system. The five categories of enablers are:

- Leadership (representing 10% of the total score, i.e. 100 points)
- Staff orientation (representing 9% of the total score, i.e 90 points)
- Policy and strategy (representing 8% of the total score, i.e 80 points)

– Resources (representing 9% of the total score, i.e 90 points)
– Processes (representing 14% of the total score, i.e 140 points).

The four categories of results are:

– Staff satisfaction (representing 9% of the total score, i.e 90 points)
– Customer satisfaction (representing 20% of the total score, i.e 200 points)
– Social responsibility (representing 6% of the total score, i.e 60 points)
– Business result (representing 15% of the total score, i.e 150 points).

The differences in the weight attached to each category shows that the evaluation according to the EFQM model primarily focuses on assessing the total quality of a company in terms of the quality of processes and customer satisfaction. The key premise is that:

> "Excellent results with respect to Performance, Customers, People and Society are achieved through Partnership and Resources, and Processes." (EFQM 2000:4).

It is interesting to see that similar to the ISO 9000 standards, the universal applicability of the EFQM model is due to both the vagueness of this premise and the categories. For example, instead of providing a quantitative measure of the term "performance", according to the EFQM, performance is "a measure of attainment achieved by an actor, team, organisation or process" (EFQM 2000:7) Thus the model falls short in supplying concrete variables for evaluating and measuring quality results. Nevertheless, the empirical studies of 140 TQM award winning companies over two five year periods by Singhal and Hendricks (2000) suggest that in the long haul, there is a positive correlation between the implementation of the TQM models such as the EFQM and the financial performance of companies (stock price, operating income and net cash flow) (Hendricks and Singhal 2000).

To some extent, the ISO 9000 is similar to excellence models such as the EFQM, because "both approaches enable an organization to identify its strengths and weaknesses, contain provisions for evaluation against generic models, provide a basis for continual improvement and contain provisions for external recognition" (ISO 9000:2000:17).

However, the key difference between these two approaches "lies in their scope of application" (ibid:18). The ISO 9000 standards contain "requirements for quality management systems and guidance for performance improvement" (ibid.) whereas excellence-based models "contain criteria that enable comparative evaluation of organizational performance and this is applicable to all activities and all interested parties of an organisation" (ibid.). In other words, the ISO 9000 focuses primarily on quality standards, excellence models like the TQM represent a holistic approach towards quality management which encompasses all processes and the entire staff throughout the whole organisation.

In addition to this differentiation by the ISO, Seghezzi points out that a second short coming of the ISO is that the ISO 9000 audits are limited to checking documentary evidence instead of providing input for planning and strategic management, thus, a new method, the so called assessment is needed for the evaluation in order to give important inputs concerning the planning and improvement of processes (ibid.). According to the EFQM, this "self-assessment is a comprehensive, systematic and regular review of an organisation's activities and results referenced against the EFQM Excellence Model. The Self-Assessment process allows the organisation to discern clearly its strengths and areas in which improvements can be made and culminates in planned improvement actions which are then monitored for progress." (EFQM 2000:1).

Third, the ISO 9000 does not promote the competition for quality between companies. Malorny argues that the aspect of quality as a competitive advantage, or business excellence, has to be exploited and therefore a European equivalent of the American Malcom Baldrige National Quality Award (since 1988) or the Japanese Deming Prize (since 1951) was to be introduced (Malorny 1999:203ff.). This measure would allow increased competition for quality among European companies and would also establish a benchmark for European and international comparison of quality levels and achievements.

In my opinion, the key advantage of the EFQM-model lies in the fact that it encourages the self-evaluation of quality standards within companies. Whereas the ISO 9000 audits provide a third party analysis by auditors, often not familiar with the particularities of the assessed industrial and technical environment, the EFQM places the responsibility for assessment into the hands of those actually working within this environment. As tools for self-evaluation, the EFQM has introduced the RADAR logic and the RADAR Scoring Matrix. The former supplies a standardised logical sequence for self-analysis, covering the acronyms: "determination of **R**esult, planning and developing of **a**pproaches, **d**eploying approaches, **a**ssessment and **r**eview of approaches" (EFQM 2000:5).

The latter, provides a series of questions aiding the self-assessment check, thus allowing companies to determine areas of improvements. To sum up, the work of the EFQM and its proposed model supplement the ISO 9000 standards insofar as they aim to institutionalise the TQM model which treats quality as a holistic system which incorporates the concerns of suppliers, customers, staff, shareholders and management alike. The number of businesses applying the EFQM model has been growing rapidly, and according to the EFQM in 2000 exceeded 20.000 businesses in Europe (EFQM 2000). In terms of differences, the ISO 9000 series "provides requirements for quality management systems and guidance for performance improvement", whereas the excellence models "contain criteria that enable comparative evaluation of organisational performance" (EN ISO 9000:2000:18).

2.7.8 Audits

Be it through the self-inspection performed by craftsmen or through the cloth show performed by guilds and external inspectors, the historical account above has shown that the control of quality in form of audits has played a key role in the evolution of standards. This importance continues today as the audit has a key function for quality management systems. Its' purpose it to check the effectiveness and efficiency of the quality management system. Thus the audit evaluates to what extent quality standards have been implemented, are applied and adhered to. According to Antoni, the audit thus is a core controlling function (Antoni 2001:139).

The DIN ISO 10 011, part 1, defines a quality audit as "a systematic and independent examination to determine whether quality activities and related results comply with planned arrangements and whether these arrangements are implemented effectively and are suitable to achieve objectives" (DIN ISO 10 011, part 1:5).

Gaster (1984) and Wilhelm (1993) differentiate between three types of quality audits: product audit, process audit and system audit. These audits can be conducted either by internal or external auditors.

Internal audits or self-evaluations, as I shall discuss in detail in the case study about the introduction of the Mercedes-Benz Production system are conduced either by actors on the shop floor or by auditors of the quality management department.

This raises the problem as to the role and influence of the auditors on the audit result. To increase the degree of objectivity, Antoni points out that so-called self-audits are insufficient, instead internal customers or line functions should be used in audits (Antoni 2001:141). According to Zink, internal audits primarily serve to give internal impulses and feedback to encourage the continuous improvement of processes (Zink 1999). By providing a feedback loop and results of the internal audits are fed back into the system, Power points out that internal audits have a "certain learning potential" (Power 1997:83). Moreover, as a "form of structured self-observation" the internal audit represents a "form of second order control" in addition to the external first order control (ibid.).

External audits serve one key purpose: to issue an audit certificate. Like the MOT (Motor Operating Test, the equivalent of the TÜV in Germany), a car has to pass, companies have to pass the audit to get, for example the ISO 9000 certification. Interestingly as insofar, both car and company are "audited" by the same external institution, the "technical inspectorate", in German the Technischer Überwachungsverein (TÜV).

Moreover, this shows that the standard setting function and the standard auditing function are treated as separate activities, performed by two external organisations: the ISO, and in case of Germany the DIN are responsible only for setting standards and accredit independent certification institutions to perform the audits of their standards. In Germany, the auditing role is predominantly performed by the TÜV as a "private-sector regulatory body" (TÜV 2002:1). For this purpose, the TÜV set up a department the TÜV Management Service Division which is „accredited to conduct registration/certification auditing to the automotive and other industries by the German Accreditation Council (DAR) and the US Registrar Accreditation Board (ANSI-RAB) for ISO 9000, QS-9000, TE Supplement and ISO 14001 certification, as well as the German Department of Transportation (KBA) for VDA 6.1 and the German member of the International Automotive Task Force (VDA-QMC) for ISO/TS 16949 automotive quality systems certification“ (TÜV Management Service 2002:1).

This division has several implications. First, the main purpose of using external auditors and audit companies is to provide a more objective view and evaluation of companies. On the other hand though, external auditors are not acquainted with the particular products, market or production environment of the company performs the audit. The accusation of companies that auditors are thus too far removed from the actual internal company practices is justified in my view, as I shall discuss in detail in connection with the role auditors in the audit of the Mercedes-Benz Production System (MPS) below.

Second, the shift towards using external standard setting and standard controlling institutions, weakens the role of planning departments, especially Industrial Engineering departments, within companies. Traditionally, their role was to plan, set and to control standards within companies. This influence is being eroded and weakened particularly as the function to control standards is now being performed by either internal or external audit departments and institutions: the role of the Industrial Engineering profession is now being taken over by the auditing professions. This marks the rise of a new elite of specialists. Moreover, the decline in the Industrial Engineering as a profession is also reflected in the decline of the influence and power Industrial Engineering associations, such as the REFA exert in German companies. The function of the REFA in the past has been to issue industry wide REFA-methods and the so-called REFA-certificate was a "standard" qualification accepted across industries and a "standard" qualification that skilled workers and Industrial Engineers alike, could take. However, in interviews I conducted with REFA-members, it was stated that the number of REFA-certificates issues has decreased drastically. The reduction in the number of staff in Industrial Engineering departments and the integration of these departments, for example into central planning departments, reflect the decline in the importance of the Industrial Engineering profession. At the same time, quality management departments and particularly audit departments have mushroomed. According to Power (1999), this shift signals "an 'audit implosion' whereby organizations have become more 'reflexive' and where company directors have been forced to acquire responsibility for internal control systems and risk management" (Power 1997:xvii). As a result an "internalisation of regulation" (ibid.) has occurred with the consequence that particularly internal auditors "acquire more of the substance of the external financial auditor's role" (ibid.).

Third, the independent validation by external auditors and audit institutions "connects the organization to other regulatory layers" (Power 1997:85). According to Power, in theory "regulatory and corporate programmes coincide in the structure of a system which serves internal economic and external regulatory goals simultaneously" (ibid.). As a result, audit systems introduce a high degree of bureaucracy into organisations. Audits are conducted at regular intervals and in preparation, staff has to update audit handbooks and prepare the relevant documents the auditor will look at. This preparation takes time and ties up human resources in indirect bureaucratic processes which do not add direct value to goods produced or services rendered: the audit preparation is a bureaucratic exercise. Simmons and Wynne (1992) underscore this argument by suggesting that the focus of external regulatory attention is concerned with abstract, bureaucratic organisational chains. For Power, quality management systems like the ISO 9000 are "abstract from performance in a substantive sense and emphasize system values and their auditability as ends in themselves" (Power 1997:85). Unlike product audits which evaluate the quality of products, "the auditability and certifiability of the quality system is a secondary process, a means to an end" (ibid.). If audits are but ends in themselves and serve to reaffirm the regulatory role of external auditing institutions why do companies willingly submit to this process of certification? In the following, my aim is to evaluate some of the major costs but also benefits companies have from submitting to the process of certification.

2.7.9 The cost and benefits of certification

At the end of December 2001, at "least 510.616 ISO 9000 certificates had been awarded in 161 countries world-wide" (ISO 2002:4). By far the greatest share of ISO 9000 certificates are registered in Europe (53.9%) followed by an increasing share of Far East countries (24.8%), particularly led by 32.126 new certificates issued in China alone between December 2000 - December 2001 (ibid.:3). The share of ISO 9000 certificates issued in North America (USA, Canada, Mexico) amounts to around 10% (ibid.:6ff.).

The annual ISO certification costs (after the initial implementation) amount to around DM 25.000 (Klotz 1996:50). According to the critics then quality means costs – quality is expensive (Becker 1995). But what are the benefits of the ISO certification? Of 325 quality managers questioned in a study by Kamiske et. al (1984), around 60% stated that the introduction of the ISO 9000 series had either led to insignificant or no reduction in the number of defect parts. A second study, intended to evaluate the benefits of introducing general standards and technical rules of 4.000 companies in Germany, Austria and Switzerland, conducted for the DIN between 1997 and 2000 adds that 61% of companies affirmed that costs actually occurred through the introduction of standards (DIN 2000:12). 37% of companies linked this increase to the necessity of making additional staff available (ibid.). Regarding the benefits, 62% of companies stated a reduction in trading costs caused by the "simplification of contractual agreements" (ibid.). Only 9.3% of companies provided actual figures of monetary savings resulting from standardisation which amounted on average to DM 466.000 per annum (ibid.).

In addition to the quantitative evaluation of the costs and benefits of introducing standard, companies regard standardisation as a "time-consuming and costly" effort (ibid.10). Moreover, companies stated that internal company-wide standards "have a more positive effect on the competitive status", than industry-wide standards such as published by the DIN (ibid.:10).

These estimates have to be treated carefully insofar as participants also admitted that the "cost of developing company and industry-wide standards are not easily quantified" (ibid.:13). And although the IFAN issued the Guideline 1 – Processes for determining the advantages of standardisation projects, giving detailed instructions about the structure and methods to be used in establishing the quantitative value of standardisation, it is still difficult to precisely evaluate the benefits of standardisation and specifically the ROQ, the return on quality, in monetary terms.

Hence, if the benefits of implementing quality management systems is difficult to determine, the question is, what are the reasons why companies nevertheless opt for the implementation of a standardised quality management systems?

Conformity to standard quality management systems, particularly the ISO 9000, has been a major criteria for the selection of suppliers. According to Franke, for many customers and clients product quality alone no longer counts, they are increasingly interested in the product and process quality of manufacturers and suppliers. They are looking for evidence that quality can be produced and hence call for transparency such as provided by the information documented in quality management systems of suppliers based on, for example the ISO EN 9001 to 9003“(Franke 1999:425). The ISO 9000 certificate is seen as proof (or mark !) of the existence of an efficient quality management system and it is assumed that those companies which do not have a quality management system are not seriously concerned about quality issues (Jackson and Ashton 1994:56). Jackson and Ashton go even as far as suggesting that ISO 9000 certification ensures the survival of companies, as it is necessary for getting big contracts (ibid.:55) and is thus the price companies have to pay to sustain successful business relations (ibid.:57). In other words the ISO 9000 certificate is a prerequisite for survival (ibid.) and the ISO then provides a "common language" (Hancké and Casper 1996:3) of quality, harmonising the interface between automotive producers and suppliers.

Especially after 1989, as the percentage of parts manufactured in-house decreased from an average of 40-50% to 20-30% by volume (Hancké and Casper 1996:15), in order to deliver the increasingly complex parts and systems, suppliers were forced to invest in new machines. In turn, "more sophisticated production necessitated a major reorganization of the work process within most supplier firms" (ibid.). In addition to the internal reorganisation, in order to minimise buffers, manufacturers expected many suppliers to deliver their parts Just-in-time. Moreover, "final assemblers argued that they could no longer inspect all incoming parts, since the essence of Just-in-time (JIT) is delivery straight to the assembly line for immediate use" (ibid.). In the late 1980s, new contracts thus introduced went as far as asking "suppliers to perform exit inspections in place of the normal entry inspection of the final assemblers that the law prescribed, pledged suppliers to a zero defect guarantee, and forced them to assume all liability costs should defective parts cause damage of any kind to either the final assembler or end consumer" (ibid.).

By shifting the liability risk to the supplier, "insurance companies immediately demanded higher premiums for liability insurance" (ibid.). In order to estimate the risk profile of the supplier, insurers "insisted on conducting expensive audits of every supplier's quality control system" (ibid.). According to Hancké and Casper, "if suppliers wanted affordable liability insurance, they would have to replace the idiosyncratic routines created by workers, however robust these may be, with a quality control system that insurance auditors could understand. This was provided by the ISO 9000 norm, which became the key to both the process reengineering of German supplier firms and one of the major instruments for making new supplier relationships tolerable with the German liability law" (ibid.). The institutionalisation of the ISO 9000 series in relation with this liability issue was firmly established when in the late 1980s assemblers inserted contractual clauses "mandating that suppliers obtain ISO 9000 certification" (ibid.:16). After discussions between the VDA and the insurers, the latter accepted the VDA audits as risk-assessment tools. As an incentive, companies achieving an A or B rating are exempt from the premium surcharges caused by the new legal risks. Walgenbach thus concludes that the guideline for the liability of warranty claims for defect products has contributed towards the widespread use of quality managements systems (Walgenbach 2000:242).

2.8 Critical appreciation

Standardisation as term, is not value-free and the introduction of standardised quality management systems is surrounded by controversy. Concerning the key themes which are at the centre of this present study, it is interesting to evaluate the link between quality management systems, learning and control.

Tuckman interprets the content of the ISO on the one hand as being critical towards „rigidly defined bureaucratic roles“ but at the same time is "through the establishment of procedures, centrally concerned with constructing such roles" (Tuckman 1994:732). Confirming Taylor's role of management as a planning and controlling authority, Tuckman hence considers the ISO 9000 a "management information system hidden underneath a quality program" (see Hancké and Casper 2000:178). Key evidence, he asserts, is that the ISO 9000 originated from economic settings, such as the UK and the USA, both firmly rooted in a Taylorist tradition (Tuckmann 1994:740). Thus, ISO 9000 was criticised for being a vehicle indirectly enforcing Taylorist organisational principles.

The issue of bureaucratic control introduced through standardisation is also pointed out by Moldaschl who warns that a negative aspect of the standardisation activities leads to a formalisation of working processes. Companies are in danger of setting rigid standards regulating processes, responsibilities and conditions causing organisations to laps back into highly bureaucratic structures. This could lead to an extreme case where the standard setting process itself is regulated by standards, hence the standardisation of standards, as seen in Japanese companies. (Moldaschl 2001:120). Quality standards call for the formal documentation of processes. In turn, these processes become more transparent. As a result the control and power of actors over these processes is curbed and as one manager interviewed by Walgenbach confirmed, this means that the information staff have is now transparent, thus curbing their power and making their work redundant (Walgenbach 2000:367).

However, based on interviews and observations Walgenbach conducted, a discrepancy between the intention of standards and their actual application on the shop floor exists. In his study about the practical implementation of the ISO 9000 in a number of German companies, Walgenbach points out that far from yielding to the new quality standards introduced, staff continues their work as they did before. There is thus a discretion between the formalised intention of ISO standards and their practical application (Walgenbach 2000:368). The author proposes two possible reasons for this divergence, first, staff remuneration is not linked to the documentation of their tasks but to the results of their work, hence the continuous updating of worksheet and documents is not considered an incentive (ibid.:371). Second, Walgenbach deduces that the missing congruence between practical application and formalised documentation is due to the natural and self-evident acceptance of routine tasks and their gradual adaptation to a changing work place environment (ibid.:373). The reason why companies decide to adopt quality management systems is then not based on a conscious awareness and need on behalf of companies to improve and control quality; instead, the competitive, social, political or industrial environment define that a quality control system is a necessary prerequisite for a company, thus structural elements are adopted, independently from their direct effect on the actual outcome of the work (Walgenbach 2000:13).

Jackson and Ashton go even as far as suggesting that those companies which do not have a quality management system, are considered not taking quality seriously (Jackson and Ashton 1994:56). A valid critique affirmed by the DIN survey on the benefits of standardisation in which 37% of participants felt that an "increase in pressure from their rivals because of the existence of European and International Standards" (DIN 2000:12).

This interpretation is also supported, when considering the research of Hancké and Caspar arguing that the effect of implementing ISO 9000 standards is determined by the particular national industrial preconditions, particularly firm governance, industrial relations and vocational training systems. Indeed, countries like Germany, where "highly skilled workers retained substantial autonomy" the implementation of the ISO 9000 "did not push work organisation down a neo-taylorist, hierarchical path" (Hancké and Casper 2000:183-4).

Arguing that the introduction of institutions, such as the ISO 9000, is a highly political process, the authors point out that "the struggles between large firms and their suppliers, between management and workers, and how these were mediated (or not) by institutions such as labour unions, industry associations and (quasi-) public agencies, were not just a distant background setting; they *were* the substance of the introduction of the standards" (Hancké, B., and Caspar, S., 1996:21). In view of the "politics of institutional transfer" thus raised, the authors doubt "as to whether everyone involved is actually transferring or introducing the same objectively existing institution" (ibid.). The research of Hancké and Caspar has shown that the implementation of international standard quality management systems does not reintroduce Taylorist principles of work organisation. Unlike Tuckman arguing that ISO 9000 standards reinforce and revive a Taylorist work organisation, Hancké and Casper stress that "diversity persists with just as much vigour as before" (ibid.).

One reason the authors point out why the ISO 9000 is thus able to reconcile standardisation with diversity lies in the "intrinsic flexibility of the ISO standards" (ibid.:19).

This flexibility is caused because the actual wording of the standards set out in quality management manuals is distinctly vague and formulated in an abstract manner (Klotz 1996:50). In the case of the ISO 9000, Seghezzi interprets their function in terms of thus providing a set of "Metastandards" (Seghezzi 1998:910) which merely propose the adaptation of a common "design code" (Seghezzi 1998:910). The advantage of such a degree of woolliness (Klotz 1996:50), is that, standards are flexible to be adapted in a variety of industrial activities and different national economic settings thus supporting the institutionalisation of standards as "a living and dynamic process which is subject to constant inspection and supplementation" (Hesser and Inklaar 1998:189). By providing this flexibility, improvements and necessary reviews are incorporated into the standards as amendments (ibid.). In other words, the vagueness of the actual wording of standards ensures some degree of formalisation of quality standards on the one hand, but also allows for a degree of flexibility in which standardisation facilitates "an optimum variety, and not by any means uniformity, rigidity and hostility to innovation" (ibid.:203). According to Seghezzi, the actual content of, for example, the ISO 9000 standards is then sufficient insofar that it provides minimum content (Seghezzi 1999:109).

The wide spread acceptance of the ISO 9000 quality management standards is also due to the fact that they are "brought about mainly by following the consensus principle in preparing a standard, by which the largest possible agreement is secured among all interests concerned with the use of standards, such as the producer, the user, the trader and the technologist. Once all these interests have been agreed and a common ground upon which to base the standard has been found, the standard acquires an authority, possibly much more powerful than a legal instrument might which has secured only a 51 percent majority vote in its favour" (Verman 1973:12). As seen above, through their representation in professional bodies, automotive manufacturers take part in this standard setting process and thus shape the standards for their industry, including both automotive manufacturers and their suppliers.[14]

Summarising, the intention of this chapter was to examine the changing forms and functions of standardisation from an historical perspective and to assess how this process is related to the rise of production systems in the automotive industry. A second strand examined was the role standard setting institutions have played in this process.

The first conclusion that can be drawn in my view from this discussion is that historically, quality represents a key function of standardisation. Over time, this function became increasingly complex and extended from providing product standards to offering process standards. Today, the holistic perspective proposed in

[14] For example, the involvement of actors from within the automotive industry has assured that the VDA standards reflect a high degree of consensus; consensus foremost in terms of the actual necessity to create national and international quality systems standards and second, a consensus regarding the actual content and wording of the VDA 6.X series of standards.

TQM-based models envisages standards to regulate processes across organisations. These models no longer reflect an isolated view of quality management only, but are more akin to production systems in so far that they consider entire processes across the company.

This evolution has two implications. First, the TQM model has evolved as a de facto standard as a company-wide quality control model and was institutionalised as the EFQM model. Moreover, the TQM approach has to some extent been integrated in the updates of other standard quality management systems, by introducing the customer focused quality perspective in the ISO 9000:2000.

Second, the establishment of a standard model of quality management systems evened the path towards the introduction of standardised production systems. Like the TQM-based models such as the EFQM, today the TSP is considered best practice and has become a de facto standard for production systems in the automotive industry. This also marks a reversal in the driving forces of standardisation from institutionally driven standardisation to company and industry-specific driven standardisation.

Third, standards contained in quality management systems do not necessarily introduce a greater degree of control over work. Research has pointed out that there is a discrepancy between the intention of standards and the actual application of standards on the shop floor. Although quality standards introduced lead to a greater degree of bureaucracy, paperwork and to some extent a greater transparency of processes, in practice, actors continue performing the work as before.

Fourth, regarding the ISO 9000, initially suppliers exploited their certificate as a marketing tool (Hancké and Casper 1996:5). Particularly for companies which were the first to be certified, the ISO 9000 offered an additional marketing advantage, a new unique selling point (Hansen 1993:156). Meanwhile, it is standard practice that most companies, be it suppliers, manufacturers or services are certified according to the ISO 9000. In other words, it is taken for granted that companies do have quality management systems (Walgenbach 2000:9).

Finally, audits take a key role in the evolution of standardisation and raise a number of significant issues. According to Power, the rapid rise and expansion of audits are a sign of far greater social evolution, what he terms the rise of the "audit society". This rise is being witnessed as a "growing population of 'auditees' began to experience a wave of formalised and detailed checking up on what they do" (Power 1997:3). This wave of formalisation extends from financial audits, to quality audits, and, as I shall examine in detail later, also to the case of the Mercedes-Benz Production System Audit: auditing has become an unquestioned, self-evident activity which is regularly performed in companies.

With the audit wave, the audit profession and audit departments have mushroomed. This trend is significant for it signals that the traditional role of the Industrial Engineer, particularly his function to control the implementation of standards is being weakened, gradually strengthening the influence of the role of the auditor. Moreover, as Zink (1999) has suggested, particularly internal audits serve as additional feedback loops and provide internal impulses to encourage the continuous improvement of processes. Insofar audits have "certain learning potential" (Power 1997:83). At the same time though, they are also a means to an end, a selfperpetuating mechanism which exists for its own sake and for the purpose of reaffirming the institutional role and status of the auditor and external auditing institutions.

I shall now extend the focus of standardisation from quality management systems and their audits to the role of standardisation in the production systems in the automotive industry.

3 The history of production systems in the automotive industry

3.1 Introduction

1885 marked the birth of the automobile when, Benz, and at the same time Daimler, introduced the first petrol engine driven four wheel carriage, the "Velozipede". Since then, automotive manufacturers not only strove to perfect the automobile as a product, but also the processes and organisation needed to build it. Standardisation played a key role in this process. In the automotive industry, the standardisation of parts initiated the standardisation of processes and work.

Production systems and their evolution represent a specific example of the changing nature of the form and function of standardisation. This significance of standardisation within production system has been long acknowledged. Historically, the theoretical discussion about standardisation and work reaches back to the Hawthorn Studies. The result of these studies have stressed the importance of the human aspect of work, thus raising the debate about the role of actors on the shop floor within the highly-standardised systems of mass production and Taylorism: the US system of mass production dissolved the traditional skills system. With this introduction of Taylorist and Fordist work organisation, the form and function of standardisation changed from the focus on standardised, interchangeable parts, to technical process standards like the moving assembly line, standardised skills and pay (the introduction of Ford's $5 Day). Beyond the shop floor, Ford extended standards to regulate the social lives of his workers by introducing a set of living standards workers had to adhere to in order to qualify for the $5 Day. Because Fordist mass production led to a decline in the quality of the products, the focus of standardisation subsequently shifted to regulating quality. With the approach towards a continuous improvement of standards, Toyota integrated the quality responsibility as part of the job of the workers on the shop floor and combined it with the highly standardised Taylorist work organisation. Intended to do away with the moving assembly line as the heart of the traditional assembly process layout and to stress the importance of the human aspect of work, Volvo introduced a human-centred production system at Uddevalla. It represents part of the movement against the dominant role of standardisation and standardised operations in production systems, associated with Taylorism, Fordism and Toyotism. Thus, it deliberately rejects the standardisation of work and represents the furthest developed example of a humanocentric system.

Covering a period from the end of the craft production system to the introduction of standardised production systems today, in this chapter I will trace the changing forms and functions of standards within production systems in the automotive industry and to historically examine its underlying driving forces. Of particular importance will be the object, intention and effect of standardisation within production systems.

To do so, I shall follow the historical time line and first examine the role of standardisation in the production organisation of automotive manufacturers during the transition from craft production to the American system of manufacturing, through to Taylorism and Ford's system of mass production. Thereafter, the two very contrasting production systems of Toyota and Volvo Uddevalla are introduced.

Concluding this chapter, I will examine the current trend of introducing standardised production systems in the automotive industry and analyse where they derived from. In this context I shall assess to what extent the Toyota Production System (TPS) has evolved as dominant model within this process.

3.2 The end of craft production

The history of production systems begins with the introduction of standardised parts for arms heralding the end of the period of craft production in America. Although this event is mainly associated with Whitney, amongst scholars, the impact he had in this process has been reduced to his role of a promoter of standardisation (Woodbury 1960:235ff.). Instead, standardisation efforts of the so-called "armoury system" became synonymously known as the "American system" or the "American System of Manufactures" (Hounshell 1984:15), and are attributed to the work of Simeon North and later perfected by John Hall (Hounshell 1984:1,28,41).

North doubted that manual work alone could support the production of interchangeable parts. He thus decided to build special purpose milling machines. This shows that the foundations of craft production and the importance of the all-round skilled worker were no longer sufficient to ensure the standardisation demands posed on the arms producers. To produce standardised parts, the use of machines became inevitable. But how could this machinery ensure a high output of identical parts? The answer lies in one of the prime objects of standardisation, the use of a "rational jig, fixtures and gauging system" (Hounshell 1984:6). Tools and measuring devices were used to check if each produced part conformed to specifications. First introduced by North, these forerunners of today's sophisticated quality control tools were improved by John Hall and in 1827 he achieved the first production based on standardised, interchangeable rifle parts.

Soon after the success of implementing machinery to produce standardised arms parts, the concept of standardisation spread to the production of sewing machines, typewriters and bicycles. The American machine tool industry was responsible for bridging the inherent gap between the production of arms and the prodution of consumer durables.

According to Rosenberg this "technological convergence" was primarily possible because machine tool manufacturers learned new metalworking techniques from their work for the arms industry and in turn could apply this know-how also to the production of durable goods (Rosenberg 1963:414ff also in Nelson 1975:5). In addition, a transfer of learning between industries occurred as seen in the example of Henry M. Leland who initially worked for an arms manufacturer, but then applied his know-how of standardisation methods to the tools and sewing sectors and eventually founded Cadillac and the Lincoln Motor Corporations (Hounshell 1984:5).

In practical terms though, the most significant standardisation object which could be applied to any production context was the jig, fixture and gauging system. According to Hounshell, Ford's production system was based on the armoury practices of the jig, fixture and gauging system. The standardisation of bodyshell parts made available by the transfer of sheet steel punch and press work was previously tested and perfected and had already been standard practice in the bicycles industry. The moving assembly line was adopted from standard production process techniques which were already well established in both the meatpackers and the flour milling industries (Biggs 1996:8ff.)[1]

In order to be applied in a range of production circumstances, standards had to be documented. Plans and drawings of parts in scale were produced and thus the standardisation in the American System resulted in the formalisation of parts' specifications. Whereas before, craftsmen used their inherent knowledge of the parts' shape and size, detailed drawings now documented the exact measurements, angles and other specifications of the part to be manufactured. This already shows that those directly concerned with the production of parts were no longer involved in the product design process itself, instead formally drawn up plans provided guidelines of the design of parts: a step towards reducing the skills and the influence of the craftsman on the shop floor already imbued with Taylorist principles.

However, the role of the skilled craftsman had not yet been fully eroded. According to Gartman, at the beginning of the twentieth century, although standardised tools, particularly the power tools with hand controls, made work easier (ibid.:28), "only skilled craftsmen of the highest skills could turn the heap of parts into a running machine" (ibid.:23). This reliance on craftsmen was evident in all production departments, particularly in the assembly and the patternmaking shop (ibid.:26), thus during the early automobile production period it was standard practice that "skilled workers were themselves largely in control of their own work" (ibid.:24).

If the owners relied on their craftsmen for immediate production decisions, their trust had to be founded on the skills level of the craftsmen and it was indeed the degree of skills, which enabled craftsmen to sustain this degree of control within the production process. According to Gartman "skills were not theoretical,

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1 For a detailed account on the origins of the industrial processes an impact of the meatpacking, milling and other major US industries, please refer to the comprehensive accounts of Biggs 1996.

not formulated into a precise body of written rules and laws" (Gartman 1986:29) However, it was acknowledged that these skills "were largely empirical, gained mainly through long apprenticeships training and experience in watching and doing work itself" (ibid.). As skilled workers retained their status as craftsmen, with the rising demand of automobiles, the automotive manufacturers also fought to get these skilled workers into their factories. This competition for skilled labour drove up wages and in turn allowed the craftsmen to chose the best paid job, as did Walter Chrysler, "I wasn't willing to stick around a shop to prove that I was good. If they did not appreciate me, if any supervisor dressed me down, I'd get my time, pack my bag, forward my tuba and head for the next shop town" (Chrysler 1937:68). It was therefore usual practice that the skills level determined the degree of mobility during these early days of automobile production. However, the relationship defined by the interdependency between the factory and the skilled workers vanished as consumer demand increased (Meyer III 1981:13ff). Taylorism was introduced in the factory to allow for higher and more efficient output thus proposing the division of labour and the fragmentation of skills previously performed by craftsmen (Gartman 1986:44). This marked the end of the system of craft production in the USA.

3.3 Taylorism and standardisation

The replaceability of parts allowed an increase in both, the volume and speed of production. Simultaneously, the consistency of product quality was ensured. Thus, "increases in speed of production and volumes of production, attended by lower prices, more uniform quality, and population growth, resulted in much larger productive units" (Skinner 1985:285). Also, an increase in plant size, facilitated through the exploitation of the economies of scale, "permitted more fully integrated facilities" (ibid.).

Having standardised machines, tools, measuring equipment and buildings, the next step in the historical standardisation process was to standardise work sequences and tasks within the production process.[2] This was the major aim of Taylorism: "to develop a science for each element of a man's work, which replaces the old rule-of-thumb method" (Ford 1911:15). It attempts to standardise work ranged from the fragmentation of skills, standard task performance, to time and motion studies. Its single goal being increased production efficiency. As a result, Taylorist standards became work standards which could be used to measure and control work and workers.

[2] In 1896, Horace Arnold in a series of articles for Engineering Magazine had proposed that standardised plant layouts affect the quality of work, thus proposing a standardised factory design Arnold, H., 1896:267.

3.3.1 Historical background

Taylor's *Principles of Scientific Management* are standards to define the relationship between worker and work. According to Thompson, these aimed "to correlate and systematise all the best of modern developments in factory administration, and to push development further in accordance with principles discovered" (Thompson 1975:4). Taylor himself considered the rules he offered an approach calling for a total revolution of attitude towards work, a "systematic philosophy of worker and work" (Drucker 1954:280), and a political framework (Waring 1995:12). Indeed, as Waring states, a period in which "new managerial capitalism emerged from a search for ways to co-ordinate operations and control workers", Taylorism represented "the outcome of technological evolution, adjustment to market forces, value choices, and political struggle" (ibid.:10).

Its intellectual undercurrents stem from Adam Smith's (1723- 1790) *The Wealth of Nations* (1776) and Charles Babbage (1772- 1871) *The Economy of Machinery and Manufacturers* (1833). From the former, Taylor deduced two ideas: first, the division of labour as being essentially positive yielding increased productivity (Smith 1776:5) and second, the necessity to match skills and job tasks (ibid.:16ff.). In other words, the primary objects of standardisation for Taylor were first the fragmentation of skills into their smallest components (division of labour), and second the separation between mental and physical work.

3.3.2 Forms and functions of standardisation in Taylorism

The core of Taylor's *Scientific Management* (1911), "is the organised study of work, the analysis of work into its simplest elements and the systematic improvement of the worker's performance of each of these elements" (Drucker 1954:280). Work content (what) and task performance (how) were standardised and therefore the principles of Taylor became known as "one best method" how to perform a job (Taylor 1911:9). According to Taylor, this idea "is directly antagonistic to the old idea that each workman can best regulate his own way of doing the work" (Taylor 1911:30). The complex set of skills a craftsman previously had to perform were fragmented into individual units, with each worker then merely performing one particular task in a manner which was considered to be the most effective and efficient way.

Introducing precise standards of how a task should be performed, Taylor's army of Industrial Engineers changed the work and job content within production. This led to highly repetitive standard tasks which workers had to perform (Jürgens, Malsch, Dohse 1989c:4), assuming that the less tasks a worker had to perform, the more familiar these tasks became for him and the better, in terms of speed and precision, he could perform them. The combination of one-best-way and the decrease in work content (or increase in job fragmentation) points to the importance of standards:

"The very idea of establishing work standards – how much output a manufacturer could expect from a certain machine tool, a work process, or a series of processes if labor did a fair day's work – is the very heart of Taylorism in particular and systematic management in general" (Hounshell 1984:250).

But how could the standard of finding one best way to perform a task be determined? In order to find out the most efficient and effective task performance, Taylor employed methods borrowed from scientific observation, namely time and motion studies. Hence, time and motion, too, became objects of Taylor's attempts to standardise skill performance. According to Taylor:

"Scientific management requires, first, a careful investigation of each of the many modifications of the same implement, developed under the rule of thumb; and second, after a time study has been made of the speed attainable with each of these implements, that the good points of several of them shall be united in a single standard implement" (Taylor 1911:62)

The combination of the deskilling process on the one hand, and the increased use of scientific methods to determine work content on the other had two consequences: first, tasks became fragmented and highly repetitive, allowing unskilled workers to perform them; second, standards determining work content and work processes were set and controlled by experts (Jürgens, Malsch, Dohse 1989c:4).

Taylorism led to the birth of a new profession, a new elite of experts, the Industrial Engineer responsible for performing time and motion studies[3] and who later in the 1920s became the protectors of the holy grail of taylorist-fordist control structures (Jürgens, Malsch, Dohse 1989c:138ff.). The work of the Industrial Engineers changed the way work was performed "as scientific managers could conduct experiments to find the one best way of working and allow rule by science to replace government by soldiering work gangs and whip-cracking foremen" (Waring 1995:11ff.).

Furthermore, once a one best way to perform a task had been found, it was the Industrial Engineer who recorded the details of times and movement sequences. The industrial engineer thus contributed to the formalisation of tasks in terms of rules or descriptions "written on a single instruction card, or sheet" (Taylor 1911:63) which had to be adhered to. In other words, a core function of standardisation in Taylorism was the formalisation of work standards and practices thus not only specifying what is to be done but also "how it is to be done and the exact time allowed for doing it" (ibid.:17).

To ensure the adherence of the new tasks, Taylor assumed that the key goals of workers and management were that "give the workman what he most wants – high wages – and the employer what he wants – a low labor cost – for his manufactures" (ibid.:1), Taylor based his theory on the standard assumption that workers were primarily driven by monetary prospects (Badham and Jürgens 1998:36). Parallel to introducing the "task idea" (Taylor 1911:62), Taylor proposed "when

[3] As general manager of the Manufacturing Investment Company (1890-93) which in turn led him to develop a new profession that of consulting engineer in management.

workmen are daily given a task which calls for a high rate of speed on their part, that they should also be insured the necessary high rate of pay whenever they are successful. This involves not only fixing for each man his daily task, but also paying him a large bonus, or premium, each time that he succeeds in doing his task in the given time" (ibid.:63). An approach which was later realised with the introduction of the $5 day at Ford.

A second strand of Taylor's objects of standardisation relates back to the historical influence of the Babbage principle, which, in economic terms, states the relation between skill level and production costs, thus suggesting that mundane tasks required unskilled and therefore cheaper workers (Braverman 1974:61). Developing this principle further, Taylor deduced that each man's individual abilities had to match the specific task:

> "The essential idea is the scientific selection and recruitment for the range of industrial jobs of those people whose capacities and aspirations match the job requirements." (Badham and Jürgens 1998:36).

Moreover, Taylor suggested that men were either born to work with their mind or their hands, and thus were predestined to perform the tasks of either management in the office or the workforce on the shop floor (Taylor 1911:3). Indeed, as the mundane physical work required less intellectual efforts, men performing such tasks were supposed to be of lower intellect. In Taylor's words:

> "Now one of the very first requirements for a man who is fit to handle pig iron as a regular occupation is that he shall be so stupid and phlegmatic that he more nearly resembles in his mental make-up the ox than any other type. The man who is mentally alert and intelligent, is for this very reason entirely unsuited to what would, for him, be the grinding monotony of work of this character." (Taylor 1911:28).

This belief in turn lead Taylor to focus on the principle of selecting only candidates with suitable prerequisites which were required for the job. In other words, Taylor's selection process matched man and task:

> "The selection of the men, then, does not involve finding some extraordinary individual, but merely picking out from among very ordinary men the few who are especially suited to this type of work. " (Taylor 1911:30).

However, the function of management was not merely limited to matching workers and tasks, but the single most important duty of management was to ensure the adherence to the scientific principles of work (ibid.:41). Thus the primary goal resulting from Taylor's attempts to standardise work was an increased level of control over work and workers:

> "It is only through enforced standardisation of methods, enforced adaptation of the best implements and working conditions, and enforced cooperation that this faster work can be assured. " (Taylor 1911:41)

As seen in the discussion of standardisation in the period preceding Taylorism, the mounting influence of technology on the production process and new responsibilities of work organisation demanded a co-ordination of man and machine within the production process: the factory replaced the workshop, a centralist organization replace a decentral one.

Taylor proposed that his principles, deeply rooted in a theoretical and scientific approach towards issues of work (ibid.:11) (therefore having the claim to universal acceptance and applicability), would allow managers to control work in the new factories. Part of their control function was their power to give incentives be it in form of "hope for rapid promotion or advancement; higher wages, higher piece-work prices or of a premium or bonus…" (ibid.:14). This particular task and other "homogenised and standardised jobs helped to simplify the functions of management to the point that some managers came to believe they were scientists applying general principles to specific cases" (Waring 1995:11). Indeed, managers embraced Taylorism insofar as "his fundamental premises met their philosophical and technical needs and by mid-century had come to dominate managerial theory and practice" (ibid.:9). Thus Taylorism was considered a new framework regarding the functions of management (ibid.:51). As a consequence:

> "Work is scientifically designed and organized by management to introduce the maximum possible division of labour and standardisation of tasks, the minimization of work cycle time, industrial engineering standards, piece rate incentive schemes and direct supervision" (Badham and Jürgens 1998:36).

The resulting control over the production process, according to Taylor, ensured the smooth and efficient flow. A prerequisite Ford used to create his system of mass production.

3.4 Ford's mass production: the foundation of modern production systems

"The generalized practice of scientific management coincides with the scientific-technical revolution" (Braverman 1974:86) and it was Henry Ford's achievement to combine Taylorist principles with technological advancement. During the American system, standardisation had made its mark by facilitating the production of replaceable parts, jigs, fixtures and gauges. In 1900, Christopher Newton introduced the grinding machine which allowed further standardisation of parts particularly for the automotive industry (Gartman 1986:41). However, it was not until 1913, when Ford at his Highland Park plant had combined these measures and created the first formalised production system, the system of mass production (Hounshell 1984:230). Particularly the fact that Fordist principles of production were transferred throughout Ford plants shows that these were considered a standard production system:

"This system is carried out in every branch and manufacturing unit, not only in equipment but in shop methods. The conveyors used at the various branches and the chains used in their construction all are standard. All stock comes in standard sizes. Blue prints are made in a certain standard form with the various information always listed in the same location on the sheet, so that no time need be wasted in hunting for it." (Ford 1926:87).

In the following I shall examine the form and function of standardisation in Ford's system of mass production: first focusing on the product and processes, in the latter part examining standards which regulated processes beyond the shop floor.

3.4.1 Standards in mass production

The key driver of Fordist standardisation measures was that there was only one standard product available (the model T) (Gartman 1986:43). This facilitated the use of standardised parts and hence enabled the mass production of cars (Hounshell 1984:218):

"Therefore in 1909, I announced one morning without any previous warning, that in the future we were going to build only one model, that the model was going to be 'Model T', and that the chassis would be exactly the same for all cars, and I remarked: 'Any customer can have a car painted any colour that he wants, so long as it is black.' I cannot say that anyone agrees with me." (Quotations from Henry Ford, McNair 1978:73).

The success and popularity of the model T were attributed to its low price, which in a period of sixteen years had more than decreased by half, from $850 in 1908 to $260 in 1924 (Biggs 1996:101). Ford made the car affordable for everyone. According to Gartman, "the low-priced cars of Ford and Olds generated the consumer demand that fuelled the drive for changes in the labor process" (Gartman 1986:40). At the same time though, these low prices created the foundation of the virtuous cycle of the US-American production model of mass production "linking process layout principles with labour market requirements, and division of labour" (Jürgens 2000:7). The five core elements which drive the virtuous cycle are:

1. A process orientation based on the principles of mass production
2. Job design is centred on highly fragmented tasks and little responsibility of direct workers.
3. Improvement and process innovation rested firmly in the hands of experts (Industrial Engineers)
4. Human resource management based on hire-and-fire strategy and skill acquisiting through on-the-job training
5. Labour relations marked by "distrust and antagonism" with management strongly defening its "right to manage" (ibid.:9).

The key driving force initiating this virtuous cycle was the fact that technological advancement had led to the creation of specialist machines able to produce identical parts, at a standard rate and in great numbers, and hence the focus of standardisation had become the production flow and handling of materials (Biggs 1996:108).

Particularly in areas where "the power of workers had already been reduced by standardisation, the division of labor, and mechanization", the standardisation of the production process was successful (Gartman 1986:100).

At the core of this process organisation was the development and installation of the moving assembly line, first to be introduced in Spring 1913 at Ford's Highland Park plant. The moving assembly line allowed for a continuous work flow system in which, during the assembly, each station was manned by a worker placing standardised parts in a standardised manner onto the moving standardised chassis.[4]

> "Along about April 1, 1913, we first tried the experiment of an assembly line...I believe that this was the first moving line ever installed. The idea came in a general way from the overhead trolley that the Chicago packers used in dressing beef. " (Quotations from Henry Ford, McNair 1978:91).

Ford's idea was not a novelty. As early as 1790, Oliver Evans applying the principle of process flow, had already recognised that "the movement of materials (grain in Evan's case) through the mill or factory is one of the most important ways to control the speed of production" (Biggs 1996:9). The process flow thus allowed grain "loaded at one end of the building to proceed through the stones and funnels of the mill to a vessel tied alongside it – supposedly without the need of interior workmen" (ibid.:11). This early example of a product and handling flow process was perfected by the meatpacking industry. As early as 1850, Evans' moving line had been installed in slaughter houses thus "eliminating the slow and cumbersome human handling of carcasses" (ibid.:27) and developments "in plant design meatpacking once again foreshadowed mass production in the automotive industry" (ibid.:29).

However it was Olds who first introduced the principle of the moving material handling process into the automotive industry in 1901. As Ford regularly visited Olds' plant, he transferred the principle to his production site at Highland Park (Gartman 1986:87).

The development towards the moving assembly line at Ford was divided into three phases. As early as 1906, Ford had experimented with work slides at the Bellevue plant (ibid.:84). In 1913, the power driven conveyance belt was installed in the flywheel magneto operation at Ford's Highland Park plant (ibid.:86) and the "monumental event" of the introduction of the moving assembly line in the final assembly took place in August 1913 (ibid..43).

Ford's aim of using a moveable assembly line was to reduce the amount of travel workers had to undertake to get from one work station to the next:

[4] For illustrations on these please turn to Hounshell 1984:226.

"If the workers were going to work like machines, Ford engineers concluded that the entire factory had to work like a machine, that the success of assembly line production depended on efficient supply of materials and parts to work stations" (Biggs 1995:53).

According to Gartman, "in an attempt to wrest the control of work flow away from workers, auto manufacturers began to transfer the handling of materials from human hands to mechanical devices" (Gartman 1986:83). An historical account from the Ford archives records this increased control over the process flow in a formal standard stating that:

"Arrange so that work will come to each man so that he shall not have to take more than one step either way, either to secure his work or release it; Keep the line moving as fast as possible." (quoted in Biggs 1996:107)

Thus this type of "progressive production" facilitated the constant flow of materials through the Highland Park factory (Meyer III 1981:31) and already three years after had become standard practice of all US automotive manufacturers. It also shows how Taylor's standard method of one-best-way were combined with Ford's standardised production flow, as seen in the following description of the sequence of assembly:

- "Place the tools and the men in sequence of the operation so that each component part shall travel the least possible distance while in the process of finishing.
- Use work slides or some other form of carrier so that when a workman completes his operation, he drops the part always in the same place – which place must always be the most convenient place to his hand – and if possible have gravity carry the part to the next workman for his operation.
- Use sliding assembly lines by which the parts to be assembled are delivered at convenient distances. " (Quotations from Henry Ford, McNair 1978:92).

Although Ford himself and later Hounshell disclaimed the direct influence of Taylor on Ford (Hounshell 1984:231ff.), stating that Fordism focused on mechanisation (machine replaces man) whereas Taylorism focused on the scientific study of one-best-way to perform a job, Fordism was marked by Taylor's methods of scientific management (Gartman 1986:50ff.). According to Jürgens, Malsch and Dohse, the assembly work conducted on the moving assembly line was the centre of the traditional taylorist-fordist control mechanism; taylorist insofar that strictly defined work methods and time limits were set, fordist, insofar that the speed and rhythm of work was determined by the moving assembly line (Jürgens, Malsch, Dohse 1989c:178).

With the help of Taylorist principles, Ford fragmented tasks further thus being able to standardise output of both machines and labour:

"The very idea of establishing work standards – how much output a manufacturer could expect from a certain machine tool, a work process, or a series of processes if labour did a fair day's work – is the very heart of Taylorism in particular and systematic management in general" (Hounshell 1984:230).

Hounshell's remark points at two issues. First, with the help of Taylorism, Ford intensified the standardisation of work content and job fragmentation, thus not only parts were interchangeable, but labour had become replaceable, too. In the words of Jürgens, Malsch and Dohse, workers were "merely an appendage of the production apparatus" (Jürgens, Malsch, Dohse 1989c:124), so that, "there was a strong element of repressive control embodied in the introduction of interchangeability and standardisation into the automotive labour process" (Gartman 1986:43).

Second, Hounshell's comment points at Ford's attempt to standardise Taylor's "fair day's work". As will be discussed in due course, the $5 day became the standard measure of the value of a fair day's work.

Let's turn to the issue of Ford's focus on the further fragmentation of tasks, first.

From the perspective of Nonaka and Takeuchi the impact of Taylorism at Ford replaced the previously un-written tacit understanding within production by a more complex system of clearly defining specific tasks as standards (Nonaka and Takeuchi 1995:64ff.). In other words, standardisation of tasks came with the introduction of Taylor's principles of scientific management (ibid.:37). Instead of having no guidelines, by spelling out how to perform certain tasks, standardisation was to limit the possibilities of how tasks were performed and therefore aimed at decreasing the overall complexity within production. By segmenting tasks into smaller units job contents were reduced and could be more controlled. Gartman cites an example from the assembly of engines, where one complete job had been divided into "eighty-four fragments, each meticulously timed down to the second and laid out progressively in a line" (Gartman 1986:47). On the one hand, this allowed higher quantities to be produced more efficiently (previously the motor assembly took 9.9 hours whereas the division of this job resulted in an assembly time of 3.8 hours – a 60 percent cut) (ibid.). On the other, the reduced job contents also lead to a subsequent shortening of cycles. Craftsmen were no longer challenged to perform complex tasks but were degraded to performing shorter and increasingly repetitive tasks:

"A worker must turn a lever the whole time in order to grind out machine parts. The perpetual, regular turning motion becomes a habit for him; he performs 30 or more turns to the right and left per minute for hours on end" (Nonaka and Takeuchi 1995:39).

This also led to greater control of management over the production process and the work of both skilled and unskilled workers (Braverman 1974:101). This degree of control is evident when considering the historical account recording the formalisation of work standards:

"Keep the work at the least waist high, so a man doesn't have to stoop over; Make the job simple, break it up into one, two, or at the most three operations" (Biggs 1996:107).

Moreover, as supervisors previously had dictated the pace, the introduction of the moving assembly line resulted in a shift from human control to mechanical speed control and foremen confirmed that "the line does a lot of your work for you. The men have to keep up with it. If I stand down at the end of my section, I can see if anything has gone wrong by one of the men, and I can find out why" (Walker, Guest, Turner 1956:13). The control function of the supervisor resulted in a shift from direct control of speed to indirect supervisory and visual control. This shift also underscored the importance of Taylor's creed of the division of labour and management, which contributed to Fordism (Braverman 1974:101).

From a human-relations approach perspective, Jürgens, Malsch and Dohse claim that this increased division between manual and mental work contributed to the curbed degree of influence workers could exercise in the production process, insofar as workers "who are most familiar with the technology and work organisation" (Dohse, Jürgens, Malsch 1985:124) were no longer tapped for their innovative ideas but instead were reduced to performing highly repetitive tasks. Standards were therefore considered as means to control the adherence of these new rules of work. According to Ford, "we expect the men to do what they are told. The organization is so highly specialized and one part is so dependent upon another that we could not for a moment consider allowing men to have their own way. Without the most rigid discipline we would have the utmost confusion" (Quotations from Henry Ford in McNair 1978:82).

This discipline was assured as the managers at Ford posted the production output of each man on a production board at the end of each row and according to Porter, the figures were "posted hourly, and the records of those who equal or better the quota set are written down in colored crayon" (Porter 1917:639). This standard measure was taken to stir up "competition among workers, who performed the same operation" (Meyer III 1981:62).

But what were the implications of Fordist standardisation?

Critical voices historically documented in films such as Chaplin's *Modern Times*, Lang's *Metropolis* (Ford 1989:7), books such as Huxley's *Brave New World* (Benyon 1973:17), Orwell's *1984* and the works of Braverman (*Labour and Monopoly Capital*) warned of the dangers of standardisation, "implying that man, too, could be mechanized" (Hounshell 1984:11).

Goldthorp et al. (1972) and critics pointing out the dangers of capitalist societies (Badham, 1986; Clegg, 1990; Thompson and McHugh, 1995), suggested that mass production resulted in "alienating the character of industrial work" (Badham and Jürgens 1998:37). According to Badham and Jürgens in their publication *Images of Good Work*, placed in a working environment which does not allow a sense of self-expression, creativity and identification with the work itself, the worker feels like an alien within the system and, underscored by the stress on money as sole motivator, is but a "self-serving cog in an industrial machine" (ibid.:36). Lewchuk argues in a similar vein:

"But converting time into effort became more difficult as work became increasingly unskilled, repetitive, and monotonous and as workers, especially male workers, became alienated from their task. For men, this alienation was partially the result of the growing gap between the nature of work under mass production and the gender norms of skilled men who, building on their and their fathers' experiences in craft shops, associated independence and decision-making power at work with masculinity. " (Lewchuk 1993:825)

The results of both the alienation of the workers in production and the sheer physical strain of the repetitive work resulted in dramatic increase of labour fluctuations. In 1913 the total Ford workforce at the Highland Park plant consisted of 13.667 workmen. In the same year the daily absences in the Highland Park plant amounted to 10 percent of the total workforce and in the same year the rate of labour turnover reached a staggering 370 percent (Meyer III 1981:80). According to Meyer III, these high levels were "individual and semiconscious reactions" against Ford's production system reflecting the "dissatisfaction with changes in the conditions of work and the character of the workplace" (ibid.).

As production had become dominated by a standard product, standard parts, processes and job contents, Ford attempted to extend standards beyond the immediate objects of production to the welfare of the workers. Thus Fordism encompassed the standardisation of the immediate working environment in the factory and the habitation of the workers. Regarding the effect of the latter, Ford's goal of setting living standards for his workers resulted in two further objects of standardisation: on the one hand, with the help of the Five Dollar Day (profit-sharing plans) and the establishment of a job classification scheme, Ford attempted to offer a standard solution "to transform the attitudes and behavior of Ford workers" (ibid.:123); on the other, concentrated in the work of the Sociological Department, Ford's welfare programme attempted to standardise "social and cultural values for men to fit the regime of the mechanized plant" (ibid.). However, neither the monetary nor the socio-cultural standards of Fordism can be considered as independently functioning units, as the following section will show.

3.4.2 Standardisation beyond the shop floor

Despite a limited welfare programme set up before 1913, an investigation into the workers attitude towards work conducted by Lee, showed that long hours, low wages, undesirable shop conditions and arbitrary and capricious foremen mirrored their concerns about their new work tasks and routines in a mechanized plant (Ford Motor Company Archives 1913). The survey resulted in two measures aiming for one to introduce a job classification system (standardised job content ranking) and an increase of wages to a standard level of 5$ a day.

The first measure aimed at offering the workers a career ladder, giving them a chance of "social mobility within the factory" (Meyer III 1981:102). In detail, the system divided workers into six ranked groups ranging from mechanics and subforemen, skilled operators, operators, helpers, labourers, to special workers (women and children).[5]

Ford believed that the workers' living conditions, status and family backgrounds shaped their attitude towards work (ibid.:104). He therefore considered two options necessary: first, to investigate if workers lived up to the stringent Fordist standards of living and second, by increasing their wages to a standard $5 day rate, a common standard of living for Ford workers would be achieved. In January 1914, the company then announced a reduction in working hours (from 9 to 8 hours) and an increase in pay from $2.50 to $5.00 per day. At first sight, the general wage level of Ford workers suddenly rocketed above the usual wages within the automotive industry at the time. However, at a second glance, the system proofed to be based on a "profit sharing feature", which did not automatically raise all workers to this high wage level.

Only those workers conforming to a range of working, living and ethical standards set out by Ford, were eligible to receive the pay rise (ibid.:115). The investigation into whether workers qualified for the profit sharing pay rise, were administered by the Sociological Department which in 1916 had set out "the requirements by which the Company regards a man as eligible to receive profits" (ibid.).

The company requested each worker to give detailed accounts for this "sociological investigation". Equipped with checklists the department's investigators[6] set out to interview the worker, his family, neighbours; they inspected the workers' houses and living conditions:

> "The Record of Investigation examined three distinct aspects of the lives of Ford workers. First, it recorded a wide range of social and biographical information of each worker. Second, it gathered information on the economic and financial condition of the worker and his family. And, third, it explored the worker's morality, his habits and his life-style" (Meyer III 1981:130).

Through these investigation or (in today's terminology) social audits, "the truth about the men was scrutinized" (ibid.). This shows that standardisation during Fordism had been expanded to the social background of the worker thus pushing control through company standards beyond one best way to perform a job, to one best way to live. Standardisation had reached the private realm of the worker. This is also evident in Ford's account of the purpose of the Sociological Department. According to Ford explaining to the Industrial Relations Commission the purpose of this department was to:

> "explain opportunity, teach American ways and customs, English language, duties of citizenship…counsel and help unsophisticated employees to obtain and maintain comfortable, congenial and sanitary living conditions, and … exercise the necessary vigilance to

[5] For a detailed account of the evolution towards Ford's job classification system refer to Meyer III, 1981: Chapter 5.

[6] Similar to the role of quality inspectors discussed above, in this case social inspect tors/auditors.

prevent, as far as possible, human frailty from falling into habits or practices detrimental to substantial progress in life. The whole effort of this corps is to point men to life and to make them discontented with mere living" (Meyer III 1981:126).

This statement reflects Fords aspiration to extend the principles of his production system beyond the shop floor, envisaging Fordism as socio-cultural programme determining, structuring and standardising the life of his workers. According to Meyer III, "the Ford program sought to remake and to restructure working-class culture on sound middle-class, industrial values" (ibid.)

Critics, particularly those supporting a Marxist view of labour, strongly warned of the dangers that:

"In this microcosm, there is an illustration of the rule that the working class is progressively subjected to the capitalist mode of production, and to the successive forms which it takes, only as the capitalist mode of production conquers and destroys all other forms of the organisation of labour, and with them, all alternatives for the working population" (Braverman 1974:103).

According to this view, the $5 day was a measure which, in Braverman's terms could be described as bribe or coercion as it rewarded those workers who endured the working conditions (ibid.). Summarising this Marxist view, Gartman states that:

"The natural rhythms of the human body and mind – work and rest, alimentation and elimination – were subordinated to the mechanical rhythms of the line controlled by capital" (Gartman 1986:98).

And yet, Fords paternalistic vision marked a progress from the formerly prevailing view of "individual and moral causes of poverty" towards the explanation of poverty in terms of social and environmental factors (Meyer III 1981:123).

This was not only a vision, but in fact, resulted in a stabilisation of fluctuation in the labour turnover. Whereas "in 1913 the rate was rate was a phenomenal 370 percent. It fell to about 54 percent in 1914 and dropped to a low of about 16 percent in 1915" (ibid.:162) This decrease was also evident regarding the absenteeism rate (ibid.).

Through the introduction of extensive standardisation measures, the labour turnover was reduced and the goal of exploiting the economies of scale was reached. With the increase in production output, the average unit cost decreased, leading to economies of scale. In the case of Ford, both internal and external economies of scale were the goals of standardisation.

Ford's intensive deployment of expensive machinery led to technical economies of scale. Moreover, following Taylor's principle of the division of work between management and production work, through "unfettered management" (Jürgens 2000:8), Ford profited from the managerial economies of scale. In addition, as production tasks required less skills, Ford's personnel expenses decreased, as unskilled workers were paid lower wages and, as discussed above, the Five Dollar Day, was an monetary incentive for selected workers only; a control tool disguised as a monetary incentive as a control tool gradually waned in the aftermath of the postwar period, the recession of 1920-21 and the rise of industrial unionism during the thirties (Meyer III 1981:199ff.)

Looking at the external economies of scale available during Ford's mass production period, being located in Detroit, the industrial centre of the automotive industry, the company could draw on a sufficiently large local workforce. At the turn of the century the Detroit area consisted mainly of mechanics, specialists and labourers as surveyed in 1891 by the Michigan Bureau of Labor Statistics. This professional base provided the source of Fords early production (Meyer III 1981:46). However, with the influx of immigrants into Detroit, the level of skilled metal workers decreased and this "massive influx of immigrant workers presented Ford officials and managers with their most formidable labor problem (ibid.:75). Immigrants primarily were peasants from Southern and Eastern Europe "without industrial work-skills and work-habits" (ibid.).

Thus, Taylorist principles of offering "narrrow skill/low responsibility jobs" allowed for the employment of these unskilled workers and resulted in the exploitation of external labour economies.[7] The labor problem was hence solved, as "with a minimal amount of training, an immigrant or farm migrant could perform one fragment of the previously skilled labor process efficiently" (Gartman 1986:53). This led to "the reduction of unit labor costs through reducing the labor time expended in the production of an automobile" (ibid.:89).

Although the Five Dollar Day and Ford's welfare system served as powerful economic incentive for these workers, World War I resulted in some fundamental changes which gradually began to undermine Ford's system of mass production. For one, "paternalism gave way for more authoritarian patterns as a means to insure social conformity" (Meyer III 1981: 196), culminating in the rise of the Auto Workers' Union. As long as Ford continued to pay high wages, workers "took the money and ran along with it" (ibid.: 197). The change occurred gradually starting with the recession of 1920-21, and when after the General Motors strike at Flint, Michigan, in 1936-37, industrial unionism had become institutionalised in the automobile plants. According to a flint striker "the inhumane high speed is no more. We have a voice, and have slowed up the speed of the line. And we are now treated as human beings, and not as part of the machinery. The high pressure is taken off...it proves clearly that united we stand, divided or alone we fall" (ibid.: 200).

Particular standards concerning working hours and working conditions, had been always fought for by the unions. This applies also for the American automotive union, the United Automotive Worker Union (UAW). After their foundation in the 1930s, the UAW fought against breaking standards in order to protect workers from speed ups of the assembly line. Unionism at Ford became institutionalised in the 1941 contract and subsequently the UAW Ford Department in negotiation with the Ford management influence a number of standards ranging from "pension plan, health care benefits, workplace health and safety protection, skilled

[7] For an extensive discussion on the effects of Taylorism and Fordism on the surplus value and surplus labour see Braverman 1974:175ff.

trades recognition, a shortened work week, more paid days off, supplemental unemployment benefits, and a guaranteed annual income credit a number" (Walter P. Reuther Library of Labor and Urban Affairs, 2003).

In Germany, through their collaboration with the REFA, union representatives attempted to shape standardisation processes at a very early stage, and to influence methods and the qualification of Industrial Engineers.

Summarising this part, mass production represents the first production system because it integrates standards which until then had not been combined into one system of production organisation. The key components of the system of mass production are: technical and process standards, work standards and social standards. Ford deployed and refined the system of jigs and gauges and not only introduced new technical standards of car parts (such as wheels) but also entire components, such as transmissions. Moreover, by developing the moving assembly line, Ford extended standardisation to production processes which thus determined the work places and work content. The rhythm of the line determined the speed and rhythm of work. Ford deployed Taylor's *Principles of Scientific Management* to regulate the sequence and timing of tasks.

The third component of Ford's system of mass production is the extension of standards from the shop floor to the social sphere of the workers. The 5$ day is an example of how Ford used the monetary incentive to get workers to adapt his social ethics. Due to the labour surplus, if workers opted to work for Ford, they had to conform to Ford's social vision and to accept and adapt to the living standards he envisaged as the American way of life. Ford's system of mass production did then not only erode the control of workers over their work, but also penetrated into the workers' private spheres, affecting their control over their private, social and cultural areas of life. It is now interesting to see how the system of mass production evolved in the decades after Ford and how the form and function of standardisation changed within this evolution. To examine this, the following part considers the role of standardisation in the Toyota Production System (TPS).

3.5 The Toyota Production System (TPS)

Whereas Ford's system of mass production evolved during a period of economic growth, the Toyota Production System (TPS) proposes another system of standards to achieve maximum economic efficiency with a minimum of available resources. Thus a key focus of the TPS is to reduce any kind of wasteful, non product-value adding activity. The core approach how to achieve this is the system of continuous improvement. Standards are subjected to the constant refinement and improvement. This concept is at the core of the TPS and also points out the difference to the system of mass production. For whereas Ford used Industrial Engineers to set fixed standards of work, at Toyota, the standard setting, and above all, the constant refinement of standards is a major responsibility of the workers on the shop floor. To examine the role and regulatory function of standards in the Toyota Production System, I shall now consider its evolution in detail.

3.5.1 Historical background

In the early decades of the twentieth century, market conditions in Japan mirrored those of Germany, as "customers were mostly limited to a small number of wealthy upper-class people with curiosity" (Fujimoto 1999:28). Local automotive production was "extremely small" not exceeding a cumulative output of "several hundred units" (ibid.34). The production of automobiles in Japan first gained significant momentum when in 1925 Ford, as the first US-automaker, set up a wholly owned subsidiary to build its knock-down plant at Yokohama introducing moving assembly lines for both chassis and body. GM followed Ford's example and also set up its knock-down assembly subsidiary in Osaka in 1927. On a smaller production scale and instead of making a foreign investment in Japan, other American automotive manufacturers, amongst them Chrysler, opted to import their parts to Japan, and deployed Japanese companies for the assembly.

Despite this US-dominance within the Japanese automotive market, during the early 1930s, the automotive branch of the Toyoda Automatic Loom Works Ltd, (later to be renamed Toyota Motor Co. Ltd.), led by Kiichiro Toyoda, commenced its research for automotive engines.[8] After having started building a pilot plant in Kariya in 1934, and aided by the introduction of machine tooling equipment from Germany and the US, the first Toyota prototype engine was finished by autumn 1934. Parallel to the development of this engine, dissembling Chrylser and Chevrolet cars, and copying genuine parts of Ford and other American manufacturers, Toyota developed prototypes for its own car bodies, chassis and gear parts (ibid.:36). In addition to this hardware, Kiichiro encouraged his staff to conduct tours of US-automotive manufacturers at their home locations in order to learn about the system of mass-production at first hand.[9] These efforts culminated in the introduction of the first Toyota prototype of the A1 model, a "five-passenger sedan with a 3400c engine" in May 1935 (Fujimoto 1999:36). According to Fujimoto, these early attempts at building local Japanese cars at Toyota were "more or less imitation and a patchwork of American automobile technology" (ibid.). With a local market share of Japanese automotive manufacturers amounting to merely 3% Toyota's early efforts in 1934 remained insignificant (ibid.:34).

In the same year, assembly output of all US-knock-down plants peaked at 92% of the total Japanese domestic demand (ibid.:36). This market dominance motivated Ford to plan a second, new and much enlarged plant, thus continuing its strategy to expand its global operations. This aided the transfer of the Ford production system beyond the USA, an approach also evident in Ford's expansion strategy in the UK, as discussed by Tolliday (1998) and Lewchuk (1992). The influence of the US-manufacturers was also evident as they dominated the production of trucks with a total of 92% of total Japanese domestic demand being either

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[8] Upon learning about the proposed sector regulation by the government, in course Toyota switched from its focus on automobiles to the production of trucks.

[9] These initiatives pre-shadowed the extensive tour of Ford plants by Eiji Toyoda and Shoichi Saito after the labour crisis two decades later.

assembled or imported by US-manufacturers (Fujimoto 1999:34). However, this dominance was soon at an end as the Japanese government, driven to ensure adequate supply for military vehicles, introduced the Automobile Manufacturing Enterprise Law in 1936. This legislative act affected the Japanese domestic automotive manufacturers in two ways. First, it "prevented the operation of foreign automakers in Japan, and subsequently led to a shut down of the US automobile assembly by the end of the 1930s" (ibid.). Second, the act subsidised three domestic truck manufacturers, Toyota (Toyota Motor Co. Ltd. Founded in 1937), Nissan (renamed Nissan Motor Co. Ltd. After being founded through a merger in 1933) and Isuzu (initially founded as Tokyo Jodosha Kogyosho and in 1949 renamed Isuzu Motors Ltd.). "Filling the gap created by the US makers' exit" (ibid.), the Kariya plant, completed in 1936, produced 150 units per month, a rather modest figure compared to the large scale production of Ford's output of several thousand units per year (ibid.:36). In order to meet the growing domestic demand for cars, Kiichiro initiated the construction of a second, bigger Toyota plant at Koromo. Upon completion in 1938, it employed 5.000 staff and produced 2.000 units per month.

Influenced by the production concepts of the Ford knock-down plants and attempting to realise the economic benefits, standardised products, standardised and interchangeable parts, special purpose machines and the moving assembly line, Toyota introduced the American mass production system at Koromo. However, these concepts could not be transferred identically, rather "their adaptation had to be selective, taking the limits of the domestic market and existing production systems into account" (ibid.:35). Compared to other Japanese automotive manufacturers, for instance Nissan relying on "packages of product and process technologies", Cusumano suggests that Toyota selectively integrated American technologies into its already existing system (Cusumano 1985:62). The intention was to use local know how and creativity to develop a production system that would suit the particular Japanese cultural and economic context (Kiichiro quoted in Ohno 1993:119). Despite attempts at this selective integration, the production operations at Toyota were still predominantly based on craft-type production principles, as a former Toyota worker noted:

> "Many elements of craft production persisted, and craft skills were required in job shop environments. Workers machined a variety of parts, while sharpening their own cutting tools. Process flows were often disturbed, work-in-process inventories piled up, and lack of balance in machine utilization occurred" (Toyota Motor Corporation Ltd. 1978:95).

Fujimoto suggests that the reliance of craft-type production principles continued up to the 1940s, and "despite the strong influence of the Ford system (also Taylorism), the flexible nature of the early indigenous (craft-type) systems of those days carried over to the early Toyota Production System" (Fujimoto 1999:37).

In the aftermath of World War II, with limited financial resources, Toyota was forced to abandon any investments in the technological update of its production. According to Fujimoto, Toyota instead was forced to improve productivity from within. Combining elements of Taylorism (standardisation of work design) with company specific elements such as a particular production flow and machine layout, multitasking (*takotei-mochi*), and levelling of production pace (*heijunka*), according to Fujimoto these measures "deemphasized the existing craft-type system" (ibid.:39). The results of these measures were twofold. First, traditionally crafts-type production was eroded leading to conflict between craftsmen and foremen on the shop floor. Second, the new measures had increased productivity - even as far as reaching overproduction in the face of recession, thus leading to a potential bankruptcy of Toyota (Japan Management Association 1985:preface). This situation forced the company to fire a substantial percentage of its workforce. Together with the increasingly standardised production methods and overproduction, this large-scale staff dismissal contributed to a labour crisis in 1950 culminating in long strike by Toyota workers (Fujimoto 1999:39).

The situation changed when during the Korean War, the American Army Procurement Agency (APA) issued substantial orders of motor vehicles. This helped to aid the recovery of the Japanese motor industry. In response, Toyota introduced several new truck models, and in 1955, the Crown RS-30 passenger car was launched. Unlike the other Japanese manufacturers, Toyota did not produce vehicles under license agreements with European manufacturers (as for instance Nissan or Isuzu did, see Nomura and Jürgens 1995:23); instead, the company relied on its own product development. According to Nomura and Jürgens, management was particularly concerned with developing own solutions in the development of production technology (ibid.:22). Parallel with the introduction of passenger cars, the company continued to deploy American management practices, shaped by the principles of scientific management. In addition, the issue of the control of quality (as discussed in the previous chapter) had been raised by Edward Deming's lectures of 1950 and 1951 in Japan and thus Toyota increasingly drew on the tools of statistical quality control (SQC), such as Shewhart control charts (Juran 1995:536ff.). First-line supervisors were trained in using these tools thus instilling the awareness on the shop-floor to continuously improve processes.

Toyota also strove to develop its own solutions within production, particularly in the case of adopting the tools of scientific management such as time and motion studies and the remuneration system. Coupled with the encouragement to continuously improve processes, this resulted in a distinct link between performance incentives and efficiency improvement which according to Nomura and Jürgens is one of the key determinants of the success of the company's production system, as will be discussed in detail below (Nomura and Jürgens 1995:23). In addition to the linkage between the continuous improvement process (CIP) and remuneration, by the late 1950s, a kanban system, controlling production and inventory levels was installed. However, these measures remained isolated attempts at improving production efficiency, and according to Fujimoto, "neither systematic approaches of technical assistance to the parts suppliers nor company-wide quality management had been effectively installed in the 1950s" (Fujimoto 1999:40).

The 1960s, the explosion of domestic customer demand for cars led to a "motorisation" mania (ibid.) and necessitating the set up of large-scale production facilities. The growth rate of the automotive industry in Japan during the 1960s averaged at 26.9% (Nomura and Jürgens 1995:28) and between 1960 and 1970, its production output rose from 500.000 units per annum to 5 million units (Fujimoto 1999:40). Moreover, the proliferation of consumer taste called for a shortening of product development times and the product life cycle of a car was reduced to four years (ibid.:42). As a result, the black box parts system integrating suppliers already during the early phases of the product development process was developed. The supplier integration into the product development process subsequently led to a divide within the automotive supplier segment into those suppliers with research and development capacities able to provide design and construction services (according to Asanuma (1984) so-called Type 1 suppliers) and those merely responsible for providing production parts and capacities.[10] Parallel to the supplier integration, during the early 1960s, Toyota introduced a company-wide total quality management system, winning the Deming price in 1965 and subsequently extending the total quality management concept (TQM) to its suppliers (Fujimoto 1999:42). Until then Toyota had not attempted to formalise its production system into a written format, but relied on a system of learning by experiencing. Suppliers were invited to witness and study how Toyota produced its cars. According to Ohno, this type of presentation allowed Toyota to demonstrate efficient production processes live, on the shop floor (Ohno 1993:61). This approach made it easier for suppliers to understand the actual running of the system on the shop floor (ibid.).

Whereas the 1960s were marked by a surge in domestic demand, for Toyota the 1970s were fuelled by a increase in international demand and hence the company intensified its export activities. The decade between 1970 and 1980 witnessed a growth of exports, particularly to North America, from 1 million to 6 million cars of Japanese manufacturers (Fujimoto 1999:43). Unlike other Japanese manufacturers, Toyota met challenges like safety problems, the effect of the oil crisis in the mid-1970s, an increasing environmental awareness calling for lower emission levels, and the expansion from a domestic to an increasingly global customer base. According to Fujimoto, the success of Toyota was due to three measures (ibid.). First, investments were made in technologies particularly for the improvement of its engines and in numerically controlled machines (ibid.:44). Second, the range of Toyota models was expanded to cater for the particular customer needs outside Japan (ibid.:43). Third, already installed elements characterising Toyota's production had to be refined "for a sharper focus on continuous improvement in productivity and quality" (ibid.:44). These improvements also affected Toyota's relations with its suppliers. According to Fujimoto, "both internal production management and supplier management were focused on improvements in manufacturing performance (quality, cost, delivery) " (ibid.). This transfer of standards "meant the establishment of tight operational ties between the assembler and suppliers, including kanban delivery...and elimination of receiving inspection for incoming parts" (ibid.:318). This process was facilitated as Toyota communicated its "routi-

[10] For a detailed discussion on the relationship between Japanese manufacturers and their suppliers, refer to Nomura and Jürgens 1995:chapter 2.2.

nised manufacturing and learning capability," (ibid.:17) thus synchronising the interfaces between manufacturer and supplier (Kenney and Florida 1988:137).

The success of Toyota's way to produce cars was soon recognised by the other Japanese manufacturers. According to Monden, by "introducing the Toyota production system partially or totally", other Japanese automotive manufacturers "conquered the depression of the oil shock" (Monden 1983:401). The spread of Toyota production principles to its suppliers pushed ahead the formalisation of the Toyota production system. A partial contributing factor in this process was a lecture series by the Japan Management Association intended to teach other Japanese manufacturers about the production approach of Toyota (Japanese Management Association 1985: preface). Including Taiichi Ohno's (then Toyota executive vice president) contributions, the first formalised attempt at a description of the Toyota Production system was first published in 1978 (ibid.). By 1985, it had achieved a rank among the top-selling books in Japan then already in its thirty-fifth printing edition. Particularly for small and medium-sized companies trying to survive in the aftermath of the oil crisis, this book "gave them new direction and encouragement" (ibid.). The Toyota Production system became synonymous with the best practice model of manufacturing for Japanese companies.

Expanding their export activities, the efficiency of the Japanese manufactures became internationally recognised during the 1980s. According to Mishina (1998), between 1975 and 1980 the export rate of Japanese cars to the US amounted to a steady 20% annual increase with the share of Japanese cars contributing to 21.4% of the US market by 1980 (Mishina 1998:101). In conjunction with a slump of 21% in the sales volume of US automakers between 1979 and 1980, a political debate about solutions for protecting the Big Three US automakers commenced. In 1981, pressured by Washington and the United Auto Workers Union (UAW), the Japanese government announced a Voluntary Restraint Agreement limiting the importation of Japanese cars on the basis of a set quota (ibid.). To avoid this quota, Japanese automotive manufacturers subsequently set up transplants foremost in North America but also in Europe.[11] In case of the US, by the mid 1980s around 200 Japanese automotive suppliers had followed suit (Fujimoto 1999:45).

From this point, the evolution of the Toyota Production System took three major paths: the evolution of the TPS in transplants and joint ventures outside Japan, in new Toyota plants set up during the 1990s in Japan, and at plants of joint venture partners of Toyota, particularly at world-wide GM plants.

[11] Honda started it operation in Ohio as early as 1979, Toyota instead decided to form a joint venture with GM and set up the New United Motor Manufacturing Company (NUMMI) in Fermont in 1984.

3.5.2 The evolution of the Toyota Production System in the 1980s and 1990s

The setting up of Toyota transplants outside Japan played a significant role in the evolution of the Toyota Production System: it contributed to the formalisation of the TPS and through joint-venture transplants introduced the company's production system to Western joint-venture partners.

Despite having attempted to issue an outline of the system for its suppliers in the 1970s, as Toyota set up plants outside Japan, "Toyota managers felt they had to reinterpret the existing Toyota system, clarify the logic behind it, translate it into English" (Fujimoto 1999:47). Moreover, Toyota's global expansion in North America during the 1980s also forced its management to consider the compatibility of its production methods with the Western production environment. They were also faced with what Abo termed the "Application-Adaption dilemma", namely the choice to "introduce superior elements of their management and production systems to the maximum extent possible (application)" or "to modify those same systems in an effort to adapt to various local environmental conditions (adaptation)" (Abo 1998:216).

Founded in 1983, NUMMI, the joint venture between GM and Toyota, was to "help Toyota learn about US suppliers and labour. For its part, General Motors wanted to learn about Japanese manufacturing systems" (Adler, Goldoftas, Levine 1989:129). According to Adler, NUMMI "made very few changes to the Toyota production system itself, " (ibid:128) pointing at a clean-sheet transfer strategy. For example, the core object of TPS standardisation, the standardised operations sheet was used at NUMMI. Copying the initial TPS approach, tasks workers performed at NUMMI "were analysed down to its constituent gestures, and the sequence of gestures was refined and optimized for maximum performance" (ibid.:132). Moreover, team leaders and individual workers were responsible for the continuous improvement of these standards.

However, regarding the issues of human resource management (particularly pay levels) and labour relations, local conditions necessitated an adaptation of TPS to US standards. Resulting from Abo's research on the degree of hybridisation, concerning labour unions, all Japanese companies setting up plants in the US, "were most anxious about union matters, fearing not only the militancy of Western unions but also their practice of organizing across company boundaries and bringing demarcation issues onto the shop floor" (Abo 1998:223). In order to appease the unions, at NUMMI, for example, the foundation of the co-operation between the unions and the management was enshrined by contract stating in its introduction that "we are committed to building and maintaining the most innovative and harmonious labour-management relationship in America" (Adler, Goldoftas, Levine 1998:136). Moreover, the unions gave up their right to strike over work standards and health and safety issues. In turn NUMMI management "was contractually obliged to consult the unions on matters ranging from the pace of work to major investments" (ibid.).

Achieving competitive quality and productivity results, the transfer of the TPS to NUMMI was considered as access particularly as "Toyota managed to transplant the bulk of its production system as well as much of its administrative structure and supplier relations to NUMMI" (ibid.:157). From a societal view, the success of NUMMI is explained in terms of its ability to adapt to the "American workforce, union, regulations, and culture" (ibid.:158). Yet NUMMI failed to "set a new global standard for performance" and Japanese companies continued to provide the bench mark with regard to their lead in the technical dimension (ibid.).

According to Boyer, the setting up of transplants thus proved an "opportunity to pick out the real and permanent roots of productivity and quality from factors that are contingent upon the Japanese context" (Boyer 1998:41). In addition, it was also necessary "to dispel some of the negative misunderstandings of the system" which had been building up for years (Fujimoto 1999:47). Thus Toyota's production methods were formalised into a printed systems description, titled *An Introduction to The Toyota Production System (1987)* and later *The Toyota Production System (1992)*. The formalisation of Toyota's production principles into what since then has become known as the Toyota Production System was driven by the company's global expansion through the setting up of American transplants.

Parallel to this formalisation process, the operations at the transplant of Japanese manufacturers and suppliers, including Toyota, became a major focus of academic research (Fujimoto 1999:45). Allowing for a direct comparison between Eastern and Western manufacturing practices, researchers attempted to analyse and explain the competitive advantage of the Japanese production methods, both at the transplants and in Japan itself. One contribution of particular interest during this research period was the publication of *From Fordism to Toyotism? The Social Organization of the Labour Process in the Japanese Automobile Industry* by Dohse, Jürgens and Malsch in 1985. Preshadowing the findings of the MIT study five years later, the authors came to the conclusion that Japanese manufacturers - foremost represented by Toyota - were "undoubtedly capable of mass producing qualitatively good automobiles with considerably less labour" (Dohse, Jürgens, Malsch 1985:118). Together with other research undertaken by Western academics or consultants, publications fuelled efforts by Western automotive companies to catch up with their Eastern rivals. The era of looking East (Nomura and Jürgens 1995:13), commenced in the 1980s, reaching its climax with the publication of the International Motor Vehicle Report issued by the MIT in 1990 (Womack, Jones, Roose 1990).

At a time when "due to shifting exchange rates, altered tax structures, and the emergence of Japanese competition in the upscale market" (Jürgens 1995a:293), Western automotive manufacturers were ever more faced with severe cuts in the essential sales of automobiles in the US market, the authors of the MIT study, hailed the Toyota Production System to be the universally acknowledged best-practice concept of the production and corporate organisation (Nomura and Jürgens 1995:14) representing a lean production solution for the dilemma the Western automakers were then faced with. A phase of "learning from Japan" (Jürgens 1993:3) commenced. Despite failing to account for the context of the TPS to the specific cultural, historical and social background of Japan (Nomura and Jürgens 1995:14ff.), through the MIT study, the TPS became the "Paradigma" (ibid.:14) within the lean production discussion; and as Dohse, Jürgens and Malsch in 1985 had already suggested, "Toyotism" became the suggested *Leitmotif* for the Japanese model of manufacturing .

At the same time as the MIT study promoted the TPS in the West, the overheating economic effect of the "bubble boom" experience during the second part of the 1980s, already dawned in Japan (Fujimoto 1999:47). At Toyota, the post-lean discussion had already begun aiming to adapt the TPS to the looming economic recession and changes in the Toyota's potential labour recruitment pool and the age of Toyota's workforce; a workforce primarily consisting of recruits of the baby-boom generation, now reaching the age around 40 (Nomura and Jürgens 1995:213). Thus two developments marking the post-lean period at Toyota can be distinguished: organisational changes and changes to the Toyota Production System. According to Nomura and Jürgens, the adaptations regarding the policies of work covered three aspects. First, Toyota flattened its hierarchy and career path by reorganising white collar work in the administrative and technical areas (ibid.:214). However, apart from easing the career path from Hancho to Kumicho[12] in 1987 (Nomura and Jürgens 1995:214), the overall hierarchy within production remained unchanged. Second, the remuneration system was reorganised, introducing an age and skill bonus, reducing the productivity bonus from 60% to 40%. Third, the remuneration structure changed and the assessment of staff potential played an increasingly dominant part in pay level differentiations (ibid.:221).

Regarding the challenges of the recession on the Toyota Production System, according to Kojima, TPS as a lean production system was improved further and developed into a system of "Super lean production" (Kojima 1995:197). During the late 1980s, Toyota had been experimenting with introducing aspects into the TPS aiming at "improving workers' morale while securing productivity" (Niimi and Matsudaira 1997:82). One way of achieving this was to change the production layout, particularly the assembly line structure. Underlying the new assembly line is the continuous improvement process (CIP). According to Niimi and Matsudaira, the assembly line "will continue to be improved and will continually evolve in response to changes in the social environment and the growth of workers in terms of skill and attitude towards Kaizen" (ibid.:83). A first adapted line was introduced at the Miyata plant of Toyota Kyushu in 1992. Three adaptations are noteworthy.[13]

First, the link between individual production lines consists of a buffer with sufficient space for four to five waiting vehicles so that differences in working pace can be buffered (Kojima 1995:32). According to Nomura and Jürgens, from the traditional perspective of lean production a classical case of waste in processes as no value is added to the vehicles moving between the mini-lines (Nomura and Jürgens 1995:232).

Second, during the bubble boom years of the 1980s, the automotive industry had acquired the so-called 3K image: Kitanai (dirty), Kitsui (stressful) and Kiken (dangerous) (ibid.:234). The potential surplus male labour pool had shrunk and

[12] Kumicho refers to the group leader or supervisor, whereas Hancho denotes team leader or foreman, see Nomura and Jürgens1995:111.
[13] For a detailed discussion refer to Kojima 1995.

fluctuation problems occurred (Shimizu 1995). For example, by the end of 1991, three quarters of the newly recruited workers in April 1991, had already resigned after having found better jobs in other sectors of the Japanese industry (Nomura and Jürgens 1995:234).

Third, whereas the production layout in other Toyota assembly plants had been centred around one long production line, at Kyushu, the line lay-out resembles more that of a fishbone structure with one central spine (main assembly line) and laterally extending bones ("mini-lines") (ibid.:232, see also Shimizu 1995).

In contrast to the traditional TPS, these buffers affect work in three ways. First, the psychological threat imposed by the pull chord is reduced as eventual stops only affect the mini-line but do not bring the entire line to a standstill. According to Nomura and Jürgens, the pressure on the individual to use the pull chord decreases and one of the key aspects of work pressure is thus being eliminated (ibid.:233). Second, the working processes within the mini-lines are structured to ideally provide holistic and related tasks (ibid.). Thus the group has received additional autonomy regarding the organisation of work and job rotation. Work in the sub-lines is organised by the teams: the management and control of the team remains the responsibility of the team itself (Kojima 1995:49).

The TPS also evolved along is through its adoption of joint-venture partners in the West, primarily throughout GM's international plants (notably in the USA at NUMMI in 1983, as pointed out above). After having learned the Japanese manufacturing techniques through its main joint ventures at NUMMI (with Toyota) GM's next step was to "emulate Japanese manufacturing methods without a Japanese joint-venture partner" (Jürgens 1998b:326). Opening in 1990, at Opel Eisenach these "experiences and human resources" were primarily provided as "a core group of General Motors managers for Eisenach who had hands-on experience under Japanese management in these various joint ventures with Japanese companies" was recruited to help in creating the Opel Eisenach Production System (ibid.). As a main function, these managers contributed to the "parenting/facilitating configuration" promoting a distinct Eisenach approach, which consisted of configuration based on four cornerstones:

- Pairing up American and Canadian managers with transplant experience with German managers with line authority
- The integration of central planners from the Technical Development Centre (TDC) in Rüsselsheim
- Role of Opel's chief executive officer, Louis Hughes who consolidated the divergent interests in the dual structure between the German technical planners, the German managers at Eisenach and the foreign transplant advisors
- The role of the works council at Opel Eisenach, particularly the head of the works council, a "true believer in the principles of the new system" (ibid.: 327) who, as a member of the metal workers union (IG Metal) reconciled this distinctly Eisenach approach with the interests of workers.

To focus in detail on the issue of the evolution and transfer of the TPS, it is important to point out that apart from the Eisenach plant manager La Sorda (recruited from CAMI), most of the transplant-experienced managers functioned as consultants/advisors. According to Jürgens, Eisenach drew "on around twenty advisors serving three year terms" (ibid.). Their advisory impact also extended to the central planning department located at Rüsselsheim and they "immediately made clear that they were to be involved in the process and insisted on demanding alternative solutions in many instances" (ibid.). Trying to balance these "divergent forces", Hughes, Opel's CEO attended all planning meetings making sure that the planners "would stick to its mission of developing a true lean production system" (ibid.). The "Eisenach Production System" was the result of various influences ranging from "General Motors' European production networks and markets, of lean-production-inspired local experiments and ideas transferred from transplant practice mostly in North America" (ibid.:329).

Regarding the transfer of TPS, Jürgens suggested that standardisation primarily occurs in the process organization and methods. For example, "employees conduct their own time studies, write and revise their standard operation sheets, and pursue continuous improvement activities" (ibid.:330). Moreover, the production flow is ensured by an assembly line, work organization is based on team-work, highly standardised instructions regulate how tasks are to be performed and define the content and extend of staff training (Reitz 1998:134). However, Eisenach is not a clean sheet copy of TPS. The Eisenach production system (EPS) is the result of "synthesizing a specific plant concept dedicated for small cars, a specific process layout and technology, and a very low degree of vertical integration, with a system of work, production and organization, and personnel policies adopted selectively from the various GM-Japanese joint-venture transplants and from other GM/Opel plants" (Jürgens 1998b:333).

Allowing thus to overcome the essential dichotomy of global standardisation (Reitz 1998:135), on the one hand, and the standardisation based on the local context (ibid.) on the other, Eisenach became the hub for transferring lean production standards, the nucleus for building new plants and GM managers from around the world are trained there (ibid.). Although the Eisenach Production System is not a cookery book from which separate recipes can be taken and implemented in new plants (ibid.:134). GM plants in Polen, Thailand, China or Argentina, do have similar building and facility structures which determine the standardised layout of machines and systems (ibid.:135).

From the historical development of Toyota and the evolution of the Toyota Production System, two central conclusions can be drawn so far. First, the TPS is the result of a company specific effort to define and formalise complex elements of production into one company-specific production system. Unlike the scientific paradigms of Taylorism and Fordism, the TPS consists of a system of "firm specific patterns of routine capabilities" (Fujimoto 1999:58).

Second, TPS evolved over time and is the result of a "cumulative and evolutionary" rather than a "revolutionary" process (ibid.:49). Striving for constant improvement, the elements of the TPS and therefore the entire system is part of an ongoing process of refinement (ibid.). According to Fujimoto, TPS evolved through a historical process defined as multi-path systems emergence, shaped by the "the interplay of both intended and unintended consequences" (ibid.:8). In combination with Toyota's specific "routine capabilities", the multi-path system emergence facilitates what Fujimoto calls an "evolutionary learning environment" (ibid.:58). Learning is considered a central aspect of the TPS (Jürgens 1994, Kenney & Florida 1993, Nonaka 1990), as I shall now discuss when looking at the forms and functions of standardisation in the Toyota Production System.

3.5.3 The forms and functions of standardisation in the TPS

According to Jürgens the Japanese model is characterised by a link between the system of production control with work and social organisation (Jürgens 1989b:21). In this model, Toyotism, represents a particular system for regulating work, not as an alternative to Fordism but an intensification of Fordist principles of organisation (Jürgens 1994:195). It is based on the complementarity of, on the one hand, a certain degree of self-regulation, involvement and participation of the worker in the working processes, and on the other, a complex system of social integration and social control (Jürgens 1989a). Amongst authors that have attempted to define the term "lean production", Jürgens states that lean production is "a set of new practices and new forms of work and process organisation" (Jürgens 1995a:298), in which the social organisation, particularly the organisation of work corresponds with the requirements of the process chain (Jürgens and Jansen 1999:35). The following diagram adopted from Monden's publication *The Toyota Production System*, gives a systems overview showing the inputs and intended outputs (cost, quality and quantity and respect for humanity):

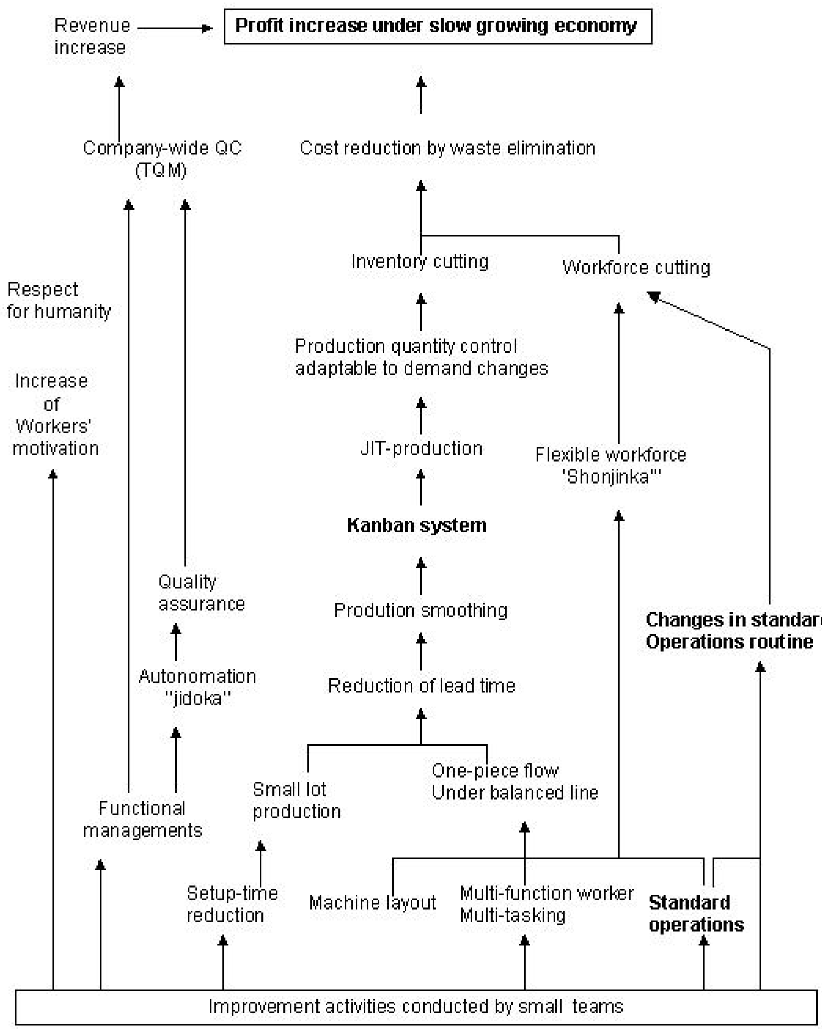

Fig. 3.1. How costs, quantity, quality and humanity are improved by the Toyota production system (source: Monden 1983:4)

Monden, as well as Nonaka and Jürgens have stressed the importance of the interrelation between these elements, particularly the interplay between features of the process organisation with features of the work organisation (Nomura and Jürgens 1995:16). For example, standard operations are continuously improved as part of the activities performed by small teams. This leads to a change in the standard operations routine and has direct repercussions on the size of the workforce, as operations are thus rationalised. This leads to a cost reduction and an elimination of waste (i.e unnecessarily high number of workers and unnecessary and unproductive steps in the work). As a result, profit increases, even despite negative economic indicators, such as a slow growing economy.

Standardisation and the refinement of standards play a key role in this dynamic process and Fujimoto suggests that "part of Toyota's dynamic capability may be ascribed to standardisation and documentation" (Fujimoto 1999:267). Standards within the TPS are not considered fixed but are subject to a continuous improvement process. This dynamic nature of standards provides the fundamental basis for the continuous improvement process. By encouraging workers to continuously refine and improve standards, continuous learning takes place. Thus standardisation, learning and CIP are at the core of the TPS. Two key objects of standardisation within the TPS are the standardisation of operations (standard operations routine sheet and the standards operation sheet), and the standardisation of the production flow facilitated by the Kanban system.

3.5.3.1 Standard operations

The main aim of the TPS is "to eliminate through improvement activities various kinds of waste lying concealed within the company" (Monden 1983:1). Both excessive inventory and staffing levels are considered wasteful (ibid.:145). Standards regulating operations therefore aim to minimise the number of workers in production neither jeopardising product quantity nor quality (ibid.). They also ensure that the available workforce is deployed efficiently and therefore regulate a "sequential routine of various operations taken by a worker who handles multiple kinds of machines as a multifunctional worker" (ibid.:11).

According to Monden, standard operations at Toyota have three main goals. First, they ensure productivity levels through efficient work. This is achieved by standardising the steps of the work routines, formulated in a standard operations routine, thus reducing the amount of "wasteful motion" (ibid.:145) for the worker. Second, standard operations aim to balance processes across lines in terms of production timing. This is facilitated by incorporating the "cycle time concept" into the standards operations (ibid.). Third, the standard quantity of work-in-process is limited to a minimum thus aiming to reduce buffers through potential work-in-process inventories (ibid.). The following overview summarises these key elements of standard operations at Toyota.[14]

[14] The three main goals are also supported by standards regulating the sub-goals of accident prevention (safety measures) and defective production (quality control).

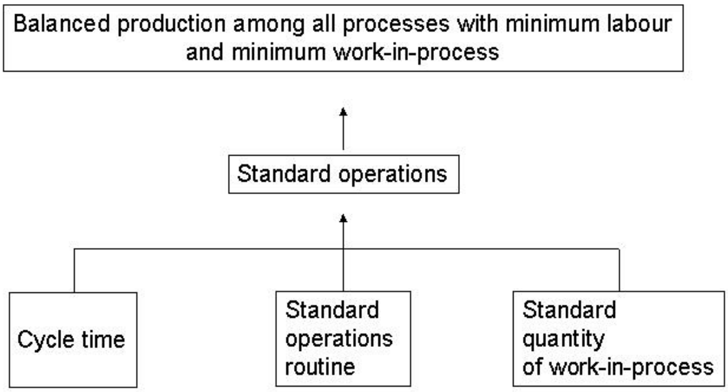

Fig. 3.2. Elements of standard operations (source: Monden 1983:146)

These routines are formalised by two written documents: the standard operations routine sheet and the standard operation sheet (ibid.:11). According to Monden, the former represents a "man-machine chart" (ibid.) mapping the link between the physical motions of the worker with the mechanical operations of the machine. It defines the "sequence of operations that should be taken by a worker in multiple processes of the department" (ibid.). The steps involved in the operation of each machine, commencing with the picking up of material, feeding and finally detaching the processed material, is listed in sequence for each machine the worker handles. All necessary steps of these operations have to be completed within the cycle time set.

The standard operation sheet, specifying "cycle time, standard operations routine, and standard quantity" (ibid..48) is "posted above the work stations" (ibid.:64) visible for all workers. Cycle time represents "the standard specified number of minutes and seconds that each line must produce one product or one part" (ibid.:11). It is deduced from the monthly market demand forecast and thus follows a push system (ibid.). Based on this information, management derives the minimum staffing levels needed (ibid.).

Both, the standard operations routine sheet and the standard operation sheet are elements of Toyota's standard operations. According to Monden, "the components of standard operations are determined mainly by the foreman (supervisor) " (ibid.:145). Nomura and Jürgens define the role of the Hancho (Team leader) as contributing manual skills, and the Kumicho (group leader) as contributing production knowledge and experience (Nomura and Jürgens 1995:110ff.).

The former being responsible for the induction (ibid.:111), the latter is responsible for quality insofar as he is responsible for setting standards for methods and times (ibid.:112). Regarding the practical task of establishing standard operations, it is thus assumed that these are performed by the Hancho (ibid.:111). Part of the task is to calculate the necessary labour time and to structure the sequence of operations to be performed by the workers. Since Ford's days, this had been the prerogative of the Industrial Engineer, placing the responsibility for standard operations into the hands of the scientific engineer, rather than the supervisor on the shop floor. According to Monden, at Toyota it is the responsibility of the Kumicho to: calculate cycle time, determine completion time per unit, standard operations routine, standard quantity of work-in-process, and to prepare standard operations sheet.

Regarding the first two items, with the help of mathematical formulas and timing devices such as stop watches, foremen arrive at standards for the cycle time and the completion time per unit. The former denoting "the time span in which one unit of a product must be produced" (Monden 1983:146). It is derived by dividing the actual daily operating time by the required daily output quantity. Unlike the net daily operating time calculated in other companies, at Toyota, no allowances and adjustments for "machine breakdowns, idle time awaiting materials, rework or for fatigue and rest time" (ibid.:147) are made.[15]

The completion time per unit (the required time to produce one single unit), is part of range of standard measures used to determine the production capacity (Monden 1983:147). Together they are individually listed in the part production capacity sheet. The completion time per unit is measured "for each process and each part" (ibid.) and consists of the manual operation time plus the machine automatic processing time (ibid.:148). In addition times for tool exchanges and the quantity of units produced with one tool are recorded. Production capacity as units of output is thus calculated by dividing the total operations time by the sum completion time per unit and set up time per unit.

The information generated on the part production capacity sheet is essential for the determination of the standard operations routine. Having established the manual and machining times for each product and process, the supervisor now determines the "order of actions that each worker must perform within a given cycle time" (ibid.:149). According to Monden, the setting of this routine has two functions. First, it structures the worker's tasks according to a routine sequence. This standardised sequence starts with the worker picking up the material. He then feeds the material into the machine. Finally, the worker detaches the processed part from the machine (ibid.). Second, the standard operations routine provides "the sequence of operations that the multi-functioned worker must perform at various machines within a cycle time" (ibid.). Thus, the order in which the machines are fed within the cycle time is established (ibid.). The part production capacity sheet plays a vital role in this process as it contains the different machining process times which have to be considered, for "the automatic processing time of a certain machine will be finished before the worker handles the same machine in the next cycle of the tact time" (ibid.). Working backwards from the cycle time, the individual steps necessary in the process are analysed according to three time measures: manual operation time, machine processing time and slack time (walking time from one machine to the next). Workers adapt this standardised routine

[15] See also Nomura and Jürgens 1995:151.

only once "the foreman can comfortably finish it within the given cycle time" (ibid.:151). In practice and in the case when setting cycle times for a new production run, Nomura and Jürgens suggest that the practical tests regarding the feasibility of new standard times and routines are conducted by the Hancho because they have most experience with production tasks (Nomura and Jürgens 1995:149).

After having established the standard operations routine, in order to achieve a smooth production flow and the "rhythmic operations of various machines" (Monden 1983:155) in one line, the minimum work-in-process quantity within the particular production line has to established. According to Monden, the standard quantity of work-in-process consists of "the work laid out and held between machines" including the work "attached to each machine" (ibid.). In line with the goal of the TPS, the amount of work between machines should be zero, providing for a system of one-piece flow in which "only the work attached to each machine is necessary" (ibid.).

The final part of the standard operations of the TPS is the standard operations sheet. It brings together and visualises the described items above but also includes aspects regarding quality inspection and work place safety. The standard operations sheet consists of six types of information: "cycle time, operations routine, standard quantity of work-in-process, net operating time, positions to check product quality and positions to pay attention to worker safety" (ibid.:157). The standardised operating sheet offers a visual control tool for worker, supervisor and management. First, it represents a visualised guideline for the worker to follow. According to Fujimoto the visualisation of standards aid the understanding of what, how and in which sequence the worker has to perform tasks (Fujimoto 1999:293). Second, it serves as a check up (Monden 1983:155) or control tool for the supervisor who is now able to compare the actual work performed by the worker and the standardised task performance description (Fujimoto 1999:64).

Third, once standard operations are set, it is the supervisors and workers task to continuously improve these standards. A potential failure to update and improve the standards operating sheet signals management that they fail to actively contribute to the continuous improvement process (Monden 1983:157). As a control tool, the visualisation of the standard operations thus drives home, what Monden considers to be the "most fundamental idea behind the TPS", namely that the "progress of a company can be achieved only by continuous efforts on the part of all members of the company to improve their activities" (ibid.:158).

3.5.3.2 The kanban system

Whereas standard operations regulate the time, motion and the sequence of tasks to be performed, "the kanban system is an information system that harmoniously controls the production of the necessary products in the necessary quantities at the necessary time in every process of the factory and also among companies" (ibid.:15). Whereas in traditional Fordist *push systems*, one process supplies parts to the next, the kanban system at Toyota is based on a *pull system* in which "the subsequent process will withdraw the parts from the preceding process" (ibid.:16). The kanban system serves as an information system informing "all processes about necessary timing and quantity of parts production" (ibid.). In addition to harmonising "production quantities in every process" (ibid.:6) and synchronising "upstream and downstream processes" (Fujimoto 1999:59), both kanban components (such as layout and size of kanban cards) and the kanban procedure (kanban post and kanban rules) are highly standardised thus facilitating that workers learn to blindfoldly handle the ordering and materials supply system.[16]

The term "kanban" alone refers to the "tag-like card that communicates product information" (Japan Management Association 1985: preface). Each card is displayed in a "rectangular vinyl envelope" (Monden 1983:16). There are two types of kanban: the withdrawal kanban regulating "kind and quantity of product which the subsequent process should withdraw from the preceding process" (ibid.); the production-ordering kanban stating the "kind and quantity of product which the preceding process must produce" (ibid.). On the withdrawal kanban, for example information is listed about the store and shelf number, kanban number, box capacity and item number. The ordering kanban only lists information about the item and the shelf.

Focusing on the withdrawal kanbans, the heavy triangular kanban made of metal is used to specify and signal lot production (Monden 1983:19). It contains information about the required lot size, the part name, the reorder point (the point indicating when the part is to be produced), pallet number, part number, store and machine number to produce the part. This triangular kanban is placed into a signal kanban box together with the material-requisition kanban used to signal the order for the actual materials used to produce the required part (ibid.).

The basic principle behind the kanban information flow is based on a highly standardised process in which basically production-ordering kanbans are exchanged by withdrawal kanbans and vice versa, thus "carefully comparing the withdrawal kanban with the production-ordering kanban for consistency" (Monden 1983:21)**.** The kanban system is enforced by so-called five "kanban rules" (Monden 1983:24ff., Japanese Management Association 1985:87ff.):

1. "The subsequent process should withdraw the necessary products from the preceding process in the necessary quantities at the necessary point of time.
2. The preceding process should produce its products in the quantities withdrawn by the subsequent process.
3. Defective products should never be convened to the subsequent process.
4. The number of kanbans should be minimised.
5. Kanban should be used to adapt to small fluctuations in demand (fine-tuning of production by kanban) " (ibid.:24ff.).

The supplier kanban system, too, is organised according to a standard time schedule. For example, the incoming lorry to the supplier delivers empty kanban boxes and supplier kanbans to the supplier's store at 8 am. The driver then switches trucks and takes the completed parts (including their respective kanbans) which

[16] Also related to the blindfold return tool cabinets as presented by Monden 1983:212.

had been ordered by Toyota at 10 pm the previous night, back to the Toyota plant, once at Toyota, the cycle commences.

Supporting the kanban system, Toyota has installed switches and visual demarcations to signal standard amounts. The Japanese Management Institute cites the example of limiting the standard stock of one particular machine to five units and "if there are only three units, the preceding process automatically begins to process and continues until the quantity reaches five units" (Japanese Management Association 1985:96). The kanban system thus functions as a "limit switch" (ibid.:97). It serves as a "work order" and as the process description and the examples have shown, the kanban system is an "automatic directional device" (ibid.:85). The kanban system represents a simple human information system with standardised formats of kanbans, colours, sizes, numbers and processes. It is a system which workers learn to handle blindly. According to the Japanese Management Institute, the kanban thus serves workers to "engage in standards operations at any time" (ibid.:86).

3.5.3.3 Continuous improvement (kaizen)[17] and learning

Standard operations and the kanban system are two elements of the Toyota Production System providing standardised framework of process and work organisation. However, they are not static standards but are subject to the continuous improvement process (CIP). The purpose of the CIP is to eliminate any wasteful activity thus contributing to the key goal of the TPS "to increase productivity and reduce manufacturing costs" (Monden 1983:177). Standard operations and the kanban system therefore do not represent fixed, static solutions but are subject to a continuous process of improvement, as the diagram below visualises:

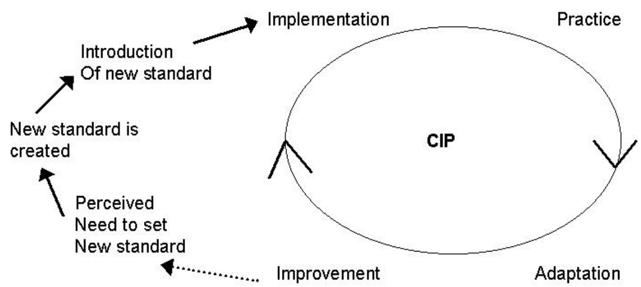

Fig. 3.3. Standardisation and the continuous improvement process in the Toyota Production System

[17] Fujimoto 1999:287.

Pertaining to cycle time, this represents a fixed time which is not revised even if the work process has been improved or technical processes have been changed (Nomura and Jürgens 1995:150). However, if improvements in manual operations can be made, the standard operations routine sheet and the standard operation sheet are changed. These changes are part of the responsibility of each team. The tasks of the team, according to Nomura and Jürgens contain direct production tasks, indirect tasks, quality assurance and material handling tasks, as well as induction training, continuous improvement activities and from a human relations perspective, integrative social tasks (ibid.:244).

Concerning their contribution to the continuous improvement of standards – an aspect I shall come back to in context to the Adler and Cole and Berggren debate - Nomura and Jürgens suggest that the key function of teams and groups concerns personnel development, qualification and social integration of new staff at the beginning of their career in the organisation and are but one element in a carefully construed tense networks which represent the core of the dynamic drive towards the continuous improvement of product, production processes and work on the shop floor. According to the authors, it is this dynamic tension between social control and social integration, between competition and cooperation, between the pressure of selection and privileges, which spur on the individual to give a top performance (ibid.). Moreover, these internal team dynamics are formally enshrined in the TPS by linking the continuous improvement process and the system of remuneration (ibid.:170). Nomura and Jürgens suggest that the actual work performed is only one part of the assessment. The contributions made in the continuous improvement process and activities, the cooperation within the team, the social competence and the ability to lead and to motivate team members and subordinates are further criteria in the performance appraisal (ibid.:246). The wage level of each worker is therefore directly linked to his contribution to the continuous improvement process and the overall success of the company (Shimizu 1995). According to Nomura and Jürgens, the pressure to improve productivity is driven by competitive mechanisms, such as the ranking achieved in the productivity league table, and hence the thus related effect on compensation (Nomura and Jürgens 1995:165). Toyota's remuneration system enshrines this link as productivity is at the centre of any activity within the organisation. The core aim of the organisation is the continuous improvement of productivity. (ibid.:170). [18]

Moreover, productivity is seen as contributions to the continuous improvement process by both the individual worker and the group. In its idealised form, kaizen activities drive a learning spiral shop floor - experts - shop floor is thus initiated. Thus the dynamic process of standardisation is internally generated by individual workers and within groups (Jürgens 2002:4). Jansen and Jürgens interpret the function of the group within Toyota as a means to increase productivity (Jansen and Jürgens 1999:35) and is used to exploit informal aspects within group relations for this purpose (Jürgens 1989b:21). According to Nanto, "each person de-

[18] For details about how remuneration is calculated at Toyota and its role as competitive factor, please refer to Jürgens and Nomura 1995: 135ff.

pends on each other person to do the job well. If one person slacks off or does not show for work, it places a burden on others" (Nanto 1982:8).

The dynamic effect of the dependence of the individual on the group is, for example particularly evident in the external process pressure exerted by the kanban system. According to Schonberger, large lot sizes and buffers can "provide a convenient rationalization for carelessness" (Schonberger 1982:28). With small-lot size inventory though, "one worker's problems threatens to bring subsequent processes to a halt" (ibid.:29). This poses a potential threat on the productivity achieved by the group and a subsequent decrease of the productivity component of their wages. Thus this process constraint in combination with a potential loss in wages forces the workers to co-operate. This also applies in the case of the Just-in-time system as it represents another external process pressure on the work of the actors on the shop floor.

So far about standardisation as external process pressure in the Toyota Production System. But what about the aspect of learning as part of this process?

As delineated in the history of Toyota at the beginning of this section, the TPS evolved over decades, a process in which according to Fujimoto Toyota developed its "evolutionary learning capacity" (Fujimoto 1999:5). The formalisation of the TPS is part of this process as it reflects Toyota's "ability to evolve competitive routines even in highly episodic and uncertain situations" (ibid.). Moreover, the standard elements of the TPS as discussed above, can be explained in terms of reflecting Toyota's "routinised learning capability" (ibid.:19); that is a company's specific "ability of handling repetitive problems solving cycles or a routinised pattern of system changes" (ibid.:17). Thus, standard operations and the kanban system represent organisational routines for "problem identification, problem solving and solution retention" (ibid.:19). Continuous improvement facilitates the ability of individuals and groups to "to formalize and institutionalize new solutions in standard operating procedures, thereby providing stability for individuals who internalise solutions" (ibid.).

In Fujimoto's description of Toyota's organisational routines, standard operations and the kanban system represent information systems. They provide a medium in which information is transformed, transferred and transported (ibid.:88). The process of information processing is driven by the CIP. According to Kenney and Florida, "this creates a powerful learning dynamic and enhances the problem-solving capabilities at the enterprise level" (Kenney and Florida 1988:132). Nonaka, explains this dynamic with the systematic tapping of the tacit knowledge of the worker as facilitated by the CIP process. This plays a key role in giving Japanese companies their competitive edge and "the centrepiece of the Japanese approach is the recognition that creating new knowledge is not simply a matter of 'processing' information. Rather, it depends on tapping the tacit and often highly subjective insights, intuitions, and hunches of individual employees and making those insights available for testing and use by the company as a whole" (Nonaka 1991:24). Dohse et al. conclude that for Japanese companies the "Taylorist reduction of the intellectual demands made on the workers is no longer the maxim" but rather, that they use their workers' "intellectual capacities for the goal of production" (Dohse, Jürgens, Malsch 1985:124).

According to Fujimoto "tacit knowledge is an attractive way of explaining the firm-specificity of manufacturing systems because it obviously does exist on real-life shop floors" (Fujimoto 1999:16). For Nomura and Jürgens the efficiency of the TPS is based on a reconciliation between standardisation and learning. On the one hand, know-how to solve problems is stimulated and the contribution of individuals in problem solving processes is encouraged; on the other, discipline, rigid working structures, highly repetitive and standardised tasks determine the system (Nomura and Jürgens 1995:253). The willingness to submit to this system is ensured by establishing a linking of the CIP with the remuneration system and thus extraordinary performance is expected (Jürgens 1989a). Jansen and Jürgens point out that this adds physical and psychological strain on the worker (Jansen and Jürgens 1999:36) and the process pressure is a constant, chronical pressure on the individual (Jürgens 1993:10).

In contrast, Adler and Cole suggest that "this constant improvement effort creates a certain level of stress, but as the worker attitude surveys show, the level is not so high as to degenerate into strain and distress" (Adler and Cole 1993:5). Indeed, their research conducted at the joint venture between Toyota and GM at the New United Motor Manufacturing Inc. (NUMMI) (Adler 1992, Adler and Cole 1993 and Adler 1993), "flies directly in the face of" (Adler 1993:98) the human relations argument. Instead, Adler and Cole perceive that the TPS, deployed at the Toyota-General Motors joint venture plant NUMMI, provides standards and procedures "that are designed by the workers themselves in a continuous, successful effort to improve productivity, quality, skills and understanding" and are thus able to "humanize even the most disciplined forms of bureaucracy" (ibid.). The NUMMI plant is thus a "learning bureaucracy" and a prime example of "democratic Taylorism" (Adler 1992). Instead of perceiving standards as a coercive force, according to Adler and Cole, at NUMMI standards provide a "logic of learning, a logic that motivates the workers and taps their potential contribution to continuous improvement" (Adler 1993:98).

As already discussed above, whereas in other companies, the Industrial Engineers conduct time and motion studies, at NUMMI this prerogative is handed onto the shop floor. Being taught the principles of time and motion studies, workers conduct work analysis, improve work routines and thus are responsible for setting and continuously improving standards:

> "Team members begin by timing one another with stopwatches, looking for the safest, most efficient way to do each task at a sustainable pace. They pick the best performance, break it down into its fundamental parts, then explore ways of improving each element. The team then takes the resulting analyses, compares them with those of the other shift at the same work station, and writes the detailed specifications that become the standard work definition for everyone on both teams" (Adler 1993:103).

This process involves all team members and thus Adler claims it improves "worker motivation and self-esteem" (ibid.). For the author, "standardised work is simply a means of reducing variability in task performance" thus improving work place safety, quality, process flows, job rotation and flexibility (ibid.). As workers perform the tasks once handled by Industrial Engineers, they acquire new skills initiating a learning process. Standardisation is provides the "stimulus" in this process (ibid.:104).

This led Adler to go as far as considering standardisation as "essential precondition for learning" (ibid.). Moreover, including the tacit knowledge of the shop floor directly into the standard setting process, each worker and each work station represents a "centre of innovation" (ibid.). The innovative ideas are directly incorporated into standards as workers, together with "leaders and engineers create a consensual standard that they teach to the system by writing job descriptions" (ibid.). In turn, the "system then teaches these standards back to workers, who, then, by further analysis, consultation, and consensus, make additional improvements" (ibid.). This "continual reiteration of this disciplined process of analysis, standardisation, re-analysis, refinement and re-standardisation creates an intensely structured system of continuous improvement" (ibid.). Driven by the continuous improvement process, the organisation learns to "change its routines to adapt better to the environment" (Fujimoto 1999:21).

Adler and Cole's stand was challenged foremostly by Berggren (1992) and other academics propagating a system of "holistic" or "reflective" manufacturing,[19] I shall discuss in the next part.

In sum, the TPS represents a next step in the evolution of production systems. One has to distinguish between the original TPS (TPS 1), as analysed by Jürgens and Nomura), its evolution during the 1990s (TPS 2), as analysed by Shimizu.[20]

The initial, "classical" TPS (1) was marked by the intention to constantly improve processes and standards with the goal of reducing any form of waste, be it faults or unnecessary movements at the workplace. The organisation of work in teams but also standards regulating operations, the kanban system or the pay system all aid this continuous improvement process.

Based on the classical systems descriptions of Ohno, Monden and Imai of the TPS 1, in my view, the importance of the workers on the shop floor for the refinement of standards is of key importance. In its ideal form, kaizen initiates a learning spiral shop floor - experts - shop floor. Insofar, the dynamic process of standardisation is internally generated. By contributing to the refinement of standards, the know-how and experience of each actor is integrated into the standards of the TPS: the individual worker is thus able to set best practice standards and hence can influence existing standards. Standards in the TPS represent initial marks, specifications about how processes are to be structured which are then assessed and improved by workers. Hence, initially in the TPS 1, standards provided

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[19] Berggren 1992 In the publication *Alternatives to Lean Production*, Berggren accuses Adler and Cole for deducing their theory merely from a series of static snap-shots at NUMMI; a theory according to the author which is but a "revamped and intensified" version of Taylorism: "rigid standardisation, minute subdividison of labor, short-cycle tasks and narrow job roles".

[20] Currently, the plant at Onnaing represents a further step in the evolution of TPS1 concerning process layout, and also a further development of the TPS2 concerning the CIP-process being increasingly expert-driven.

an input, an improvement opportunity which then allows the worker to bring in his know-how and experience to refine them. Most significantly, the willingness and understanding that standards need to be subject to constant improvements, are enshrined in the attitude of the workers. The TPS 1 promotes an attitude of striving for constant improvement. As a result of the inclusion of the know-how and experience of the workers in standards, this knowledge is shared and hence the TPS contributes to the creation of an "evolutionary learning environment" (Fujimoto 1997:58).

One often neglected aspect concerning the introduction of standardised production systems is the fact that the Toyota Production System has evolved further. In fact, the TPS 1 has meanwhile developed further from the image we still have of it (Jürgens 2002:14). With the emergence of the crisis of work during the "bubble economy" period, Toyota launched a "humanization of the production system and of work" (Shimizu 1995:400) at its Kyushu plant in 1992 (Fujimoto 1999:225). The "human-friendly" "new Toyotism" (Shimizu 1995:401) might be far removed from the reflective production system of Uddevalla, I shall come to now, however, it represents an attempt to "escape from the fatalism of the assembly line and to give a more humane dimension to assembly work" (ibid.). Toyota intended to humanise its production system and work at the Kyushu plant, by "improving working conditions, by developing a new conception of the production line, by allowing segments of the line to keep buffer stocks, by making social relations of work more equitable and rational" (ibid.:400),

3.6 The reflective production system of Volvo Uddevalla

The name Uddevalla stands for a concept of production, which instead of focussing on technology and production, is primarily concerned with the human being within production. (Jürgens 1998a:1). Its roots date back to the 1970s when the Volvo Truck Operation experimented with the team work concept in the assembly of "complete trucks at a stationary dock station" (Ellegård 1997:192). Pehr Gyllenhammar, who in 1972 took over the post of CEO at Volvo, restructured the corporation into decentralised units, Gyllenhammar intended to "democratise the corporation from top to bottom" (Rehder 1992:61). The assumption being that structural changes inside the organization facilitate the implementation of sociotechnical systems in production. The layout of the assembly line and the material flow played a key role in the evolution towards the reflective production system of Volvo Uddevalla.

3.6.1 Creating the reflective production system at Uddevalla

According to Engström, Jonsson and Medbo (1999), work cycle times determined by Industrial Engineers through time and motion studies represent a mere "theoretical abstraction of a complex reality" (Engström, Jonsson, Medbo 1999:194).

These set times "fail to accommodate inter-operator and intra-operator variation" and contribute to generating "idle operator time and/or need for re-work" (ibid.: 193). In order to eliminate this waste of working time, either a "parallel flow assembly system" or a system of buffers between workstations has to be established in order to smooth these variations (ibid.:194). In addition, to these technical solutions, Engström et al. suggest that by braking down the strict division of labour, and encouraging workers to help each other, work will be performed ahead of schedule (so-called working-up) (ibid.). Thus new assembly system designs need to promote "group work as well as working-up" (ibid.:195). The authors suggest that the answer lies in the introduction of a parallel flow assembly system which takes account of combining the "operator needs and priorities with management requirements for efficiency, quality and flexibility" (ibid.).

Moreover, the rigid time and motion standards are done away with as "work groups will tend to develop their own norm system with regard to quantity and quality goals, how to handle sick-leave, etc. " (ibid.). In conjunction with a traditional serial flow, the first attempt to introduce this parallel flow assembly line was undertaken at the Kalmar plant in 1974 (ibid.:199). The layout was based on 27 work groups initially separated by intermediate buffers (ibid.). Using a mixture of serial and parallel flows, assembly systems were "winding around the outer walls of the plant" (ibid.). According to Medbo et. al this was done to enable workers to "stand by the window and perform traditional assembly work using a costly and complex AGV-system (Automatically Guided Vehicles) to carry the automobile bodies" (ibid.). The materials flow was standardised insofar as materials were supplied by a two-storey high materials store located at the centre of the plant (ibid.), a feature later to be adapted at Uddevalla. In 1987, in order to adapt to the longer assembly time required for the Volvo 760 model, the Kalmar plant was extended and "intermediate buffers were largely eliminated, since most AGVs in the buffers had to be converted to work-station use" (ibid.:200). These changes increased production flexibility as changes in the production sequence could be made during the production run, and turned Kalmar into a line assembly system (ibid.). Driven by the need to improve work place ergonomics, in 1989 a parallel flow assembly was introduced in the subassembly of engine and gearbox (ibid.). While the experiments with the assembly line lay out at the Kalmar plant were primarily seen to aid Volvo's public relations, its system of elastic serial flow allowing flexibility of production pace and product sequence, inspired and evolved into a system of rigid parallel flows at Volvo Uddevalla.

Encouraged by the positive development of its export sales and the prospect of generous state subsidies for the conversion of the former Uddevalla wharf into an automotive, Volvo decided to build a new assembly plant primarily for its 740 model in 1985 (Jürgens 1998a:2). Developing from its previous experiences at Kalmar, the production system at Uddevalla placed human considerations at its centre. According to Jürgens, the creation of this reflective production system was aided by three circumstances (ibid.). First, decreasing unemployment figures and Swedish government regulations promoting full employment were feared to result in problems of work force fluctuations and absenteeism; the repeat of a situation as witnessed during the 1970s when the fluctuation rate amounted to 28.1% at

Volvo's main plant in Torslanda (ibid.). By creating a more human working environment Volvo intended to curb potential labour fluctuations. Second, Volvo's CEO Gyllenhammar recognised that the plant at Kalma is not an ideal work shop. It is a first step towards a new organisation. But concerning new working structures, a lot remains to be done, particularly concerning the degree of freedom and independence workers have over their own work and working processes (Gyllenhammar 1991:143). Thus the intention to support the new production system at Uddevalla, received top management support. Third, in addition to receiving support by the employer side, the unions increasingly began to focus on issues of work organisation and quality of work. At the congress of the Swedish unions in 1985 a programme called the good work had been ratified. The support for the creation of a more human working environment and production systems was extended to a further programme called "Solidarische Arbeitspolitik für die gute Arbeit" (solidary work policy for good work) in 1989 (Jürgens 1998a:3). Thus both, the interest of employers and labour representation encouraged the development of a new production approach.

The first planning concept was based on Volvo's Kalmar plant which consisted of partly parallel, partly serial work processes and cycles of 20 minutes (ibid.:5). However, Gyllenhammar rejected this proposal paving the way for academic consultants to realise their ideas and concepts (ibid.). The output capacity of Uddevalla was set at 40.000 units annually based on an eight hour shift. In addition to setting the production target, six key goals the assembly at Uddevalla had to achieve were agreed upon. The underlying objectives of the production system at Uddevalla were to ensure quality, flexibility, overall efficiency (Ellegård 1997a:191, Jürgens 1998a:3). In addition, work at Uddevalla should offer the best possible development opportunities for staff, a flat hierarchical structure and work should be based on the concept of group work, namely the creation of the smallest possible self-efficient units (Jürgens 1998a:3).

In December 1987, the production plans based on a parallel flow assembly system or complete assembly were decided. The first production work shop (PWS) started in August 1989, and the set up phase was concluded as the final fifth PWS commenced in October 1990. The planning and setting up of Uddevalla thus took almost six years, yet the decision to close the plant was made two years later, in November 1992 and the last car left the Uddevalla plant in May 1993. Since then Volvo together with its joint venture partner TWR, decided to re-open the plant, now named Autonova and production of the so-called Uddevalla II assembly commenced in June 1997.

3.6.2 The role and function of standardisation in the reflective production system

The Uddevalla plant consisted of six parallel assembly workshops grouped around two test shops (Engström, Jonsson, Medbo 1999:200). The production flow was regulated by a standardised system of materials supply. Adopted from the Kalmar plant, at Uddevalla a centralised, "separate materials workshop prepared materials fixtures" (ibid.). The parts for each vehicle were combined as individual kits, configured for assembly on special material handling containers. These kits were precommissioned in the materials workshop and from there were delivered directly to the various assembly workshops (Engström, Jonsson, Medbo 1999:201). According to Engström et. al., "the hardware (structure) was identical though the number of plastic containers and the actual materials in the fixture differed" (ibid.:218). These commissioned kits for each individual car are ordered and thus serve as assembly description for the workers (Jürgens 1998a:6). The commissioned kits according to Ellegård also contributed to the aspect of learning as, "if the components were given to the assembly teams in the form of previously prepared material kits (with the components arranged exactly for the specific tasks of the assembly team), then the extended assembly work became easy to learn and perform" (Ellegård 1997a:195).

Engineers in the planning group developed this idea and suggested that "they prepare kits of 1/8th of the car, corresponding to a cycle time of around 20 minutes" (ibid.: 195). However, in accordance to holistic learning principles, to assemble only 1/8th of a car is "too limited to reap the potential generative effects of these principles" (ibid.). Instead, the minimum assembly competence level was estimated to be at least 25% of the Volvo car, because "only then could each worker relate his own part of the work to the whole – the essential idea behind holistic learning" (ibid.). These theoretical assumptions were also supported by practical experiments conducted which focused on investigating "the human potential for the learning of long work cycles" (ibid.). Two incidents provide practical examples of the application of this potential: a previously untrained worker "learnt to assemble a complete car using the principles of holistic learning and materials arrangement" (ibid.); a sixteen year old apprentice who after two weeks training managed to assemble on his own one quarter of the entire car at almost full production speed (Jürgens 1998a:6).

A second key aspect of the materials flow system at Uddevalla was the automatically guided vehicle (AGV) transport system which made it necessary that all fixture stands were standardised throughout all workshops. The link between this combination of a highly standardised system of materials supply on the one hand, and a highly individual work organisation in the workshops, on the other did not harmonise. According to Engström et. al. then, "the production scheduling system in Uddevalla allocated each individual order to a specific work group, defining a production sequence for each group. These sequences were synchronised to one planned overall sequence (standard) for the total plant" (Engström, Jonsson, Medbo 1999:219). However, Jürgens points out that this standardised material supply system could not be reconciled with a highly autonomous work organisation, "both the flexibility and performance were negatively affected" (Jürgens 1998a:7, Engström, Jonsson, Medbo 1999:219).

Regarding the organisation of work in each workshop, initially, the "provocative idea" initially was that 12 people assemble an entire car together (Ellegård 1997a:190), by 1986 though this idea was revised and according to Ellegård, around 50 to 60 workers in product shops were to assemble 25% of an entire car (ibid.). One year later, this number was reduced to 16-20 workers within one team zone and by 1988, around 7-10 workers working in one team were able to assemble one quarter of an entire car (ibid.). This system thus allowed each worker to structure his work according to his own preference, termed by Ellegård reflective production system as it drew on the "inherent human needs, abilities, and ways of learning" (Ellegård 1997b:321).

As a result, "large variations in work methods and work group sizes existed" (Engström, Jonsson, Medbo 1999:203). For example, in one group seven operators assembled an entire car in a work cycle time of 100 minutes, whereas in another workshop two female operators assembled an entire car "resulting in mean work cycle times in excess of 300 minutes" (ibid.:212). Ellegård points out that, in one case, each worker assembled one eighth of the car. The expectation being that each worker had the competence to assemble one quarter of the entire car (Ellegård 1995:132, also Jansen and Jürgens 1999:46).

In a survey conducted by Engström et al. (unpublished 1996) between August 1991 and October 1992, around 90% of assembly workers contributed to around 15% (1.2 hrs) work to the entire car. Just below two thirds worked in cycles of 2.4 hours contributing 30% of the assembly work on the entire car, around one third of workers worked in cycles of 3.2 hours contributing 40% or a cycle of 3.2 hours work. Around 30 workers had the certified skills to complete the assembly of an entire car. Regarding the assessment of their competency, workers rated work content and competence highest at a degree of assembly completion between 20 – 40% (Jürgens 1998a:9).

Regarding productivity, according to an estimate by Berggren, in January 1992 the assembly of one car took almost 50 hours. Nine months later, by November 1992, this figure had dropped to 32 hours (Berggren quoted in Jürgens 1998a:14). Compared to the Volvo Torslanda plant, the assembly hours for nine vehicles at Uddevalla averaged between 10.0 to 12.0 hours, whereas the assembly time for the same units in two lines at Torslanda were consistently around just below 16.0 and 17.0 hours (Jürgens 1998a:18).

Thus workers were allowed to "control their own pace of work," (Rehder 1992:9) and the team itself received a high degree of self-regulation. Initially, teams were intended to be structured "to balance ages and genders" (Rehder 1992:8), which according to Leif Karlsberg, head of the Uddevalla plant, served to "achieve greater social harmony and balanced values, experience and judgement within teams" (Karlsberg in Rehder 1992:8). However, the team soon regulated and decided on team composition, membership, replacements, selection and training of new team members. These examples show the extent of the increased self-regulation, autonomy and responsibility the team received at Uddevalla.[21]

Analysing the effect of this increased self-sufficiency of the teams, Jürgens also points out that the extension of the freedom to self-regulate work resulted in higher stress levels. In other words, although workers affirmed that the new production system had improved their influence on and control over work, and over-

[21] For an indepth analysis of the impact of autonomy on group work see Schumann, M., 1993:168ff.

all had created more stimulating work, on the other hand, the demands posed on them by the new system,[22] particularly the demands on their socio-emotional competence, were considered considerably higher than in the old system of mass production (Jansen and Jürgens 1999:47). This shows the importance for production systems to strive for a balance between providing a routine in terms of a framework and aid to structure work, which does however not cause work to become monotonous. Work structures provided by production systems as need to provide meaningful, varied work contents and comprehensive tasks, yet without overburdening the worker. The case of the reflective production system at Uddevalla points out the difficulties of achieving this balance.

According to the Engström et al. survey, around 50% of assembly workers rate the socio-emotional competence of their work as being relatively high. Regarding the challenges of physical versus intellectual/mental work, just below 50% of workers rated the demands imposed by physical work to be high, whereas more than 50% of workers perceived the intellectual competence demanded to be of an average level. These results were underscored by comparing the psychosocial factors influencing the work of Uddevalla workers with those of assembly workers in other companies (Jürgens 1998a:11). The results confirm the claim that Uddevalla represents a more human system of work, for Uddevalla workers consistently scored higher when rating their impact and control over their work, their relationship with superiors, the stimulation they receive through their work and their social relation with other workers. Overall then, around 50% of male assembly workers and more than 70% of female workers at Uddevalla are considerably content with their work (ibid.:12). These results apply specifically for those workers having worked for four or more years at the plant (ibid.:13). Concluding from their findings, Engström et al. list five advantages of the parallel flow at Uddevalla:

- Simultaneous assembly of different products and variants
- Selective introduction of new models in individual groups
- Work content increases through an extended cycle time thus encouraging staff to acquire new skills ("knowledgeable workforce") and hence being able to handle a diverse range of products
- Application of multi-purpose tools
- Necessary administrative support, such as variant specifications, increase transparency and "enhance flexibility" (Engström, Jonsson, Medbo 1999:217).

Concerning the quality of the products assembled, there were considerable differences in the quality of work between groups (Jürgens 1998a:31). According to Engström, "this variation in quality might be one of the negative aspects of the Uddevalla production principles" (Engström, Jonsson, Medbo 1999:214). However, for the sake of creating a human centred production system and to facilitate

[22] For a controversial research comparison between the job satisfaction under Volvoism and Toyotism refer to Adler and Cole 1993:85ff.

holistic learning, the authors also point out that "it is better to have a low variation in quality and a slightly lower average quality" (Engström, Jonsson, Medbo 1999:214). Interestingly, the authors also point out that there "was no really good explanation for this quality variation" and at times the workers were well aware of the importance of the defect on the overall quality of the car. In my view this shows that by providing more human-focused forms of work and thus providing more comprehensive and meaningful work, one cannot prevent human errors to occur. It is this point which distinguishes the Taylorist and Fordist production systems which envisage the worker to function like a machine, and the human centred production system in which the worker is treated more human, including the consequences the human aspect has on the quality of the product.

However, the resulting quality problems encountered at Volvo have to be relativised. Despite the quality variations pointed out above, according to J.D. Power statistics of 1993, Volvo nevertheless ranked first in the list of quality improvements made and for the 940 model (later renamed 740 model) manufactured at Uddevalla, complaints per 100 cars had decreased from 132 to 87 Berggren 1998:340). Within Volvo, "Uddevalla and Kalmar, improved most of all and had a clear lead in comparison to the Gothenburg plant" (ibid.). Whereas Uddevalla headed the quality within Volvo, based on the average number of assembly mistakes made by 42 teams in 1071 cars between August 1991 and October 1992, Engstöm et al. figures show that 40% of all teams were responsible for a mean assembly defect score of between 40 – 49. (Engström, Jonsson, Medbo 1999:214).

In addition to the effect of the humanised production system on quality and efficiency, the fact that workers could organise their work individually without following precise standards also posed a challenge to the role of management at the Uddevalla plant. To place the human being at the centre of the production organisation and management meant a loss of power and control of management (Jürgens 1998a:21). The classical management function was reduced to setting the production programme/schedule (output quantity) and to contribute "expertise to the process" (Hancké and Rubinstein 1995:183). Ellegård goes as far as pointing out that the managements' "power base was being threatened" (Ellegård 1997b:320).

Coriat on the other hand, argued that management was still able to exert pressure on the workers, so that one the one hand, working speed for one set of workers was still set from outside the group, on the other, the group was free to structure the given assembly time (Coriat 1995:31). For example, the "rigid parallel flow" underlying the production scheduling system restricted the groups influence on the planned production sequence, thus preventing the accumulation of the necessary "working-up". For, according to Engström et al., as "the production schedule was planned minute by minute weeks before the manufacturing moment, the human flexibility was therefore not fully utilised" (Engström, Jonsson, Medbo 1999:220).

Moreover, the computerised control system necessary for controlling the flow of cars on the AVG's was not integrated into the system, particularly as "a specific AGV did not recognise what product it carried, nor was it possible to have detailed control over all transports or give priority to the most important transport assignments according to the status of the assembly work" (Engström, Jonsson, Medbo 1999:219). There was no structural congruence between the transport and material handling system and the autonomous work structure within the assembly work shops.

The impression visitors got was that the Volvo plant at Uddevalla rather resembled a cluster of garage shops than a proper factory for automotive assembly (ibid.). According to Jürgens, the impression visitors had was fundamentally counter to the principles of engineering and industrial planning. Instead of transparent, determined processes and clearly defined structures, chaos ruled at first sight. Instead of impressive technology in big assembly halls, the picture rather resembled that of uncoordinated buzzing small workshops (ibid.:22).

To give the main points of this part, the reflective production system at Uddevalla offered an alternative to the traditional system of mass production. Instead of introducing a system of standards intended to regulate and control the work of the individuals, the actors in production performed tasks according to their individual best way. This created a flexible factory which could be adapted to the developing skills of the workforce (Jürgens 1998a:26). In my opinion the key point about the reflective production system is that the intention of humanising work was achieved by the decision not to set standards regulating the work of the actor. Instead of controlling and regulating what and how workers have to perform tasks, as traditionally done through standard routines in the system of mass production, workers at Uddevalla organised and performed tasks themselves. Moreover, instead of following standards regulating the number of tasks workers have to perform, the reflective production system offered workers the possibility to complete the assembly of a car and thus encouraged the creation of holistic and functional tasks.

However, this does not mean that standardisation was not completely abolished at Uddevalla. The material handling system (kits) and the transport system were standardised. To some extent, these standards did curb the well intended freedom workers had over the organisation of their work. For one, the pre-commissioned kits consisted of components already arranged according to the specific tasks of team and laid out in the sequence for assembly. The kits thus somewhat influenced the sequence of tasks workers performed.

Uddevalla did away with two key factors traditionally associated with the alienation of work: short cycle times and highly repetitive work. Instead of setting standards regulating task content and cycle time for individual assembly stations, by training workers to potentially assemble an entire car, the reflective production system then offered the workers the opportunity to decide on the extent of work content and thus their individual cycle time: work was structured and organised around the skills of the worker. Far from causing the alienation of work, this allowed workers to gain a holistic view of their work.

This reflective approach towards production was later applied at Saab Trollhättan. It influenced the introduction of so called modular units at GM and VW, and as I shall come back to later, the Mercedes-Benz plant at Rastatt I.

3.7 The current trend: standardised production systems

The purpose of the final part of this chapter is to give an overview of the current form and functions of standards in production systems in the automotive industry. I shall focus on an analysis of the evolution of this trend and its implications.

The introduction of standardised production systems in the automotive industry today shows a clear trend that companies primarily model their production systems on the Toyota Production System. Insofar it seems that the TPS has evolved as the dominant reference model, the de facto model of standard production systems. This process towards institutionalising the TPS, is rooted in the lean production discussion during the early 1990s.

The MIT study propagated the universal principle of lean production late to be termed lean thinking, as universally applicable principles for the organisation of production systems (Jürgens 2002:6). The current trend of introducing standard production systems represents one approach toward implementing this message of the MIT study and marks a new stage in the evolution of production system.

Whereas during the phase immediately preceding the publication of the MIT study, during the early 1990s, Western managers had flocked to Japan to study the principles of lean production at first hand but remained reluctant as to the adaptation of the Japanese systems, today exactly these principles are being introduced as part of standardised production systems in the automotive industry. Seemingly through the back door, the Toyota Production System as become institutionalised, best practice standard and today represents the reference model for standard production systems of automotive manufacturers in the West.

A key factor driving this process is the need to achieve a competitive position within the world class in order to survive global competition and in a first step during the early 1990s, companies resorted to benchmark studies to examine the claims of the MIT study in detail (Leibfried and McNair 1996:46).

Taking the example of Mercedes-Benz plant Untertürkheim, prompted by the publication of the MIT study, and following their colleagues from other manufacturers, Mercedes-Benz managers flocked to Japan.[23] These so called benchmark trips were organised by McKinsey and Andersen Consulting. Groups consisted of centre managers, controllers, production planners and the heads of the respective production departments. Separate bench mark trips were organised for the union representatives. The benchmark trip was prepared and structured in advance by the consultants. First, the benchmark targets, those Japanese companies to be subject to the benchmark study, were selected. Factors such as product variety, company size and turnover were considered in order to provide a realistic comparison with the respective power train units of Mercedes Benz.

Second, a list of criteria to be examined was drawn up and each member of the team was delegated to examine and analyse one particular item during the visits at the selected Japanese company. The criteria to be examined covered for example,

[23] Account is based on interviews at DaimlerChrysler.

production methods deployed, work organisation, and production layout and space.

Third, during the benchmark trip, team members looked at the selected production sites and conducted their examinations. At the end of each day the teams met and presented and discussed their findings. The results of each team member were combined in one formal paper documenting the benchmark trip. Upon returning to Untertürkheim, these results were compared with those of the individual Mercedes-Benz powertrain units. Overall, the competitive lead of the Japanese companies was affirmed. In the case of the transmissions, the benchmark evaluation of 1992 showed a performance gap which showed that the average production costs of Japanese manufacturers were 30 – 35% lower, than those of Mercedes-Benz. As a direct consequence of these results and the bench mark trips to Japan in the early 1990s, management at Mercedes-Benz decided to introduce a new powertrain units. Also, it was decided to cut the percentage of parts manufactured in-house from 50% to a target level of only 30%. This cut could only be realised with the introduction of new models.

However, Western companies were rather adamant in adopting lean production principles and Japanese production concepts as elements into their own production systems. True, isolated concepts like kanban and Just-in-time were introduced, but the holistic systems approach, such a seen in Monden's description of the Toyota Production System was not adopted. In practice, companies applied a range of production systems, according to Jürgens these consisted of a range of modular solutions determined by different professional disciplines such as planners and engineers, but also due to different work policies and plant agreements (Jürgens 2002:7). These already existing routines had gradually evolved as grown structures, principles, beliefs which coherence and incoherence had been institutionalised behind the backs of the actors, instead of having been subject to organisational ratification (ibid.).

The introduction of explicit, formalised production systems marks a shift away from these local, idiosyncratic solutions and informal experience-based routines: production systems contain a deliberate selection of organisational principles (ibid.) which define processes and responsibilities. They thus represent a system of formalised routines. This aspect deserves particular attention, for it points out a change in the form and function of standardisation: where standards in Taylorism and Fordism served a regulatory function, in the production systems today, the term "standard" denotes a best practice routine, which is a variant of the elements of the Toyota Production System.

Initiated by the discussion about lean production methods, during the 1990s companies have gradually adopted best practice methods such as group work, CIP, TQM, and JIT, all derived from the Toyota Production System.

During recent years however, a number of big manufacturers and suppliers started developing and implementing entire production systems, in which all the above mentioned best practice methods are combined under one roof. Springer refers to these as so-called holistic production systems (Springer 2003:14). Thus for example, DaimlerChrylser (DCPS, DaimlerChrysler Production System), Opel

(QNPS, Quality Network Production System), ContinentalTeves (CTPS, Continental Teves Production System), and Volkswagen, have production systems.

At first glance, this development suggests, that each company has developed its own company-specific production system then. However, when comparing the contents of these various systems, it is evident that they are all derived from the TPS. According to Springer, differences in name tags of production systems suggest differences where in fact, non exist (Spinger 2003:15). He explains the similarity of the various production systems with the reason that the principles and methods of lean production have to be adapted to the particular organisational circumstances and context in order to be accepted (ibid.). Obviously, standard methods and principles derived from the TPS, need a company-specific name label for management and staff to identify with.

To examine the similarity between the systems and to analyse their relation to the TPS, in the following I shall discuss two production systems in detail, first the Ford Production System, and then the Audi Production System.

Similarly to other automotive manufacturers, Ford gradually adapted TPS principles.

Commencing in 1980, Ford had been implementing particular elements of the four cornerstones of its production system. In the wake of the discussion Japanese production methods and quality during the 1980s, at Saarlouis, Ford had already experimented with job enrichment, job enlargement, quality circles and the integration of indirect functions such as quality control. During the 1990s, driven by the effect the MIT-study had on the automotive industry, Ford introduced lean management principles such as Just-in-time. It also developed the "Q101 award", one of the first quality awards developed by an automotive manufacturer for its suppliers and derived from the NASA's Failure Mode Effects Analysis (FMEA) model. Moreover, semi-autonomous group work became enshrined at Saarlouis in the formal factory agreement of 1991 (ibid.:43). This agreement formalises the responsibilities of groups for the achievement of corporate goals such as: fulfilling target production output, Total Productive Maintenance, Total Preventive Maintenance, Quality control, cleanliness and tidiness, assuring adequate material supply, adherence to work place safety regulations, improvement of working conditions and flexibility concerning working hours, tasks and rotation (ibid.).

The formalisation of the FPS occurred towards the end of the 1990s. It was driven by three key developments: the introduction the Ford 2000 programme the globalisation policy of Ford; second, the introduction of ISO 9000 certification systems; third, the growing reliance on suppliers as seen in the setting up of supplier parks such as the 220.000 qm sized supplier part at Saarlouis, where eleven first tier suppliers manufacture and supply their modules and parts just in time and just in sequence directly to the final assembly line (ibid.).

The Ford Production System was created to bring together all individual processes the company has under one roof. These Ford Production Processes are divided into seven categories ranging from Personnel Processes, to Industry, Material, and Material Handling Systems, Process Control, "FTPM (Ford Total Production Maintenance) ", Factory Technology and Quality Systems (ibid.).

Despite the difference in the terminology used, these processes are but variations of the key processes defined in the TPS.

A second example of a standard production system recently introduced is the Audi Production System (APS). Driven by its global expansion, Audi developed and introduced its production system in 1997 (Spanner-Ulmer 2000:59). According to Spanner-Ulmer the intention of the project was to create a holistic concept which would formalised the main production principles of Audi; comprehensive insofar as it is seen as a network of concepts related to production, interplant sturcutes, standardisation and organisation, with the human being at the centre of it. (ibid.). It contains similar TPS elements, as discussed in the case of Ford. However, the connections and causalities between its elements is far more stressed than at Ford.

Thus Audi envisages a close interlink between the nine key elements of its production system, which are: CIP, visual management, Teamwork Problem Solving Processes, Standardised Work, Material Handling Systems, Work Place Organisation, Quality processes, Total Production Maintenance (ibid.: 60). Rather than defining work organisation as function of group work, at Audi, an ergonomically sound and safe working environment, transparency, clearly defined processes, cleanliness and tidiness, quality improvement, to name a few, are attributed to an efficient material flow system. Of further importance in the Audi production system are flexibility concerning production schedules and purchasing (suppliers), and its global strategy, particularly the creation of lean hierarchies in green field plants and the management of the logistic processes, such as for example from and to the Audi TT assembly plant in the Györ/Hungary (ibid.:63-65).

The two examples pointed out above are representatives of the fact that TPS elements have become integrated into production systems of automotive manufacturers: be it the production systems of Opel/GM, VW, Skoda, Renault or Porsche, looking at the content of these production systems, they all contain similar key elements. Be it sub-systems, core elements, basic principles, tools: they cover a set of common production methods derived from the TPS: group/team work, standardisation, quality, just in time and continuous improvement (Jürgens 2002:9) and they represent highly formalised production systems (Jürgens 2002:slide 5).

Furthermore, the MTM in collaboration with REFA proposes the introduction of an all industry encompassing general standardised production system, the so-called holistic production system. It is based partly on this set of TPS standards which has crystallised but it also contains standards which have been already used and propagated in the REFA-methods (Fischer 2002).

The function of this MTM production system is identical to the function of production systems of the automotive industry that is to provide a framework, a system, a toolbox which contains the complete instruments needed in a production system (MTM 2002:2). The instruments it refers to are based on the same set of standards dissected from the TPS: "Work organisation, CIP, Process optimisation, JIT, Quality Management, Standardised work, Robust processes, Leadership/Management, Visual management and in addition health and safety, and environmental protection" (MTM 2002:5).

The variations between these various examples of production systems are twofold. For one, as seen in the case of Audi, they vary as to the degree of integration of methods into one overall system. According to Jürgens, whilst some systems stress the interrelation between its constituent elements, others stress the interrelatedness of its elements.

A second difference between the production systems concerns the issue of standardisation. Along Adler and Cole's argument, some companies stress the significance for organisational learning and the continuous improvement of processes, whereas the issue of standardisation in other production systems is less prominent or is even rejected (ibid.).

Apart from the inherent differences between the focus of their content, there are significant differences regarding how production systems are implemented and what function they play within the company. I shall discuss these aspects in detail with reference to the Chrysler Operating System (COS) and the Mercedes Benz Production System (MPS). Suffice at this stage to point out that the implementation of both the COS and the MPS is based on a top-down cascade system intended to ensure the knowledge management and identification ibid. To control the implementation process and also the continued application of the production system standards, Mercedes, for example specifically developed a production system audit.

In sum, the purpose of this chapter was to present the evolution of production systems in the automotive industry and the form and function of standardisation therein. There are three distinct models of production systems.

Incorporating Taylor's principles of scientific management, mass production represents the first production system because it integrates standards which until then had not been combined into one system of production organisation. Its key components are: technical and process standards, work standards and social standards. Ford extended the form and function of standards as he refined the system of jigs and gauges and introduced new technical standards of entire car components. He also extended standardisation to production processes which thus determined the work places and work content. Refining Taylor's *Principles of Scientific Management*, Ford deployed standards to regulate the sequence and timing of tasks. Thus Taylor's "one best method" approach became best practice in the automotive industry. Under Fordism, the forms and functions of standardisation extended to the social area. Through the inspections of the social department at Ford, living standards were checked and inspected. Worker had to adopt these standards in order to quality for the 5$ day wage.

The second major model of production systems which has evolved over time is the Toyota Production System (TPS). Although it originates from Ford's system of mass production it has introduced distinctly new forms and functions of standardisation. Thus standard operations and the kanban system represent information systems as they provide a medium in which information is transformed, transferred and transported. This process is driven by the continuous improvement process which "creates a powerful learning dynamic and enhances the problem-solving capabilities at the enterprise level" (Kenney and Florida 1988:132). The inclusion of the shop floor know-how and experience plays a key role in the constant refinement of standards (Shimizu 1999). Thus "the centrepiece of the Japanese approach is the recognition that creating new knowledge is not simply a matter of"processing" information. Rather, it depends on tapping the tacit and often highly subjective insights, intuitions, and hunches of individual employees and making those insights available for testing and use by the company as a whole" (Nonaka 1991:24), thus the workers' intellectual capacities are used for the goal of production (Dohse, Jürgens, Malsch 1985). This led Adler and Cole to go as far as considering standardisation as "essential precondition for learning" (ibid.) and they envisage that each worker and each work station represents a "centre of innovation" (ibid.). As the innovative ideas are directly incorporated into standards, workers are able to influence standards. By combining standardisation and the continuous improvement process, organisational learning takes place.

In contrast to the key role standardisation thus plays in the Toyota Production System, the reflective production system of Volvo at Uddevalla deliberately rejects the use of standards to regulate the work of the individual actor on the shop floor. Its intention is to create a human centred production system in which workers have the freedom to organise and perform their own work according to their individual skill level and their own methods of work.

Looking at the current situation in the automotive industry, the introduction of standardised production systems reflects a continuation of the introduction of lean production principles to Western automotive manufacturers with a specific orientation towards the Toyota Production System. This link is evident in the key elements these production systems contain: group work, standardisation, quality, Just-in-time and continuous improvement are core elements current production systems (in more or less the same form) contain. However, these standard production systems are not clones of the Toyota Production System, but differ with regard to the interrelation of their elements and the role standardisation plays.

This industry-wide trend of implementing one specific reference model is has, as mentioned above, been triggered by the MIT study, and the consultancy profession. The target has been the management. This raises the question as to the influence the unions have over the adoption of production systems?

Historically, unions supported standardisation, particularly standards regulating the protection of workers health, working conditions and their acquired rights. During Taylorism, on the one hand, time and motion standards served, that a specific efficiency level was achieved; on the other though, standards protected workers from the pressures existing on the shop floor, specifically from the threat of "speeding up". Conflicts concerning "speed-up" represent a classical cause for strikes in the labour relations in the USA and became subsequently regulated by collective wage agreements.

In Germany, time and motion studies became regulated in the collective bargaining agreements between employers and unions and are thus an issue of co-determination, right of union representatives to voice their opinion concerning company work policy). In order to prepare these union representatives for their role in this decision making process, they underwent the Industrial Engineering training as offered by the REFA and hence learned the methods and work practices of the Industrial Engineers at first hand. The intention to control the standard setting function of the Industrial Engineers (time and motion standards) by both employers and worker representatives, was particularly evident in the industrial nations in the West. Thus the influence of the Industrial Engineer to control and improve speed and standards at work gradually declined. Instead, standardisation, time and motion, and ergonomic standards and became key subject to the conflicts and negotiations between unions and employers. Thus during the 1980s, Industrial Engineering departments were restructured. The advent of lean production thus represented a welcome opportunity for deregulation.

Returning to the main research task, in the following I shall examine the evolution of production systems further by focusing on the specific case of the Mercedes-Benz Production System (MPS).

4 The case of the Mercedes Benz Production System

4.1 Introduction

The Mercedes Benz Production System (MPS) exemplifies one particular company-specific solution within the development and introduction of standard production systems currently witnessed in the automotive industry. The introduction of a unified, plant-wide production system resulted from the merger between Daimler-Benz and Chrysler in 1998. Looking at the diagram below, with their decision to implement a standard production system, the DaimlerChrysler concern- followed a number of competitors which either already had or were in the process of introducing company-specific production systems, too.

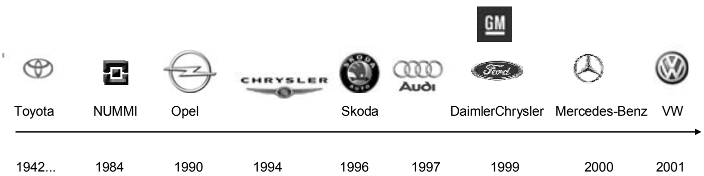

Fig. 4.1. Overview introduction of company-specific production systems. Adopted from Winnes (ed) 2002

At least since the oil crisis in the 1970s, the automotive industry had been aware of the efficiency of Japanese manufacturing techniques. With the formalisation of the TPS in the early 1980s and the joint-ventures of Toyota (primarily the New United Motor Manufacturing Inc., NUMMI joint venture with General Motors in the USA), the Toyota Production System gained wide-spread recognition as a company-specific production system. Although the lean production debate in the early 1990s had pointed out the need to improve production efficiency through the introduction of production systems, the time line shows that the wave of introducing company-specific production systems was set in motion only during the second half of the 1990s.

Created in 1999 and implemented since 2000, the MPS exemplifies one specific solution within this trend. The effort put in for the development of a company-wide production system for DaimlerChrysler, its structure, content and also its own audit system was extensive, thus suggesting that it will affect the evolution of automotive production systems to come.

Its roots go back to the merger between Daimler-Benz and Chrysler in 1998. Whereas at the time, a company-wide production system did not exist at the German manufacturer, since 1995/6, Chrysler had already begun to implement a production system: the Chrysler Operating System (Jürgens 1999:4). With the cut in development time for new models resulting in an intensification of outsourcing activities, quality had become a major concern for Chrysler during the early 1990s. To eliminate this problem, between 1992 - 94, Chrysler conducted extensive benchmark studies at Toyota. As one solution to the quality problems, the studies recommended the implementation of a production system modelled upon the Toyota Production System: subsequently the COS emerged in 1994. Its implementation commenced during 1995/96 (ibid.).

With the merger between Daimler-Benz and Chrysler, the issue arose to create a company-wide production system. Amongst other post-merger integration teams set up to identify the potential synergies of the merger, one team was issued the task to establish a roof under which both brand specific production systems, the Chrysler Operating System and the Mercedes-Benz Production System, could be integrated. As a result, the DaimlerChrysler Operating Model (DCOM) was created and ratified by the Board of Management in summer 1999. Thereupon, the Mercedes-Benz Production System (MPS), to be applied in all Mercedes-Benz passenger car plants world wide, was developed. It was modelled upon the DCOM. Involving both management and representatives of the works council, the contents of the DCOM were adapted to fit the particular production situation at Mercedes-Benz passenger car plants and to adapt the production system in accordance with individual factory agreements which exist between the works council and the management. The final draft of the MPS was ratified by the end of 1999 and its implementation commenced in January 2000 and is scheduled to last two years until December 2002. The MPS, together with the Mercedes-Benz Development System (MDS) which provides standards for the research and development activities, represents one of the major standardised systems used throughout the former Mercedes-Benz organisation.

4.2 Case study focus, approach and structure

The focus of the next two chapters is a case study of the MPS. I shall relate the three core aspects of this study to the specific case of the MPS: that is, to examine the form and function of standards within the MPS, particularly the nexus between the Toyota Production System and the MPS; the process of the institutionalisation of standards within one particular Mercedes-Benz plant; and the effect the implementation of the MPS has particularly in terms of learning and control on the actors on the shop floor. To do so, the first part of the case study presented in this chapter draws on documentary analysis, qualitative and quantitative empirical research findings generated during the formalisation and implementation phase of the MPS. I conducted this research primarily at the Mercedes Benz plant Untertürkheim, predominantly at one of its production centres (denote throughout the text as centre Z) and its three main production departments (denote throughout the text as departments/sub-centres A, B, C). In addition, the case study draws on research I conducted at the centralised departments of work policy at the DaimlerChrysler Headquarter in Möhringen and during internal international meetings and conferences. All information thus collected has been treated confidentially and where referred to, individuals, as well as products or individual centres, sub- or cost centres have been neutrally coded. As English is the main company language at DaimlerChrysler, most documents referred to and quoted in the following discussion are published in English (and also in German). It needs to be stressed that I cannot account for possible translation mistakes and linguistic inconsistencies contained therein.

Concerning the structure of the case study, I shall first focus on giving an entire process overview of the development of the MPS ranging from an account of the production organisation at Mercedes-Benz and Chrysler, to the development of the DaimlerChrysler Operating Model, the introduction and organisational support structures of the brand-specific MPS right up to its implementation and audit on the shop floor. In the latter part of this chapter I shall look in detail at the structure and content of the Mercedes Benz Production System, relating it to existing production methods, as issued by the REFA, the German Association for Work Design / Work Structure, Industrial Organisation and Corporate Development and comparing it to the Toyota Production System.

The next chapter draws exclusively on quantitative findings of two surveys I conducted and thus focuses on the question concerning the impact the introduction of the MPS has on the work of actors on the shop floor, particularly in terms of learning and control.

4.3 Case study background

Before starting this presentation, presuming that the reader is not acquainted with the organisational and hierarchical structure of Mercedes-Benz plants, it is first necessary to give some basic facts about the plant Untertürkheim. Covering a total plant area of 2.025.000 qm of which 797.400 qm is purely for production, the plant Untertürkheim has a total workforce of 20.758 (DaimlerChrysler 2002). The plant is a so-called power-train plant, manufacturing axles, engines and transmissions for all Mercedes-Benz passenger cars.[1] These are produced in production centres which are decentrally organised. Each production centre in turn is divided into different production departments, called sub-centres. On the shop floor each, sub-centre is divided into cost centres. The following diagram visualises this organisational structure:

[1] The plant also includes a grey cast iron foundry, a light alloy foundry and a forge.

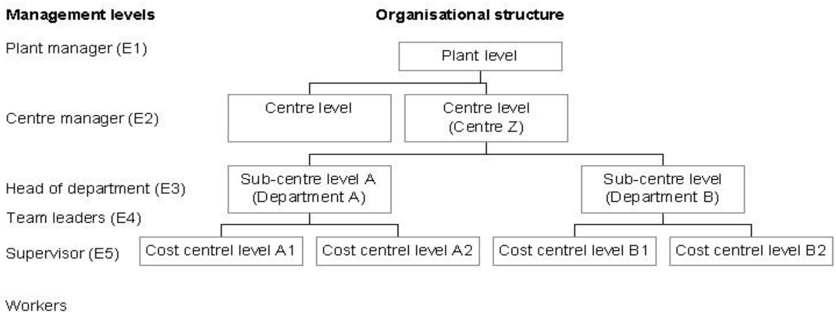

Fig. 4.2. The organisational structure and corresponding management levels of the DaimlerChrysler plant Untertürkheim

The plant is headed, by the plant manager (level 1, E1), the production centres are managed by centre managers (level 2, E2) and sub-centres are led by department managers (level 3, E3), these are supported by team leaders (level 4, E4) who are responsible for specific cost centres in the production and their supervisors (level 5, E5).[2]

After this general introduction to Mercedes-Benz plant Untertürkheim, I shall start with the case study about the MPS which is divided into three parts. Setting the scene for the creation of the MPS, in the first part I will give a brief historical overview of the production organisation at Mercedes-Benz and Chrysler prior to the merger in 1998, and the post-merger process which first led to the creation of the DaimlerChrysler Operating System and subsequently, the brand-specific Mercedes-Benz Production System. From an institutional perspective, I shall examine the role, the project team responsible for writing the DaimlerChrysler Production System, had in this process and the subsequent institutionalisation of the MPS throughout the DaimlerChrysler plant Untertürkheim.

The second part of this chapter relates the institutionalist perspective to the process of implementing the MPS. I shall focus on examining what processes are used to institutionalise the MPS (cascade training), the role organisational units play within this process (organisational structures), and the function audits have as control tools in this process (the MPS audit).

In the third part, I shall then focus on the MPS specifically: on its content, structure and the implications that can be drawn about the role of standards therein. Adding a comparative approach, I shall first compare the MPS with the REFA methods, establishing differences in the directions they point at.

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[2] The titles E1 - E5 are commonly used throughout the production plant organisation of DaimlerChrysler, however variations as to the function and responsibility exist, particularly when comparing plant management levels and the equivalent management level at headquarters.

One focus of the discussion so far has been the extent to which the TPS has evolved as dominant model for production systems in the automotive industry. I shall extend this examination to the specific case of the MPS by comparing it with the TPS.

4.4 Pre-merger production organisation at Mercedes-Benz

During the period leading up to the merger, Daimler-Benz did not have one company-specific production system. Although since 1995, individual plants had started to introduce plant-specific production systems, these attempts were rather sporadic, isolated solution which differed considerably between plants (Stühmeier and Stauch 2002:95). Thus, the closest to any standardised regulations used were plant-specific factory agreements and plant-wide statutory regulations of factory work.

In the mid 1980s positive sales forecasts led to the decision to set up new plants, such as for example, the Mercedes-Benz plant in Rastatt. As a greenfield plant, both employer and employees wanted to use the new plant to introduce new working structures (Fischer, Zinnert and Streeb 1996:47). At the time, the previously predominant view of the high-tech fully automated factory lost its vigor (Bahnmüller 1996:12) and the soft factors of corporate and social organisation gained momentum. The focus now was on the intention to use the innovation, motivation and skills of staff more efficiently (ibid.:13).

The connection between union representatives of Mercedes-Benz and Volvo Uddevalla which had been established since the introduction of the reflective production system in Sweden, influenced the planning of Rastatt I. According to Jürgens, "the planning for the Rastatt plant was modelled after the Swedish example, especially the Uddevalla plant" (Jürgens 1995a:305). Attempting to transfer the experience of their colleagues in Sweden, the German union representatives proposed to abandon the assembly line concept at Rastatt and to restructure work based on autonomous working teams (Fischer, Zinnert, Streeb 1996:48ff.). However, management was adamantly against such dramatic changes and instead agreed to selectively adapt Uddevalla methods. As a result, "a complex process layout was developed based on the principles of modular production" (Jürgens 1995b:208). For example, the interior trim or wiring harness installation operations which were primarily affected by model-mix variations, were transformed into stationary work places with individual work cycles ranging between 70 up to 120 minutes (ibid.). Deploying moving assembly line platforms, other trim operations with work cycles between 20 to 25 minutes were integrated into the modified moving assembly line. The similarity between Rastatt and Uddevalla is evident as in parallel, small groups of eight to ten workers assembled cable harnesses and cables in around 20 minutes per car. The cars were transported to and fro by radio controlled vehicles. Workers were able to set their own cycle time by pressing release buttons for the next car. The individual groups were not only responsible for the complete assembly task in their sector but also for the related pre-assembly and material commissioning within their working area. In this specific area of the plant, the moving assembly line was actually abolished thus realising working structures closely related to Uddevalla (Fischer, K.H., Zinnert, U., Streeb, G., 1996:48). Furthermore, group work was introduced "as a universal principle at Rastatt" (Jürgens 1995a:304).

Despite the introduction of these human-centred production principles of the Uddevalla production system, the production system at Rastatt failed to incorporate two of the core innovations of the Swedish plant (Jürgens 1995b:208): it did not fully abolish the assembly line and the competence of small teams of workers to build complete cars was not realised. Moreover, a formalisation of the selectively adapted Uddevalla principles into a written, company-specific Rastatt production system did not take place.

In 1992, when the decision was made to build the new A-class at Rastatt II, the product and production schedule called for the reorganisation of both, the assembly layout and work organisation. In 1995, the formerly decoupled assembly box/team layout was abandoned and the full assembly line reintroduced. The long working cycles were cut and the job enrichment through the inclusion of indirect tasks was reversed. Union representatives viewed these changes as a U-turn on the Uddevalla-type human centred production approach which had been using until then. As the human-centred, modular production approach was abandoned and instead the lean production based new assembly line system was introduced, the term "Rastatt Production System" was coined.

In 1997, the Mercedes-Benz plant Untertürkheim introduced ist production system Prosys. It preshadowed the introduction of the MPS, insofar as it was an attempt to write down work procedures and standards and to organise them under one umbrella term, and to call it production system.

Rather than providing a coherent set of standards regulating production at the plant Untertürkheim, Prosys consists of a loose collection of production process descriptions intended to help workers to understand eleven selected production themes such as for example, "Quality", "Labour management" and "Standardised processes and methods". Each theme is subdivided into different parts. The structure of the content of each theme follows a standard pattern which I shall exemplify by the arbitrarily selected Prosys-theme "Labour management". To give workers an understanding of what the theme is about, at first a general definition is given. In the case of the selected example, "labour management organises the relationship between workforce, machinery and organisation" (Prosys 1997, Labour management:1).

In a second step, to explain the purpose of the theme, a list of goals is given. Some of the goals of labour management listed are, "to improve and safeguard productivity and quality and to improve working conditions" (ibid.). In a third step, the constituent parts of the theme are listed. Labour management, for example comprises five components: "Teamwork, Continuous Improvement, Agreement on performance standards and targets, Organisation of working hours/operating times, and remuneration" (ibid.). In the wake of introducing group work on the shop floor, an agreement to reorganise compensation systems and to deregulate time management systems (REZEI) was introduced. According to this agreement, work performance based on piecework becomes part of the target agreement. Furthermore, an agreement with the works council to introduce the continuous improvement process (CIP) was ratified (alternative Zeitung deutsch-ausländischer MetallerInnen bei Daimler-Benz, September 1999, express 1/2000, Betriebsspiegel).

Whereas, the Prosys-themes represent general principles of work used in the plant Untertürkheim, the description of their components is in relation more detailed and more specifically targeted to provide practical examples for the worker to relate to. A key aspect of this presentation is to get the workers to understand the importance of these parts for their work. For the purpose of exemplifying this, I arbitrarily selected "Teamwork" as component of the Prosys-theme "Labour Management". The following quotes are taken from the official English translation of the Prosys and I cannot account for any translation mistakes included therein.

First, the team task is defined. It consists of "direct tasks regarding the product, indirect tasks, planning and organisation of tasks, and ongoing improvement (product, productivity, quality)" (ibid:4). These tasks are described more specifically, such as for example the task to "safeguard quality and productivity", "machinery care", "fulfilling production schedules", and "materials requisitioning" (ibid:5).

What follows after the listing of general team tasks, are other aspects of team work such as the team responsibility to organise its own training (ibid.:6), "rotation" (ibid.:7), "the selection of a team spokesperson" (ibid.:8), "the responsibilities of the team spokesperson" (ibid.:9), and the "function and guidelines of team meetings" (ibid.:10,11).

The level of description is kept very general throughout, and is suffices to give one or two example to see this. "Rotation" is only generally and very simplistically defined as "team members change their job in the team at specific times. The skills and know-how of each individual are taken into account…the team is responsible for ensuring that the flexibility acquired through training is preserved or extended" (ibid.:7). In a similarly general vein, the "responsibilities of the team spokesperson" are defined as "the team spokesperson, as representative of the team, is the appropriate contact for managers and other teams" (ibid.:9).

Conclusively, Prosys is targeted at the workers with the intention of defining in very general and simple terms, the major themes that are important for the production organisation in the plant Untertürkheim. These descriptions do not contain detailed standards regulating HOW to conduct the various steps, for example, how to check select the team speaker, how to perform job rotation in the team, and how to conduct team training. Instead, Prosys, represents a simple introductory document intended to educate the workers in the most basic organisational aspects which determine their work at the plant Untertürkheim. Although its title suggests that Prosys represents a production system, as stressed, it does not represent a complex integrated system of production standards, such as, for example the systems description of the Toyota Production System by Monden.

4.5 Pre-merger production organisation at Chrysler

At Chrysler the situation was different, as before its merger with Daimler Benz, the company had already established a formalised set of standards, the Chrysler Operating System (COS).

The reinvention of Chrysler at the end of the 1980s, resulted from a radical change in the product development process. This was primarily caused by the introduction of platform teams and subsequent shift in the degree of vertical integration, hence a greater reliance on external suppliers. According to Jürgens, in the mid 1990s, shortcomings of existing structures and processes became evident. (Jürgens 1999:3). Quality was one of these deficiencies of the system. Chrysler products scored low in the J.D. Power league and the inferior quality of Chrysler cars prevented the company to successfully enter the European market (ibid.). Driven by the urgency of these problems, and initiated and encouraged by Pawley (Vice President for Manufacturing), a Chrysler study group conducted a number of benchmark studies at Toyota in Japan. These studies were conducted in 1992/94. The bench mark results recommended the TPS as the most efficient production system and with Pawley as driving force behind this process, the COS was subsequently modelled upon the TPS (ibid.:4). In the following a brief overview of the structure and content of the COS is given in order to relate the impact of the TPS on the COS. The COS consists of three core elements:

1. Just-in-time delivery and buffer minimisation
2. Team organisation and responsibility for quality (pull chord/quality stop)
3. Error analysis/quality problem solving activities (ibid.).

In addition, the COS contains, for example, standards for operating procedures such as work instructions, standardised operation sheets, preventive maintenance standards and statistical process control (SPC) standards (ibid.).

Jürgens points out that the particular aspect of the COS it not its content but its approach (ibid.:5). This approach defines a standard sequence, the so-called "game plan", which sets out a cascade implementation process for the COS. According to Jürgens one core aspect is the slow approach reflecting that the necessity for change has to be understood and comprehended by all associates (ibid.). After management had been trained in the basic principles of the production system, the COS was gradually introduced stressing that staff should slowly learn to comprehend the importance of the COS standards for their particular work. Training took place in two ways. First, based on the cascade training format, superiors trained their staff in COS methods. Instead of drawing on the external expertise of consultants, learning thus took place inside Chrysler and actually on the shop floor.

In addition to the cascade training, active learning took place in so-called learning lines (Springer 2000:71). These were set up in the production plants for workers to experiment and experience the COS standards hands on through learning by doing (Jürgens 1999:6). The goal was to encourage workers to make process improvements inline thus optimising the production flow (ibid.). The aim of this constant improvement of standards was to improve production efficiency and product quality. This also meant that workers were encouraged to refine standards to find solutions for the most efficient use of both material and human resources. This shows that instead of perceiving standards as fixed and restrictive, the COS standards are considered flexible and in constant need of improvement.

Regarding the implementation schedule, the COS was not implemented in a company-wide roll out campaign. Instead, its implementation focused initially on three selected plants of Chrysler (Windsor/Ontario, Toledo/Ohio, Dayton/Ohio). Upon complete implementation, the COS was intended to be certified by the so-called COS Assurance, combining both quality assurance standards set out under QS 9000 and COS standards.

4.6 The DaimlerChrysler Operating Model

Upon the announcement of the merger between Daimler-Benz and Chrysler in May 1998, in each company two project units were set up with the purpose to support the integration of the two entities into the DaimlerChrysler concern. These two so-called "Post Merger Integration" (PMI) project units were merged in autumn 1998. Just to comprehend the extent of the project: under one roof, twelve topic coordinators are responsible for bringing together the 29 "Issue Resolution Teams" with 69 working teams to form in total 98 project teams working on 98 different topics (Appel und Hein 1998:189). The intention of these teams is to determine (both in quantitative and qualitative terms) the synergies to be exploited from the merger. The topics these teams focused on were, amongst others, the product development process, time-to-market, global strategies, and logistics. The development of a company-wide production system was also identified as one of the priorities of the post merger integration process. Affiliated to the topic "Volume Production, Cluster B", which was led by the heads of the respective passenger car divisions, Henson from the Chrysler side and Petri from the Daimler-Benz side (DaimlerChrysler - DCPS 2000:7), subsequently the "Post Merger Integration Team" (PMI-team) - Cluster B Operating Systems" was set up as part of these 98 teams.

In an interview I conducted with a former member of this team, it was pointed out that Chrysler had defined the topic Operating System as a Post Merger Integration Project (PMI) with the intention of driving home potential synergies. As pointed out above, Chrysler already had an operating system and in the context of the merger, the question now arose, as to whether Daimler had something similar and if the two systems could be merged into one. However, as already stated, Daimler did not have one standard operating system and was now somewhat in a tight spot. Moreover, this shows that the creation of the common operating system was driven by Chrysler and the company's positive experience with the COS.

Commencing its work in February 1999, the PMI-team was divided into five multi-functional teams responsible for the following 5 working areas: "Human Infrastructure, Standardisation, Quality Focus and Robust Processes and Products, Just-in-time, Continuous Improvement" (DCPS 2000:4). Each team drew on a body of experts from the departments of Change Management, Logistics, Human Resources, Planning, Work Policy, and the Chrysler Continuous Improvement Group (DaimlerChrysler - DCPS 2000:5). The goal of the PMI team was defined as to find the definition and description of one common DaimlerChrysler Productionsystem based on the Operating Principles Framework of Chrysler and the Mercedes-Benz Production System (which yet had not been defined) (ibid.:3).

The topics covered by the five working teams represent the so-called five subsystems of the DaimlerChrysler Operating Model. These elements are identical with the core elements of the Chrysler Operating System. Both production systems also share the same four goals: safety, quality, delivery, cost, moral/motivation. The obvious link between the Chrysler Operating Model and the DaimlerChrysler Operating Model is also evoked by the similarity of the two names. Interestingly though, the name DaimlerChrysler Operating Model was used only during the post merger integration phase. Thereafter, the name was changed to DaimlerChrysler Production System. This seemingly insignificant formal change in my opinion has nevertheless a several relevant implications.

The fact that the Chrysler Operating System had been modelled upon the TPS was a known fact within the automotive industry. Particularly for the German IG-Metal union, work councils and union representatives at Mercedes-Benz, the TPS was like a red rag for a bull. One key argument they raised was that the introduction of Toyota-based production system would result in a reduction of working cycles, job content, and an increase in repetitive work and physical and psychological strain: in short, a revival of Taylorism. As the COS had been modelled upon the TPS, to some extent it was also imbued with this image.

Although it is difficult to determine how far the problem of "image" played a role in the renaming of the DaimlerChrysler Operating Model to the DaimlerChrysler Production System and to what extent a deliberate strategy was pursued in this process, in my opinion though, there are nevertheless two possible causes which might have affected this change. For one, either the name was changed to signal that the two systems, the Chrysler Operating System and the DaimlerChrysler Production System are (at least by name) different. At least formally on the outset, this distinguished the two systems, thus appearing to give the DaimlerChrysler Production System a less "contagious" image; or, the name was changed to signal that, equally to Toyota, the newly emerged DaimlerChrysler corporation had its own company-specific production system.

After the PMI team had thus determined the five core sub-systems for the DaimlerChrysler Operating Model, the PMI team set forth to fill these five subsystems with best practice examples. From the outset the intention was to collect, evaluate and nominate best practice standards which would then feature as formalised de facto standards in a written, so-called best practice handbook intended to give to managers examples of effective and practical solutions and tools which would help to implement the DaimlerChrysler Productionsystem (DaimlerChrysler 2000b:3).

In my view, this step in the standard setting process implies a number of significant points which need to be addressed. By definition a bench mark represents a standard reference point and the purpose of conducting bench mark studies is to identify a list of potential standards which are then evaluated and compared upon a previously established list of criteria they have to fulfil. Thus, in the bench mark process, the bench mark team identifies best practice methods. In case of bench mark projects conducted by companies, upon completing the bench mark study, the bench mark team presents the results within the company. For example in case of conducting benchmark studies, say about the production of transmissions for passenger cars, the bench mark team reports back to the responsible production managers and his departmental heads (the latter are often members of the actual bench mark team). Once agreement is reached that the identified best practice methods represent an improvement on a current methods used, they are introduced.

Although the bench mark approach has evolved as a common practice within companies, it raises a number of issues. First, the problem is that there are an infinite number of solutions that need to be evaluated, yet the scope of the benchmark study has to be limited somehow and within a given time frame can evaluate a limited number of solutions only. Second, concerning the evaluation of methods, how in-depth should the examination and assessment of methods be?

In the case of the bench mark process to identify best practice methods that should be included in the DaimlerChrysler Operating Model, the time scale for the bench mark study was limited to six week period only. During this period a marathon tour of 18 international DaimlerChrysler plants was conducted with visits lasting a merely 3 - 4 hours.

Considering the significance of the task, after all the PMI-team was responsible for creating a production system for a multi-national company, with brands including, Mercedes-Benz, Chrysler, Jeep, Dodge and smart, commercial vehicles of Mercedes-Benz, Freightliner, Sterling, Western Star, Setra, Thomas Built Buses, Orion and American LaFrance, production locations in 37 countries world-wide and 372,500 staff, a time limit, which in my view, is far too short to justify the significance of this task (DaimlerChrysler 2002). By limiting the potential choice of best practice methods to the DaimlerChrysler concern alone, the methods identified do not represent best practice examples within the industry, but represent best-practice routines within DaimlerChrysler. Thus the potential of learning from methods external to DaimlerChrysler is not being tapped and instead an insular company-only focus is pursued. Moreover, best practice standards were selected according to the speed and effort needed for their implementation and the visibility of results. Thus best practice methods were selected which could be implemented quickly, with little effort and causing the most visible results.

As seen in Fujimoto's account (1997), the TPS did not emerge over night, but gradually grew and matured since the 1950s to the highly integrative system we know since the early 1980s. Compared to this time span of nearly half a century, the benchmark study conducted to define the DCOM content lasted merely four weeks, the entire DCOM project lasted merely five months (January 1999 to the official management approval of the DCPS in May 1999).

At the end of the bench mark study, the best practice methods were grouped into different categories. These categories represent the "Operating Principles" of the production system and in turn are grouped under the five key themes, the "Sub-systems." Thus the DaimlerChrysler Operating Model consists of three levels: 5 subsystems divided into 15 operating principles defined by 83 best practice methods, so-called tools (in the following interchangeably referred to as tools or methods)

For example, "Leadership", "Role Clarity" and "Work Group Organizational Structures" (amongst others) represent operating principles and are grouped together in the subsystem "Human Infrastructure". The operating principles "Production Smoothing", "Pull Production" and "Continuous Flow Processing", (amongst others) are grouped together in the subsystem "Just-in-time".

At the level of the tools, for example, "Policy Deployment", "Employee Feedback", "Employee Opinion Surveys", amongst others, are grouped under the operating principle "Leadership", which in turn is part of the subsystem "Human Infrastructure".

The introduction paragraph to the DCOM presents a model which visualises the connection between these seemingly fragmented parts and how they are integrated within the production system, as depicted in the visual below:

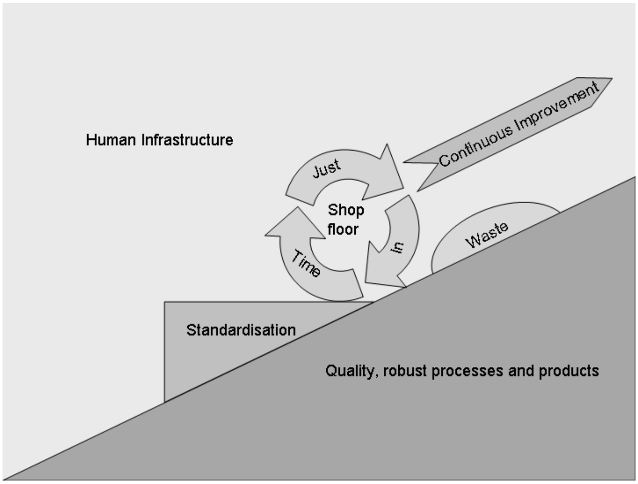

Fig. 4.3. The reference model of the DaimlerChrysler Operating Model

In this model, the link between the five subsystems is explained using the analogy of pulling a wheel (in this case represented by the subsystem Just-in-time) up a slope, a process which is aided by the remaining four subsystems. Unlike the complex systemic model of the TPS, presented by Monden, however this rather simplistic model of the DCOM fails to establish the interrelation of parts and structures and hence does not explain the systematic relation between the fragmented parts the DCOM contains. For example, the purpose of the five subsystems is explained in very general terms such as, "for the corporation to succeed in the world economy our processes must be continuously improved to higher levels of quality in both products and processes. To enable continuous improvement waste must be eliminated" (DCOM 1999:10).

Four months after starting the project, the PMI project team had finished its task and presented the description of all DCOM tools, operating principles and subsystems in a systems description/handbook called the "DaimlerChysler Operating Model" to management in May 1999. Its ratification at the general management meeting in Auburn Hills marked the end of the PMI project and the diagram below gives an overview of the link between the DCOM, COS and MPS.

Fig. 4.4. DaimlerChrysler Production Systems Overview

The first level consists of the DaimlerChrysler Operating Model. It serves as a roof, an *Überbau* for the already existing Chrysler Operating System (COS) and the Mercedes Benz Production System (MPS), which was created after the completion of the post-merger integration process.

Shown at the second level of the structure in the diagram, the COS and the MPS thus represent the brand-specific production systems of the two passenger car divisions of the concern, Chrysler and Mercedes-Benz.

Focusing on the latter, the third level is represented by the MPS as implemented at the plant level such as for instance the "MPS plant Untertürkheim" or the "MPS plant Sindelfingen". The differentiation between plants was conduced to reflect the differences between the type of plants and the respective MPS methods used. For example, MPS tools might be suitable for an assembly plant, like Sindelfingen, however they might not equally fit the power train plant Untertürkheim, an aspect I shall come back to when discussing the MPS in detail. Before doing so, an account of how the MPS was created is given.

4.7 The Mercedes-Benz Production System

The MPS is an adopted version of DCPS (as pointed out, after the merger, the name DaimlerChrysler Operating Model, DCOM was changed into DaimlerChrysler Production System, DCPS and shall be used henceforth). The major difference between the two production systems are issues concerning work policy. Whereas the PMI-team did not include union representatives, the team responsible for creation the MPS comprised both representatives of the central works council and specialists from the area of work policy. Thus, from the beginning, the reconciliation of existing factory agreements made with the respective works councils, with the DCPS was a major task and influenced the adaptation the DCPS content into the then prevailing conditions and organisation of work at Mercedes-Benz (Gerlach 2000).

This difference is also reflected by the fact that that the task of the post-merger team was to draft and write the DCPS, whereas the task of creating the MPS was primarily a process of negotiating a consensus between management and works council to accept and adopt the DCPS for the Mercedes-Benz passenger car brand. Interestingly, whereas the drafting and writing of the DCPS took five months, this negotiation phase lasted seven months (from June 1999 to December 1999) and, was marked by intense and long discussions. In interviews and during observations I conducted during this phase, management repeatedly acknowledged that in hindsight, it had been a mistake not to include the union representatives in the PMI-process, thus saving a lot of time and effort for the adoption of the DCPS later.

From the perspective of the works council, the DCPS was criticised for two reasons: one, it had been created under considerable time pressure, two, its American heritage was clearly visible (Gerlach 2000:4). The key issue, the representatives of the central works council pointed out was that a production system for the car plants of Mercedes_Benz has to take into account this particular context (ibid.). The fear was that through the MPS policies of work would be created not taking into consideration present structures (ibid.:5), thus eroding already existing plant agreements particularly concerning team work. The works council feared that by introducing formal standards regulating production procedures and processes, the principles of Taylor would be revived leading to shorter work cycles, a subsequent decrease in work content and a deskilling of the workforce. According to one works council member, the fear was that cycle times would be reduced resulting in a decrease in work content and the elimination of indirect tasks. This could lead to increasing physical strain and a decrease in the skills demanded (Gerlach 2000:5).

The task of the MPS-project team was thus to integrate already existing factory agreements concerning work structures with the standards set forth in the DCPS. To do so, the first step was to get the DCPS translated (the document had originally been written in English, the official concern language agreed upon after the merger). Whereas linguistic problems were overcome quickly, the key problem remained the issue of achieving an agreement with the representatives of the central works council to accept the content and to support the implementation of the MPS.

In December 1999 the agreement regarding the content had been reached and according to the works council all Mercedes-Benz plant agreements concerning work policy have been firmly anchored in the MPS and remain mandatory (ibid.). The accordance of the MPS with existing work policy agreements is formally enshrined in the preamble of the MPS "Systems Description" stating that "although our common DaimlerChrysler Operating Model will assist us in operating as one company, actual operating methods and procedures will still be influenced by local conditions, customs, and agreements in our manufacturing locations throughout the world" (DaimlerChrysler 1999:1). The final version of the MPS "Systems Description" which started to be implemented in January 2000 is structurally identical to the DCPS, with the difference that taking into account existing work policy agreements at Mercedes-Benz (such as for example work policy agreements between management and the works council on teamwork and training), the MPS contains in total 92 tools instead of 83 in the DCPS.

Apart from the reconciliation between MPS and factory agreements, a second problem arose during the creation process: the issue of how to account for the differences in operations of Mercedes-Benz plants, say between assembly and purely manufacturing plants. Some MPS tools, like "Quality Alert System/Quality Stop/Machine Stop" (Pull chord) are appropriate for an assembly plant but not suitable for a machining work dominated manufacturing environment. To account for the differences in production focus, the 90-10 rule was introduced. Of the 92 tools around 90% are plant independent, around ten tools reflect the plant or product specific considerations (legal and pay agreements) (Stühmeier and Stauch 2002:94). Thus plants are requested to implement a minimum of 90% of the MPS tools with the remaining 10% of tools depending on the particular production environment and plant specifications (assembly plant or production plant). This in a sense evokes a false sense of freedom of choice that plants have a choice to select 10% of the MPS content. Fact however is, on the grounds of their particular production focus and location, they may select and reject only 9 of a total of 92 MPS tools, but have no choice but to implement the remaining 83 tools.

4.7.1 The MPS organisation: central – plant and centre level structures

To give an overview of the different levels of MPS organisation, the diagram below shows that the organisation of the MPS is broken down into central, plant and centre level.

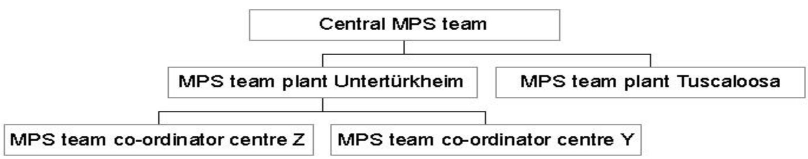

Fig. 4.5. Organisational levels of MPS organisation

4.7.2 The MPS: central organisation

The central MPS team, is responsible for the concern-wide implementation as well as the conceptional support and coordination between plants (Stühmeier and

Stauch 2002:97). They thus aid the progressive implementation of all 92 MPS tools.[3] As part of the planning department, the team is reporting directly to the Deputy board member, Passenger Car Division, Mercedes-Benz Passenger Cars , which reflects the top-down approach of the project stressing its importance (ibid.), a factor which, according to the authors has significantly contributed to the success of the implementation of the project (ibid.). This reporting structure thus reflects that the institutionalisation process of the MPS is driven by a central planning institution. As executive institution, the MPS central team functions as an extension of the authority and power of top management.

Regarding its composition, a group of eight members is responsible for the concept, the continuous evolution, and the controlling of MPS, a second group of five, so-called production system specialists, is responsible for training the MPS-trainers. The main task of this team is to prepare the MPS implementation, its co-ordination, support and controlling.

4.7.3 MPS: plant level organisation

Responsible for the implementation and the provision of expertise at the plant level, individual plant MPS project teams exist (ibid.). At the plant Untertürkheim for example, this is the plant MPS project team project.[4] It was initially headed by one of the PMI team members who was subsequently replaced by a member of the quality management department. At the beginning of the implementation phase the plant level MPS team consisted of three employees. Together with the central MPS team, it initiated so-called sub-projects supporting and aiding the implementation of MPS. The topics covered in the working-committees concern topics such as project steering, communication, methods, audits, committees, feedback and evaluation, qualification, interfaces planning and development, interface logistics, training of MPS specialists.

The work of the plant-level MPS team is supported by the so-called core-team and the MPS Trainers. Apart from representing the three main production centres (axles, engines and transmissions), the members of the core-team are drawn from the foundry, maintenance, logistics, personnel, quality and planning sections. The team also includes two representatives of the works council. The function of the team is to facilitate the flow and exchange of information between the centrally organised MPS team and the individual centres. Specialists provide additional know how and expertise regarding the background of the MPS Tools.

The MPS Center Co-ordinators are selected by each centre. They are functionally responsibility for co-ordinating and supporting the implementation of the MPS at centre level, and report directly to the MPS project leader; however, in terms of line function, the MPS Centre Coordinators are team leaders (level E4)

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[3] 25 MPS tools were implemented in 2000, 34 MPS tools were implemented in 2001 and the remaining 33 MPS tool were implemented by the end of 2002.

[4] Throughout the Mercedes-Benz concern, plants are numbered and "Werk 10"is the official abbreviation of the Untertürkheim plant.

and hence report directly to their head of department (level E3) at centre level. The tasks of the MPS centre co-ordinator are to represent (the interest of) their centre at meetings of the MPS core team at plant level, to provide general support for the central MPS project team, whilst at the same time ensuring a smooth flow between their respective centre to the central MPS project organisation. In addition, they prepare and chair MPS working groups at centre level, co-ordinate any MPS-related activities such as workshops and Cascade trainings. They are also responsible for supervising the work of the MPS trainers of their respective centre.

MPS trainers represent each of the three power train production centres plus the foundry. For every 1000 staff at each centre, one MPS trainer was selected from a pool of skilled workers or supervisors. This selection was conducted by the respective centre management in collaboration with the personnel department. Once selected, the trainers received a so-called MPS Intensive training which consisted of visiting the selected best practice plants of Mercedes-Benz. In addition, they received formal communication and MPS theory training. The MPS trainers are accountable to the MPS centre co-ordinator. They have a dual function insofar as they are expected to support the implementation process at the level of the shop floor and also contribute to the daily work of the MPS plant team. Based on my observations, this dual-role led to conflict between the MPS plant team and the production centres. The reasons being that MPS trainers were selected and are paid by the centre to aid the implementation of MPS at centre level. However, at the same time they were officially accountable to the manager of the MPS plant team. They therefore sat between two chairs being responsible to do their work at centre level, but also being accountable to the plant level MPS manager. This led to frictions between the MPS plant team and centres particularly as the former suffered staffing problems and initially deployed the MPS trainers to help them managing their own workload. At the same time, the MPS trainers were needed at the centre level, to perform their actual job, to inform staff about MPS and to facilitate the exchange of information between centre level and the MPS plant team.

4.7.4 The MPS: centre level organisation

The MPS implementation organisation at centre level is broken down into three levels: the MPS steering committee[5] at the management level, sub-projects at interdepartmental level, and working groups within each department.

[5] In practice, the name of the production centre is included in the title of this steering committee.

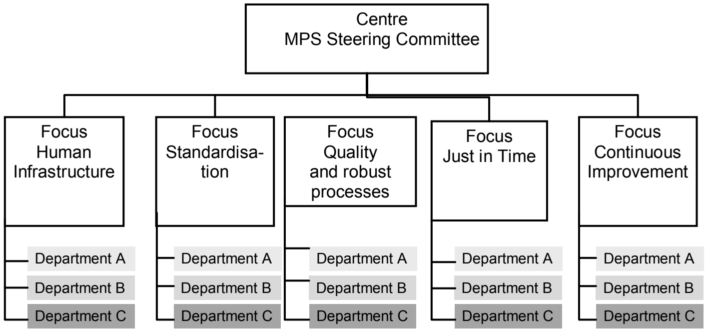


Fig 4.6. The MPS implementation organisation at centre level

The centre manager is responsible for the overall implementation of MPS at his centre. Regarding the organisational structure, the centre manager chairs the MPS centre level steering committee. The purpose of this committee is to discuss MPS standards and their appropriateness for its particular production context and it may suggest, alter or adapt standards to fit its particular production needs.

In accordance with the above noted 90-10 rule, if one particular MPS standard is considered inappropriate for the production context of one department or throughout the entire centre, the MPS centre steering committee may reject this MPS standard as inappropriate and instead departments may suggest a more suitable standard. For example, in one centre this has been the case during the MPS implementation phase concerning pull cords, included in the standards of the subsystem Quality Focus and Robust Processes and Products. Being a machining work, manufacturing focused centre, this standard which is primarily applicable for assembly plants, was rejected with reference that more production focused standards, such as for example, the in-built quality control checks in the actual machines are more appropriate for the production environment. As I shall discuss in detail in the section about the MPS-audit, part of the MPS controlling function of the MPS Centre steering committee is to receive feedback from the MPS auditors and to instigate actions upon the MPS audit recommendations issued.

In addition to this MPS steering committee there are project teams for each of the five MPS subsystem topics.[6] Each team is chaired by one member of staff specialised in the respective topic. For example, the group responsible for the MPS subsystem "Quality Focus and Robust Processes and Products" is chaired by the head of quality management. His function is of key importance as he is responsible for MPS implementation with the department and the actual MPS implementation on the shop floor (ibid.:98). At their departmental level, representatives of these teams together with supervisors, team leaders and heads of department, evaluate MPS standards according to feasibility, practicability and economic benefit on the shop floor. Thus standards are improved to fit the particular production

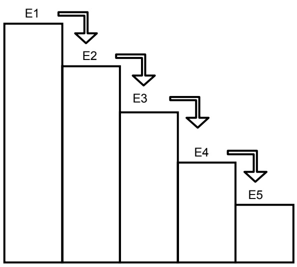
[6] "Human infrastructures", "Standardization", "Quality Focus and robust processes", "Just-in-time", and "Continuous improvement".

context. For example, the issue of standardised floor marking colours led to conflict between centres and the MPS organisation which arose because some centres already had marked their floors but each using different colours. Should floors be repainted ? If so, what colour ? Being drawn between the pressure to score high in the MPS audit on the one hand, and on the other not having clearly defined instructions by the plant MPS team and the planning department, departments and centres decided to interpret MPS standards according to how they best fit their present production situation. Instead of introducing new, costly visual for example, individual departments decided to update their present scoreboards, thus saving time and money.

I shall now turn towards the process of how the MPS was implemented at centre level. For this purpose I will give a brief account of the MPS cascade and recount some observations I made during training sessions at centre Z.

4.8 Implementing the MPS: the cascade training

Similarly to the COS, the implementation of the MPS was based on a cascade training concept. In the case of the plant Untertürkheim, cascade training commenced with the head of the plant (E1) "teaching" the production centre managers, they in turn "teach" their sub-centre managers (heads of department, E3), and so on.[7] The cascade training ended with the team leaders (E4) "teaching" the supervisors (E5).



E1 = Plant Managers, E2 = Centre Managers, E3 = Department Managers, E4 = Team leaders, E5 = Supervisors

Fig. 4.6. The MPS cascade training

The workers on the shop floor were not integrated in this cascade training process. During the allotted time for regular communications[8], selected, general informa-

[7] The Board of Management and the E1 managers also received an introduction about the MPS.

[8] "Regelkommunikation" means that a fixed time per week is alloted for groups to receive information from their immediate superiors. Information is thus filtered from top down.

tion about MPS was communicated to workers on the shop floor. For example, at first two pages consisting of comic pictures borrowed from the familiar Production System Untertürkheim (Prosys), were shown to workers to communicate what MPS actually is and why it is needed.

Training of the C–E4 levels was scheduled to last one day, the supervisors received a two day training. An initial self-evaluation aiming to evaluate what MPS tools are already being used was conducted by the supervisors during their training. After the initial cascade, the MPS is introduced gradually in three waves: in 2000, 25 tools were scheduled to be implemented, followed by 34 and 33 methods in 2001 and 2002 respectively.

Compared to the COS, the implementation of MPS was far more concerned with providing theoretical standards, rather than allowing workers to experience and experiment with MPS standards on the job. For example, during the cascade training all 92 MPS tools which are contained in the MPS "Systems Description" were individually read out and discussed, instead of examining their practical use on the shop floor. The criticism voiced by one supervisor was too much input in too little time. Taking part does not necessarily mean that the topics discussed are fully comprehended.

The stress on learning about the theoretical aspects of the MPS is also underscored by the fact that, apart from occasional workshops, no learning and experimenting facilities, such as learning lines were installed. Thus workers could not try out or experiment with standards but initially the MPS tool were implemented on the shop floor in accordance to their description in the MPS "Systems Description".

This approach differs significantly from the learning based approach, Chrysler used when implementing the COS. According to Jürgens, the COS was initially introduced in three plants only with the intention of realising success quickly and at an early stage and to then roll out the system to other plants (Jürgens 1999:6). Through learning lines, the COS was gradually introduced. The main focus was on hands-on training instead of "endless presentations" "(ibid.). With neither a gradual implementation approach, nor the use of learning lines, the implementation of the MPS resembled rather the latter, a process of "endless presentations". This is also confirmed when looking at cascade training process in detail. I attended three cascade training sessions (Cascade E3 - E4, heads of department "teaching" their team leaders) in the three major production departments (A, B, C) of production centre Z

Each superior reports to his staff about issues discussed during meetings with his fellow peer managers and his immediate boss. For example, if a supervisor meeting headed by the respective team leader takes place on Monday, the supervisor should pass on the relevant information from this meeting to his group during the regular communication scheduled during the week. In practice however, regular communication for the groups on the shop floor does not take place every week, but allocated times for regular communication are added up. Thus, for example, instead of conducting a 15 minute regular communication meeting every week, a 45 minute regular communication meeting takes place every three weeks.

The observations I made pointed out three significant issues concerning the cascade training: time allocation made available for training, the selection of MPS training material and the influence of the subjective opinion of those conducting the training.

Although the Cascade training at each level was fixed to last over a specific time (standardised duration of training), in practice the time spent for training differed considerably between groups. Of the three trainings I observed, the time spent for the cascade ranged between 6 hours and 2 hours. The reasons stated for devoting less time for the MPS training were that it was regarded more important to keep up with production schedule.

Concerning the content that was taught during the Cascade, a standard folder containing power point slides, and overhead transparencies had been supplied by the MPS plant team. In addition, a detailed training plan indicating, what to do, how, why and how long each activity should last, was provided. In practice, though, each presenter, did not use all the material supplied but pre-selected a number of slides. Thus neither the standardised cascade training content, nor the training plan were adhered to. If neither content nor training schedule is standardised, how can it be possible to ensure that staff and workers comprehend the importance of using standards? This doubt is also linked to the manner in which the cascade training content was presented. As noted already, despite having provided standardised MPS cascade training manuals and schedules, the subjective opinion about the MPS directly voiced or indirectly remarked by each presenter contributed significantly to the first impression staff received about the MPS. For instance, the critical opinion of one presenter escalated in a fierce debate as to the fundamental usefulness of standard routines in production. In another instance, the presenter related the contents of the MPS to specific examples from the shop floor in his department, thus showing how the descriptive content of the MPS can be applied in practice on the shop floor. This approach helped participants to understand and comprehend how MPS standards are applied and how useful they might be for their particular work.

The observations reflect that despite the attempt to use a standard format and content for the Cascade training, it is important how the content of the MPS is actually communicated.

This particularly applies to the teaching of supervisors in the cascade. They are responsible for communicating and implementing the MPS on the shop floor. It is their key function to convert the descriptive content of the "MPS System Description", into a practical context and they have to teach and convince workers of the usefulness and appropriateness of the MPS routines for their work. To support the work of the supervisors, the central MPS team organised a supervisor forums ' where delegations of supervisors from each Mercedes-Benz centre were invited to meet management at the DaimlerChrysler Conference Centre Lämmerbuckel, in January 2002. The purpose was to give supervisors the possibility to exchange their experiences with implementing the MPS on the shop floor and also to give them the opportunity to state what further support they need from the top management to help their tasks of implementing the MPS on the shop floor. For this purpose a survey was conducted before the conference asking supervisors in all centres to evaluate their experience with implementing the MPS. The question included for example, what do expect from your superior, the MPS support team and the works council concerning the implementation of the MPS in 2002? What positive/negative experiences have you made with the implementation of the MPS so far?' (Questionnaire: Sharing experiences, Supervisor Forum 2002). Amongst the positive aspects reported by the supervisors of Centre Z were that through the implementation of the MPS, workers on the shopfloor are more integrated into the organisation of work. In addition the pointed out that processes have become more transparent, for example through the application of the 5A tool “Sift, Sort, Sanitize, Sweep and Sustain”. The work place is cleaner, tidier and thus work can be done faster and more efficiently." (Evaluation Production Centre Z).However, supervisors also raised the point that the MPS is not yet lived and that description of the MPS-Tools were too vague and are not useful as guidelines. For many, the MPS is not part of their daily work (Evaluation Survey MPS 2002). As a result, supervisors called for more detailed descriptions which would clearly and precisely define processes. Supervisors were thus not only calling for more routines but also for more details and descriptions of these routines to be added to the MPS. In my view a highly important aspect, for it reflects that the worker on the shop floor needs precisely defined structures and routines. So far about the initial implementation process of the MPS. Regarding its completion, by the end of 2002 all MPS tools are to be implemented and the MPS plant teams will be replaced by a permanent centralised functional institution, the so-called MPS-office it will be responsible for the permanent support, consultation and further development of the MPS at the plant Untertürkheim. It will be staffed by members of the MPS plant team, headed by an E3 manager (level: head of department), and 4 MPS experts. Its main tasks will be to serve as a type of production system consulting agency, providing consulting services, MPS workshops and training, and will also be responsible for the MPS audit thus ensuring the MPS-conform design and optimisation of working systems, the assurance concerning the degree of implementation and the assessment that all MPS methods and standards are applied on the shop floor. (DaimlerChrysler 2000). Thus the key responsibility of the MPS-office is to control the adherence of implemented MPS standards throughout the plant. On the one hand, the centralised position of the MPS-office might help creating a more transparent organisation of standards facilitating interfaces between centres to check if there are better standards available, thus generally providing a platform encouraging organisational learning.

On the other, the decentralised profit-centres, such as centre Z, fear that by centralising the organisation of the MPS at plant level, their autonomy and their ability to adapt standards according to their particular needs might be somewhat curbed, particularly as they fear that henceforth the standardisation is driven by staff not familiar with the shop floor and production environment. An argument pointing towards the revival of a Taylorist division between planning and production activities. Moreover, this re-centralisation which would also limit the degree in which the experience and know how of workers is integrated into the continuous improvement process of standards as the freedom to improve and adapt standards at centre level will be increasingly influenced by the central MPS-office. It remains a matter of future research to establish the impact of the MPS-offices on the decentral organisation and the workers on the shop floor.

4.9 The MPS-audit

In chapter two I examined the function of audits as standard practice to provide for the independent "verification and evidence" (Power 1997:69). I drew a parallel between what Power has termed "audit explosion" with the current trend to introduce standardised production systems in the automotive industry. With the introduction of standardised production systems the need to control and check their correct implementation raises the need to develop standardised production system audits. In the case of the COS, this audit function is fulfilled by the COS Assurance, a certification system which contains all COS and QS-9000 criteria (Jürgens 1999:6); at Mercedes-Benz, an entire audit system for the MPS has been developed to control that the MPS tools are correctly implemented and used. Within this system, the central annual MPS-audit functions to identify, initiate and control preventative or corrective measures concerning the implementation of the MPS. (DaimlerChrysler 2000). Based on the structure of the VDA 6.1, the MPS audit specifically serves to assure that the MPS goals, delivery, safety, cost, quality and moral are achieved. The assumption being that these results are achieved once all 92 MPS methods are fully and correctly implemented.

The purpose of the following part is to give an account of the development of the MPS audit and the role of the auditors in the audit process. Based on empirical observations at the three sub-centres A, B, C , I shall then examine the audit process on the shop floor and point out a number of observed audit strategies actors developed and discuss the effectiveness of the MPS audit.

There are three types of audits conducted to control the progress of implementation and to check the adherence of MPS methods (Stühmeier and Stauch 2002:109): the "E3 audit" (E3 denoting the management level 3: Head of department), the self-audit and the annual MPS-audit.

The so-called "E3-Audit" is conducted by the head of the department (internally referred to as "E3") on the shop floor. One supervisor area and a number of methods to be audited are selected (random or non-random selection principles are applied) (ibid.). Basis of the audit are the same questions posed during the annual MPS-Audit. The intention of conducting audits at this level is to give the supervisors and teams direct feedback about how their superior rates their effort of implementing the MPS. However, the audit results are not exclusively used as information and feedback tool between management and staff within the departments. But in the case of the engine production centre, but also other centres, the results of these audits are presented in the centre meeting which is attended by all Departmentheads (ibid.). This transparency stresses that both the workers on the shop floor and management are responsible for implementing the MPS and are accountable for the results.

In addition to the results of the E3 audit, regular self-audits are conducted by workers on the shop floor. Similar to the E3 audit, for these self-audits the workers use the MPS-Audit questions of the annual MPS-Audit (ibid.:101). Teams of workers either audit their own working area or that of another team working in the same production area. During interviews I conducted on the shop floor, workers stated that they favour this self-audit method across teams for several reasons. The most obvious factor is that the degree of control is reduced as fellow workers conduct the audit and not superiors. Without the inherent threat underlying the inspection by superiors, the audit process is not perceived as control mechanism but as an opportunity for improvement. Workers are more willing to listen to the recommendations of their colleagues. They stated that for them, these self-audits across teams represent an opportunity to learn from and share the know-how and experience with their colleagues. A major factor contributing to this learning process is the fact that the audit is performed by "auditors", co-workers who are familiar with and are part of the production process and not superiors who might have the theoretical know-how but are not acquainted with the actual production processes on the shop floor.

Whereas the "E3-audit" and the self-audit are conducted regularly within production departments, the MPS-audit is conducted once a year throughout all plants of the Mercedes-Benz passenger car division. The reasons for establishing the MPS-audit were twofold: to control and check the correct implementation of MPS tools during the implementation phase and beyond it. First ideas for a MPS audit were presented at the MPS project management meeting in February 2000. The MPS audit content and process were determined in collaboration with plant audit experts (DaimlerChrysler 2000d:2).

A majority of the audit experts come from the area of quality management. This selection is not surprising because, as pointed out in the second chapter, audits have a long standing tradition in the field of quality management. Rather than developing own individual audit guidelines, the MPS-audit was modelled upon these already existing audit system used inside Mercedes-Benz but also throughout the automotive industry, notably that of VDA 6.1, which is the standard quality audit system used throughout the automotive industry (in Germany, but also acknowledged internationally).

Starting their work in early March 2000, a group of audit experts proposed so-called principles for the MPS audit prescribing three core points: standardised processes, openness and honesty of all participants, and a policy of non-accusation. In addition, the four corner stones of the MPS audit were defined clarifying: first, that the audit will check the degree and extent of the MPS implementation (ibid.:3); second, the audit method is analogous to that of VDA 6.1; third, during the implementation phase of the MPS, audits are conducted at intervals progressively auditing an increasing number of MPS tools; four, the first MPS audit should take place at the end of 2000.[9] Furthermore, the choice was offered to continue the MPS audit as either an individual MPS audit or as a combined audit in conjunction with the VDA 6.1 quality management audit. Regarding the com-

[9] This was later postponed until early February 2001.

bined audit, MPS is considered to be lead system for the audit (DaimlerChrysler 2000d:10).

The MPS-audit consists of a manual containing a set of audit questions. In this document the degrees of implementation of MPS methods are described Stühmeier and Stauch 2002:101). In accordance with the VDA-scoring system, implementation levels or degrees are rated on a scale from 0 to 20, analogue to the VDA-Audit Scoring System (ibid.).

The advantage of basing the MPS audit on the industry-wide institutionalised VDA 6.1 audit, is that the latter also represents a well-established audit and staff are already familiar with the type of audit questions and audit scoring system. Moreover, by adopting the VDA 6.1 audit system, the MPS audit receives a legitimate base and auditees are less likely to either doubt or question the usefulness and significance of the MPS audit and its results. The legitimate control function of a standard audit such as the VDA 6.1 represents within the automotive industry, is transferred upon the MPS audit. In practice, this similarity is confirmed, after the first year of implementation, centres may chose to conduct a so-called "combinded-audit" in which both VDA 6.1 and MPS audit are conducted simultaneously using one audit questionnaire (DaimlerChrysler 2000f:10). This combination has several advantages. For one, time and effort are saved by combining audits. However, as already noted above, the former focuses only on auditing quality management, whereas the latter is used to audit a production system. I doubt whether the quality-focused VDA 6.1 audit scope can account for the specific topics, such as Just-in-time management, the continuous improvement process and standardisation, as set out in the subsystems of the MPS. Whereas it might be useful to use the VDA audit questions to audit the MPS "Subsystem Quality Focus and Robust Processes and Products", it is difficult to envisage how the VDA audit questions can be used to audit the Mercedes-Benz company-specific appraisal system. Rather than integrating the MPS-audit into the annual VDA audit, in my view a MPS-specific audit has to be drawn up, in which appropriate VDA audit questions can be included but which also contains audit questions which are specifically targeted at evaluating the implementation of the MPS.

4.9.1 Auditors and the audit procedure

An audit team consists of 3 members: the "lead-auditor" - member of the Quality Management department of the plant to be audited, a co-auditor - MPS specialist from another plant (minimum qualification is the MPS short training), and audit observer(s) - the MPS specialist(s) of the plant to be audited (no direct audit function).[10] Each lead-auditor also receives special MPS and MPS audit training. The intention of this combination between an internal and an external auditor is to add to the objectivity of the audit, as the external auditor provides an external view. Auditors spend around 3 to 5 days in each production centre (including prepara-

[10] As is the case with the present study, if requested, auditors allow internal researchers to accompany the audit process.

tion and audit evaluation) and a total of 30 production centres and 92 E3 departments are to be audited.

In terms of total costs, 240 working days are needed (2 auditors[11] x 30 production centres x 4 days). Each team of 2 auditors will audit 2 production centres. The intention of focusing in detail on the specific production centres is that auditors get to know the specific production processes and the individual centre environment.

Concerning the comparability of results between production centres, because different MPS tools are selected in each production centre, a direct comparison between the MPS implementation levels across centres and between plants is not possible. Thus results as such cannot be compared. In practice though, there is an informal competition between centres and MPS results are compared as centre and plant MPS audit score ranking lists are drawn up.

Regarding the audit procedure, based on an arbitrary selection, in each centre, two production departments are drawn by the lead auditor and his co-auditor (i-bid.). With regards to the observations I conducted during the MPS-audit in spring 2000 in Centre Z, three production departments (A, B, C) were selected and three cost centres each were audited (A1,A2,A3, B1,B2,B3,C1,C2,C3). Next, a selection of MPS tools to be audited was made. The selection criteria are based on three objectives. First, MPS methods audited have to be clearly visible and tangible (ibid.). Second, they should contribute to the economic efficiency of DaimlerChrysler's production (ibid.). Third, they represent key measures which fulfil necessary preconditions for the implementation of other MPS tools (ibid.).

After the selection, the actual audit processes commences and auditees provide documentary or verbal evidence and the auditor rates the level of this evidence according to a nominal scale or a multiple choice set. During this process particular attention is placed on the collaboration of workers from the shop floor as well as the proof of the economic and qualitative improvement of processes and results (Stühmeier and Stauch 2002:109). Once all questions are thus rated, the auditor then looks at the overall feedback to the questions and then rates how and with what effect the MPS methods have been implemented (ibid.). Similarly to the VDA 6.1. audit, the auditor uses a scoring instrument to express his rating quantitatively. As pointed out above, the implementation level is evaluated according to a scale ranging from zero to 10 points (denoting zero percent of implementation, or no implementation, to one hundred percent of implementation, or full implementation). The auditors give a score of zero points for methods which are not implemented in accordance with the description of methods the MPS "Systems Description", six points are given for MPS methods which are in accordance with the "Systems Description" and have been implemented area-wide", ten points are given for the successful, complete implementation of methods in accordance with the "Systems Description" (DaimlerChrysler, 2000).

[11] Note, that the third auditor, the audit observer does have a direct auditing function and merely accompanies the auditors, and hence is not included in this calculation.

4.9.2 MPS-audit observations

Based on my observations during the MPS-audit in 2000, the audit structure followed the already existing VDA 6.1 audit procedure. In the first step, the auditors collected evidence by sighting through documents and conducting interviews with staff. For this purpose team leaders, supervisors and group speakers were called upon to give documentary and verbal evidence. Following the sequence of questions presented on the audit sheet, the auditors primarily asked supervisors and group speakers to give evidence as to how the particular MPS method had been implemented at the cost centre. During this audit stage, I observed that auditees pursued two distinct tactics. The first was the "overshowering tactic". As I observed, this approach was used across the board by group speaker and team leaders alike. Without being directly asked for, the auditees presented numerous documents, folders and presentation material documenting their MPS implementation activities. This created the impression of having done more than expected to implement MPS. This tactic worked because auditors "rewarded" high audit scores.

Using the second tactic, the "kinship tactic", a group leader responsible for quality management at the selected department, a colleague of the auditors then, presented the documentary evidence. The auditee and auditors thus shared the same expert "language" and professional background. Also, the auditors seemed more likely to trust one of their own colleagues rather than someone from a different department or a person of a lower hierarchical level, say a skilled worker. This strategy, too, worked as auditors gave high audit marks.

Generalising from these two tactics I observed in the audit process, auditees adapt their behaviour strategically in response to the audit process. This raises the question about the neutrality and objectiveness of the auditor and the extent to which auditees can use the audit as a playing field for the interest of their departments.

After collecting the documentary evidence, the auditors continue the audit by examining to what extent the MPS tools have been put into practice on the shop floor. With their MPS audit-lists they go through production, physically checking the implementation. For example, this goes as far as inspecting drawers to see if screwdrivers and other tools had been properly and orderly stored. Auditors also asked workers to explain how they had implemented (or why they had failed to implement) the MPS methods to be audited. Concluding their audit, the auditors presented their findings and the department audit result to the team leaders, supervisors and group speakers of the audited department, giving indications about any shortcomings and necessary improvements.

In the case of Centre Z, in spring 2000, the auditors thus audited three cost centres at three production departments. Upon completing all audits in these cost centres, the auditors presented their final results to the MPS steering committee, chaired by the centre manager. This report contains a summary and comparison of all audit results. Although, as I pointed out, a direct comparison of audit results between centres and plants cannot be conducted as different MPS tools had been audited, in this presentation the auditors nevertheless did so, thus comparing "Apples with Oranges". For example, the audit result of Centre Z was compared to the results of other Centres and the average MPS audit results of the plant Untertürkheim was compared to the results of the plants Sindelfingen or Rastatt. In my view a rather inappropriate comparison, not only because these results were not based on the evaluation of the same set of MPS methods, but also because each centre and plant has its particular production conditions, culture and environment, its specific products, production levels and programmes which have to be taken into consideration.

One part of this final presentation also outlined the difference between the MPS-audit result and the results of the self-evaluation which had been conducted previously.

Prior to the MPS-audit in 2000, all cost centres at Centre Z were requested to conduct a self-evaluation audit. Conducted primarily by supervisors and supported by team leaders, based on the MPS-audit questions, this self-evaluation was intended to give an indication of how far MPS tools had been implemented. Interestingly, the variations between the results of the initial self-evaluation and the MPS-results in some cost centres varied considerably. I examined these variations further and detected a distinct pattern. From this pattern, a distinct self-evaluation tactic in some cost centres can be deduced. To explain these in detail, below is a summery comparing the self-evaluation results with the MPS-audit results.

The table below summarises the results as follows: the average percentage ratings of these self-evaluations is presented in the first line below. The second line states the average percentage results of the actual MPS audit; the variation between the results is presented in the third line. The minus signals that the MPS audit result is lower (worse) than the self-evaluation, a plus signal that the MPS audit result is higher (better) than the self-evaluation.

Table 4.1. MPS audit evaluation department A (in %)

Selected cost centres of Department A	A-Average	A1	A2	A3
Average self-evaluation	48.9	53.3	46.7	46.7
Average A audit result	46.7	73.3	40.0	26.7
Average A deviation	-2.2	+20.0	-6.7	-20.0

Table 4.2. MPS audit evaluation department B (in %)

Selected cost centres of Department B	B-Average	B1	B2	B3
Average self-evaluation	55.0	75.0	40.0	50.0
Average B audit result	36.7	20.0	40.0	50.0
Average B deviation	-18.3	-55.0	0.0	0.0

Table 4.3. MPS audit evaluation department C (in %)

Selected cost centres of Department C	C-Average	C1	C2	C3
Average self-evaluation	43.3	40.0	55.0	35.0
Average C audit result	55.0	50.0	50.0	65.0
Average C deviation	-11.7	-10.0	5.0	-30.0

The results show three distinct cases: the results of the self evaluation are in line with the actual MPS audit results (A2,B2, B3, C2);[12] the MPS audit results are considerably lower than the initial self-evaluation (A3, B1); the MPS audit results are considerably higher than the initial self-evaluation (A1, C1, C3).

These latter two categories of cases are grouped in the table below.

Table 4.4. MPS audit results – overvalue strategy (in %)

Cost centre	Average	A3	B1
Overvalue strategy result	60.9	46.7	75.0
MPS audit result	23.4	26.7	20.0

Table 4.5. MPS audit results – undervalue strategy (in %)

Cost centre	Average	A1	C1	C3
Undervalue strategy result	42.8	53.3	40.0	35.0
MPS audit result	62.8	73.3	50.0	65.0

The two cost centres A3 and B1 which overvalued their implementation levels in the self-evaluation, achieved considerably lower MPS audit results. On average they rated their implementation levels at 60.9% the average MPS audit score they received was 23.4% and the overall average at Z was 40.3%. Regarding the overvalue approach there might be two possible future effects. The first effect might be that, the results of the MPS audit will force cost centres to readjust and realign their self-appraisal. The MPS audit will help departments to objectify the view of their MPS implementation efforts. Their efforts to implement MPS will be intensified. In the long run, this may lead to higher MPS audit results. The effect might be that the cost centre will question the appropriateness and effectiveness of the MPS audit. Rejecting the necessity and usefulness of the MPS audit, the cost centre will continue to implement MPS according to their own view, objectives and

[12] Self-evaluation results within a range of and up to 7% from the MPS-audit result are treated as being in line with the MPS-results.

needs. Future MPS audit results might be thus lower as the cost centre ultimately will doubt the usefulness of MPS as a system.

The three cost centres which undervalued their implementation level (A1,C1,C3) received higher MPS audit results. On average they rated their implementation levels at 42.8% the average MPS audit score they received was 62.8% and the overall average at Z was 40.3%. The undervalue strategy is exemplified by the result of cost centre A1, as self-evaluation levels showed a consistent under valuation of 20%. However, this is not an average overall trend within the department, as can be seen when comparing the results of the average self-evaluation marks and average audit results of the other two cost centre of A.

One possible future consequence of the undervalue approach is that the further MPS implementation efforts are considered less urgent because the auditor's opinion has proved to be less stringent than the self-evaluation of the cost centre. This could reduce motivation levels regarding the implementation of MPS and hence lower future MPS audit results.

But what are the reasons for these trends and their implication?

In my view, the significant deviation between MPS audit results and the self-evaluation can be explained by the following two self-evaluation tactics which the shop floor actors deployed:

In the first case, actors deliberately used very stringent self-evaluation measures thus undervaluing their MPS implementation efforts. The intention behind this tactic being that the actual MPS audit results will provide higher results and thus the cost centre would "look better" than assumed.

In the second case, actors overestimated their MPS implementation efforts considerably, thus the MPS-audit result was considerably lower than the self-evaluation result. If this was used as a deliberate tactic, the intentions behind it are somewhat difficult to comprehend. However when looking at the cost centres which did overrate their self-evaluation, two factors might have affected their evaluation. The first reason is that for a department producing the "cash cow", and running on a three-shift production schedule, it is difficult to take away manpower resources from the production process to conduct self-evaluations for the MPS-audit. The priority is on keeping the processes running not on conducting seemingly unproductive paperwork exercises, so the reasoning reflected in interviews I conducted there: "Why bother with this exercise, when the MPS-audit will audit the processes anyway ?" Instead of wasting time and effort on this self-evaluation it is more important to keep up with the tight production schedule.

A second reasoning behind these high self-evaluation results is that particularly in department A, the opinion prevails that the MPS does not necessarily introduce something new, and that this department had been the first to develop and implement standards which are now being implemented throughout the organisation as MPS tools. Thus the high self-evaluation of the MPS methods, reflecting that "we have practised these standards for a long time and the MPS is nothing new for us", a statement that has been voiced during interviews I conducted at department A and observations I collected whilst working on the shop floor there.

These observations show that despite the regulatory control underlying audits, actors adapt tactics to undermine this control aspect of audits. The influence actors hence have on the audit outcome is not restricted to the tactics of the auditees alone but even the supposedly "neutral" auditor, as pointed out above is not entirely subjective and particularly does not necessarily have the know-how and practical expertise to understand what he actually audits.

Although, as seen above, the auditor was selected on the basis of his experience with audits (notably quality management audits). The MPS audit requires a different, more general insight and understanding of the production environment and its processes and although auditors, during their specific MPS training, received information about these processes, their expertise does not cover the entire range of production issues. There is thus a discrepancy between the theoretical know-how of the author and his practical experience with issues concerning the shop floor. For example, in theory according to the principles of lean production, buffers between stations are considered inefficient. However, if two lines, due to difference in machinery and production complexity, run with a different cycle time, then a buffer between them is an inevitable result. During my observations, auditors failed to comprehend that what is ideal in theory is often impossible to actually implement in the real context of production. Furthermore, the auditors did not suggest improvements regarding the harmonisation of cycle times between the two lines, but merely concentrated on their task of giving audit scores. However, the role of the MPS-auditor, is not merely to collect information but to know about how the MPS tools and to some extent act as an external consultant helping to improve the implementation of the MPS on the shop floor.

The auditors remained pragmatic and restricted their task to collecting evidence and giving audit scores. This was also evident during the first part of the audit when documentary evidence was presented. Empirical observations suggest that upon hearing the necessary key-words contained in the descriptions on their MPS-audit sheets and gave scores. The following example elucidates on this point. The audit question in the MPS audit question catalogue asks if induction training for new workers covering work place safety issues takes place before they commence their work. A high score was given for an answer which included the words work place safety, at the beginning and before starting to work and auditors willingly ticked the question and continued with the next one.

Second, regarding the role of the auditees, the qualitative observations point at a link between the professional kinship between the auditee and the auditor, the seniority level and experience of the person providing the information and the audit result. For example, audit results based on information provided by a team leader responsible for quality management were higher than audit results based on the information provided by group speakers. During an interview conducted with one group speaker after the audit, the person admitted that he had never spoken in front of a larger group of mainly managers, with his superiors present. Faced with an unfamiliar situation and not well equipped with the communicative skills, this particular group speaker was unable to communicate the required information in a convincing manner. Moreover, he admitted that he felt pressurised during the audit as he feared he could not provide the correct information. This example affirms a link between how information is presented to the auditor and the audit result. Moreover, it points at the notion that workers associate the MPS audit with some form of test or check up of how well they perform their work in general. This was also evident, as frantic last minute improvements were conducted by workers. For example, notice boards were overloaded with information to show auditors that visualisation of figures is actually practised. However, auditors detected these last minute "beautifications" and criticised them for representing artificial facelifts, but not actual attempts at truthfully implementing MPS tools.

4.9.3 The effectiveness of audits: theory versus practice

The key function of the MPS audit is to ensure that the MPS is implemented in accordance with the "System Description" and that the MPS tools are thus applied correctly. The question though remains is if the MPS audit is actually successful in achieving this? In other words does the MPS merely represent a structural façade or is it actually lived on the shop floor ?

In the following part I shall present a number of observations I made on the shop floor which show that there is a difference between what the MPS "preaches" and how actors live the MPS on the shop floor. These findings certainly have to be seen in relative terms, however, they indicate that there is indeed a difference between the theory and practice of the MPS standards.

For instance, in theory, the MPS contains a standard which describes how workers ought to calculate the productivity level by using the machine productivity formula (K-Number). The MPS audit can check if workers in each shift use the sheets attached to each machine to fill in the K-Number. However, the MPS audit cannot establish how efficiently this is done. At centre Z, whilst working as a fully employed student worker on the shop floor, during my three week long field study in summer 2001, I witnessed instances where instead of using this standard calculation, a rough estimate was made, or the calculation was simply forgotten. Providing standards for calculating productivity does not necessarily mean they are correctly calculated. In my opinion, one reason for this discrepancy between setting standards and their practical application is linked to the issue of standardisation and control. By using one particular productivity formula throughout production, supervisors and management are able to compare the productivity in different areas. Supervisors regularly check machine productivity on the shop floor and issue a report to management. If, for example the figure indicates a decrease in productivity in one area, control measures, such as a closer observation of this working area by the supervisor and a regular report to management about this working area are taken. As the worker is considered to be responsible for the running of the machines, a decrease in the productivity figure is associated with his ability to maintain and control the machines. Productivity figures are therefore an indirect control tool signalling how efficient the worker is in maintaining the productivity of the machines which he is responsible for. This puts pressure on the worker and, as observed on the shop floor, workers often copy previous figures or make a "good estimate" about the productivity of their machines during the shift.

A similar discrepancy between the theoretical, formalised routines and actual shop floor practice is seen in the process of instructing novices. The MPS prescribes that the induction of new staff is to be performed according to a standard sequence described. The following description of the actual shop floor practice is based on my own observation whilst being inducted on the shop floor and shows that actors on the shop floor have their own rules. In the case of inducting novices, an experienced, usually older worker, will tell the novice how to perform the work. During this instruction, the experienced worker uses the four step REFA method and performs the sequence of tasks at first very slowly, pointing out what is important to consider and also providing additional tips on how to ease the work. The overriding principle is to focus on good quality. For this purpose, gauges are used to check that the parts are assembled correctly. In the next step, the novice performs the task slowly, the more experienced worker encourages the novice to verbally go through each step as he performs it. This adds to the mental retention of the assembly steps. Once the experienced worker is satisfied with the work of the novice, he continues with his own work. After a period of around half an hour, he returns to see how the novice is doing. He reiterates the main points and gives additional hints to improve the work. Once this phase is finished, the novice has to sign a form confirming that he has been inducted. In some cases he then receives a stamp with a number on, and subsequently has to mark all the parts he assembled. In case of quality problems, the number can be rooted back to the individual worker and to the location in the work flow where the error occurred.

During this induction process, reference to neither the MPS method "New Hire Orientation", nor "Standardised Work Instructions" was made, instead both the structure of the initial induction and its content is determined by the worker singled out to teach the novice. This shows that despite the existence of the MPS, the organisation of work on the shop floor is still being largely determined by commonly practised, informal shop floor routines.

4.10 The structure and content of the MPS

The MPS consists of three tiers: subsystems, operating principles, tools. As pointed out above, the five subsystems were derived from the COS and are broken down into operating principles. Both subsystems and operating principles are the same concern and world wide (Stühmeier and Stauch 2002:94). The subsystems represent the main themes in production, whereas the operating principles serve to differentiate between the different aspects of these themes. At the third level are the tools. They describe the main methods, the best practice routines used in the production organisation throughout the Mercedes-Benz passenger car plants. These three parts are described in the MPS "Systems Description". Overall, the MPS contains: 5 subsystems divided into 15 operating principles defined by 92 tools (as pointed out above, in the following the term tool and method are used interchangeably)

The structure visualising the subsystems and operating principles is shown in the table below.

Table 4.6. Overview MPS-structure: Sub-systems and Operating Principles

Human infrastructure	Standardisation	Quality Focus and Robust Processes and Products	Just-in-time	Continuous Improvement
Leadership (12 tools)	Standardised methods (8 tools)	Quick Issue Detection & Correction (8 tools)	Production Smoothing (2 tools)	Waste elimination (10 tools)
Role Clarity (3 tools)	Visual Techniques / 5S (2 tools)	Robust Processes / Products and preventive quality assurance (12 tools)	Pull Production (4 tools)	
Employee involvement and development (6 tools)		Customer Focus (internal & external) (4 tools)	Continuous Flow Processing (6 tools)	
Work Group Organisational Structure (9 tools)			Customer Demand Rate (2 tools)	
Safe work practices and environmental awareness (4 tools)				
34 tools	10 tools	24 tools	14 tools	10 tools

The MPS tools, represent the most detailed and specific level of the MPS and are ordered like legal paragraphs. For example, the 12 methods listed under the operating principle "Leadership" are listed as 1.1.1. to 1.1.12. This standardised system of numbering tools is used throughout the MPS:

- The first digit refers to the number of the subsystem
- The second digit refers to the number of operating principle
- The third digit refers to the number of the tool

The purpose of giving this detailed account is to show that MPS is set out like a toolbox consisting of a clearly identifiable set of tools. Thus, these methods can be identified and used to solve problems in one particular area. The clear structure of the MPS and the listing of MPS methods according to a set of paragraphs, this allows users to quickly get an overview of the topics and to find the necessary answers in the tools provided.

Interestingly, when comparing the number of tools with the number of operating principles listed, the subsystem "Human Infrastructure" with a total of 5 operating principles and 34 tools seems to receive particular attention. It is followed by the subsystem "Quality Focus and Robust Processes and Products" which consists of 3 operating principles" and 24 tools. On average, operating principles are defined by 6 tools. The fact that twice as many methods are listed in these two operating principles shows that they represent topics of the MPS which are considered particularly important. This overriding importance of the subsystems "Human infrastructure" and "Quality Focus and Robust Processes and Products" within the MPS link is also confirmed during interviews I conducted with heads of production, planning and quality departments.[13]

Similar to the structure of the COS, the MPS is based on a structure of seemingly independent parts. Remembering Monden's system overview, the Toyota Production System consists of a highly interrelated structure. Its starting point is "improvement activities in small groups" (Monden 1992:4) and from there develops a cause and effect chain driving towards the goal of the TPS: "profit increase under slow growing economy" (ibid.). The key to the TPS is to understand how these different parts of the causal chain, such as for example kanban and Just-in-time production are linked and affect each other. The importance is to understand that a production system is a system of interdependent parts. The MPS is not based on an interdependent structure and rather consists of a collection of independent sets of methods.

In the next step, I shall examine the content of the MPS tool. For this purpose I selected two types of tools contained in the MPS: "hard" tools, contained in the subsystem "Just-in-time" and "soft" tools, contained in the subsystem "Human Infrastructure".

4.10.1 The MPS tools

Below is an overview of all the operating principles and tools of the MPS:

[13] Semi-structured interviews conducted at one production centre at the plant Untertürkheim between December 1999 and May 2002.

1.1 Leadership
1.1.1 Policy deployment
1.1.2 Employee Feedback
1.1.3 Employee opinion surveys
1.1.4 Employee recognition
1.1.5. Appraisal system
1.1.6. Checklists and monitoring
1.1.7 Evaluation by management
1.1.8 Standardised communication channels
1.1.9 Team development activities
1.1.10 Management assessment system
1.1.11 Management development training
1.1.12 Attendance improvement program

1.2. Role and task clarity
1.2.1 Job descriptions
1.2.2 Process descriptions
1.2.3 New hire orientation

1.3 Employee involvement and development
1.3.1 On the job training
1.3.2 Performance standards
1.3.3 Suggestion system
1.3.4 Selection process to employ new team members
1.3.5. Shop floor training area
1.3.6 Continuous improvement implementation area

1.4. Work group organizational structure
1.4.1. Integration of tasks
1.4.2 Team leader
1.4.3 Team meetings
1.4.4 Integration of members with disabilities
1.4.5 Process for evaluation of team work
1.4.6 Team boards
1.4.7 Rotation
1.4.8 Training matrix

1.5. Safe work practices and environmental awareness
1.5.1. Health and safety regulations
1.5.2 Visual safety signs
1.5.3 Ergonomic evaluation of work processes
1.5.4 Refuse / Waste separation
1.5.5 Environmental awareness, activities and protection

2.1 Standardized methods and procedures
2.1.1 Standard work instructions (SWIs)
2.1.2 Standard work documentation
2.1.3 Standard work-in-process
2.1.4 Scoreboards
2.1.5 Shop floor measurement
2.1.6 Standard shift change procedure
2.1.7 Standardised equipment
2.1.8 Quality gates (MDS-Mercedes-Benz Development System)

2.2. Visual techniques / 5S
(Sift, Sort, Sanitize, Sweep, Sustain)
2.2.1 5S
2.2.2 Labelling, Marketing & Foot Printing

3.1 Quick issue detection and correction
3.1.1 Quality feedback loops on the shop floor
3.1.2 Root cause analysis
3.1.3 Boundary samples
3.1.4 Shop floor section audit
3.1.5 Quality alert system/Quality stop/machine stop
3.1.6 Quality alerts/production information boards
3.1.7 Production tests 1,2,3
3.1.8 Approval for series production

3.2 Robust processes &products and preventive quality assurance
3.2.1 Total productive maintenance (TPM)
3.2.2 Error proofing
3.2.3 Mistake proofing
3.2.4 SPC (Statistical process control)
3.2.5 Certification / audit
3.2.6 Process audit
3.2.7 Single point lesson
3.2.8 Problem solving process
3.2.9 Process FMEA (Failure Mode Effects Analysis)
3.2.10 Supplier quality management
3.2.11 Process assurance plan
3.2.12 Monitoring of test equipment/checking of measuring capability

3.3. Customer focus (internal and external)
3.3.1 Quality agreements
3.3.2 Quality/Zero defect gate in assembly
3.3.3 Customer quality measurement method
3.3.4 High level quality feedback loops

4.1. Production smoothing
4.1.1 Production planning schedule
4.1.2 String of pearls

4.2 Pull production
4.2.1 Material flow planning
4.2.2 Tugger transport with mixed loads
4.2.3 Withdrawal and fill up
4.2.3 Order cards (Kanban)

4.3 Continuous flow processes
4.3.1 Kitting
4.3.2 Quick set ups / die changes
4.3.3 Small lot containerisation
4.3.4 One piece flow
4.3.5 FIFO
4.3.6 Single stage stock strategy

4.4. Customer demand rate
4.4.1 Fixed takt time
4.4.2 Takt time / cycle time bar chart

5.1 Waste elimination
5.1.1 PDCA(Plan, Do, Check, Act)
5.1.2 7 Wastes
5.1.3 5 Whys
5.1.4 Process map
5.1.5 Staff CIP workshop
5.1.6 Expert CIP workshop
5.1.7 CIP workshops
5.1.8 Engineering change control
5.1.9 Practice sharing benchmark
5.1.10 Simultaneous engineering

Fig. 4.7. The MPS operating principles and the 92 tools

As part of the subsystem "Just-in-time", the operating principle "Continuous Flow Processes" contains six tools: Kitting, Quick Set-ups/Die-changes, Small Lot Containerization, One Piece Flow, First in First out (FIFO), Single Stage Stock Strategy.

The description of each tool is structured in three columns. The first column denotes the name of the tool defined, the second column describes the method, and the third column presents the benefits of using it. This structure provides a clear focus on presenting only the most essential information based on short, to-the-point, factual statements.

To assess how detailed the tools are described, in the following I shall exemplify this by examining in detail two of the above listed tools: "4.3.1. Kitting" representing a "hard" process routine and is listed in the operating principle "Continuous Flow Processes", and a "soft" process routine, "1.4.1 Integration of Tasks", listed in the operating principles "Work group organizational structure".

Kitting is described in note-form (a standard presentation structure used throughout the MPS) as:

> " - Filling one bin or container with the parts required to complete a work element or task
> Used with CMA (central material area) or "supermarket" located near the point of use.
> Used with tuggers, mixed load conveyance, for part conveyance
> Parts are kitted and sequenced according to broadcast (i.e. customer built sequence)
> One kit contains the material needed for one task
> Kitting may be group task
> System implementation must be compared with conventional delivery to line - must be more economical" (MPS 2000:77)

The benefits listed for using kitting as a standard procedure are: "delivers multiple parts for assembly in one container, reduces walk and reach for the operator and lineside floor space, improves visual control by avoiding excessive storage at the work station, allows for error proofing (i.e. only the correct parts for each job in the bin)" (ibid.).

These descriptions represent the most detailed level of description provided by the MPS. The first point to remark is to point out the obvious: the descriptions are kept at a quite general level. They give a basic description and do not specify details or regulations of HOW this standards is to be applied: is there a standard container to be used? How is the kitting to be grouped according to tasks? Overall, the description lacks detail. The same observation applies to the benefits which fail to give details. For example, in what way does kitting contribute to error proofing? and how does it improve visual control ? Overall, the descriptions of kitting as a standard promoted through the MPS, are rather general. To enhance this observation, I shall consider the example of a "soft" tool.

The "Integration of Tasks" within teams states that:

> "- the group is responsible for direct and indirect defined tasks (e.g maintenance, quality, time studies and parts replenishment)
> - indirect tasks are part of the in-group rotation system
> - indirect tasks are done by trained operators within the team" (ibid.:44).

The benefits listed for integrating tasks within the team are to "reduce overhead costs, to improve responsibility and involvement of employees, to promote employee development and to provide ergonomic relief" (ibid.).

As in the example above, these quotes show that the descriptions, the MPS contains are kept at a very general level. The definition does not specify the content of indirect tasks, for example, what tasks workers have to perform concerning quality control and assurance. Also, what qualifications are necessary for a trained operator. One key aspect raised in this description is the responsibility of the team to conduct time studies. This implies that the team uses stopwatches and has thus influence over time standards. However, no further details are given to specify the timing function of the team, such as for example observed by Adler and Cole at NUMMI.

These are literal quotes from the English Version of the MPS. Keeping in mind the intention of the MPS, to represent a production system for the Mercedes-Benz passenger car production, the arbitrarily selected examples show that the methods the MPS contains are all kept at a very general, descriptive level. This runs like a red threat through all descriptions contained in the MPS. They do not specify HOW standards are to be drawn up, what further details are needed and what particular steps should be undertaken.

By failing to give describe standards in-depth, the MPS standards in my opinion fail to provide regulatory control for production processes. They are far too general and indeed far too ambiguous to be considered as regulatory instruments. Indeed, the responsibility of defining standards in detail is, in some instances such as for example in "Tool 2.1.6 Standard Shift Change Procedure", is to be "defined locally" (ibid.). That is, the standard as framework is given, but its content, that is how this standard ought to be performed is defined locally, in other words, on the shop floor.

This reinforces and supports that "the nature of standards is not that they are fixed forever but enhanced continuously by improvements" (ibid.). Subjecting standards to the continuous improvement process, workers on the shop floor must contribute to the setting and refinement of standards. Thus the tacit knowledge of workers is tapped, integrated and spread throughout the organisation. Seen from this perspective, this encourages the inclusion of shop floor know-how and experience into production standards. This is a new approach because previously, workers were encouraged to make suggestions regarding the general improvement of their work and process; now, in addition to retaining the suggestion system, MPS encourages workers to focus on the improvement of production standards specifically. This development in a sense reflects that now workers potentially have greater control and autonomy over their work, a proposition, I will assess in detail in the following chapter. Before doing so, I shall however continue to analysis of the MPS by comparing it first to REFA-methods, and second to the Toyota Production System.

4.11 The Mercedes-Benz Production System and REFA-methods

The case of the MPS and the DCPS, shows the growing importance of company-internal standardised systems thus pointing out that, for example external standards such as issued by the REFA, the German Association for Work Design / Work Structure, Industrial Organisation and Corporate Development are seemingly no longer appropriate for the needs of their users. Thus, the REFA-methods are now being substituted by standardised production systems. In the following I shall point out some of the reasons for this shift and the implications it has, by comparing the REFA-methods with the standards set forth in the MPS. First, I shall give an outline of the role of the REFA and the REFA-methods for the automotive industry. In a second step I will compare the REFA methods and approach to that of the MPS.

REFA-methods are drawn up taking into consideration statements of representatives of industrial associations and industrial unions (REFA 1987 PS:6). They are thus based on a consensus between management and unions. Amongst other reasons, this is a key factor why traditionally REFA-methods have been adopted across all industries. Considering that the REFA is rooted in the tradition of Taylorist Industrial Engineering (REFA 1984:25 MLA), it is interesting to see that nevertheless both management and unions agree on both the training content and use of REFA-methods.

The REFA not only issues methods, but with the REFA-training has developed its own training system for workers, supervisors and engineers alike. The REFA-training system and its qualifications are officially accepted by the industry and employers. According to the respective skill level, the REFA training caters for the needs of skilled workers and graduates alike (ibid.). The training, based on a modular system leads to industry-wide accepted REFA-qualifications. For example, the so-called REFA-basic qualification (the basic degree), the next higher step, the REFA-administrator, consists of two courses in "working systems and process design", and "process data management". The former stretches over 120 hours (15 days), the latter over a training period of 140 hours. The target group consists of skilled workers, craftsmen and union representatives. The purpose of this basic training to enable participants to analyse work and factory processes methodologically thus creating structures which are efficient as well as adequate for the human beings working therein (ibid.) To do so the courses cover an extensive range of topics such as the history of work studies rooted in the principles of Taylor's scientific management, the basic principles underlying the organisation of companies, components of the work system, work place ergonomics, the role of motivation for work and group work in production, and the legal context of work such as for example labour law.

Compared to the brief cascade training sessions used to teach staff about the MPS, the REFA training thus provides a far more sophisticated grounding in the principles of work organisation. The REFA methods cover a range of themes. What is generally referred to as so-called "REFA-Methods", consist of a set of principles regulating work which are published in a series of books under the umbrella term REFA-method training. To give an indication of its extent, the table below gives an overview of the main REFA-publications (excluding the updates of the original publication date).

Table 4.7. Overview REFA-publications

Methodology of work organisation	Methodology of Planning and Controlling	Methodology of Business Organisation (MLB)
Fundamentals, 1971	Fundamentals, 1974	Planning and Design of complex Production Systems, 1981
Data processing, 1971	Planning, 1974	Work pedagogic, 1981
Cost accounting, Work place design, 1971 Personnel calculation and grading, 1972 Remuneration differentiation, 1974 Induction and training, 1975	Controlling, 1974	Fundamentals of work place design, 1991 Work place design in production, 1991 Work place design in the administration, 1991 Remuneration differentiation, 1991 Data Processing, 1991 Personnel calculation, 1991 Corporate structures, 1992
		Processes in the administrative sector , 1992 Corporate Statistics, 1992

These publications are divided into three series of which the REFA Methodology of work organisation, the REFA Methodology of Planning and controlling, provide a general framework of methods underlying work, the third series, the REFA Methodology of Business Organisation is the result of the further development of the already existing spectrum of methods. It serves to provide standards for the planning, design and controlling of work systems (REFA 1984:73) It represents the basic level of the traditional REFA qualification and is the result of a collaboration of scientists and researchers from the fields of work policy, business administration, experts from the practical field and is approved of by both sides of the industry. (REFA Ausbildung 2002:1).

This overview shows that since the 1970s, REFA has not exclusively been preoccupied with setting work place design standards. As seen in the third column, these standards have been updated and adopted to the particular context of production in the 1990s (for example Work Place Design In Production, 1991). Since the 1980s, the REFA has also issued standards for the planning and creation of production systems (as seen in the publication planning and design of complex production systems, 1981). In the following, I shall compare this REFA approach with the MPS.

The REFA acknowledges the importance to create work structures capable of combining economic considerations with human needs. Thus work structures should serve to improve the efficiency of the corporation at the same time though should be attractive for associates thus increasing work place satisfaction levels (REFA 1991a:201). For the organisation of work it thus proposes four standard principles: job enlargement, job enrichment, job rotation, group work/team organisation (ibid.:203).

The REFA also proposes the use of longer cycle times which could contribute to higher levels of job satisfaction (ibid.:367). Indeed, the REFA goes as far as suggesting the introduction of holistic tasks which in addition to direct tasks could include planning and (quality) testing tasks. For example, workers could assemble complete sets of components (ibid.).

In addition to principles calling for longer cycle times, the REFA also suggests the use of buffers to decouple work in the assembly into sub-lines (REFA 1987a:34). These buffers should be placed between work stations thus facilitating the decoupling of adjacent work stations from the cycle time (ibid.:35). The decoupling effects according to REFA leads to a situation in which workers no longer have to work in set cycles and thus potential standstills in one station affect the work flow of to the next station to a lesser degree (as buffers can be used to even out such production fluctuations.(ibid.). This is in direct contrast to the MPS Just-in-time tools which prescribes that production ought to be based on a pull system using the principle of one-piece flow and zero-buffer. Moreover, the "7 Wastes" lists unnecessarily high inventory levels among the seven types of waste the MPS aims to eliminate. This example shows that REFA methods were influenced by the German programme the Humanisation of Work (REFA 1991:201) concepts,[14] whereas the MPS is far more imbued in the notion of "lean thinking".

The influence of a human-centred production approach on the REFA methods is also reflected as the REFA supports the use of teamwork as part of the structure of work. It proposes principles of group work, such as for example: clearly defined and related tasks within groups, relative group autonomy concerning the organisation of work within the given process, training opportunities within teams and job rotation within the team (REFA 1991a:210). According to REFA, the advantage of team work is that the degree of outside control is decreased. This could potentially lead to higher levels of job satisfaction (ibid.). However, REFA does not envisage team work to represent the best solution but concedes that group work cannot be imposed as part of the structure of work for all workers, as not all

[14] The human-centred approach of these REFA methods of work organisation has been influenced by the German programme for the Humanisation of Work ("Zur Humanisierung der Arbeit") (REFA 1991:201) but some aspects are also reminiscent of the reflective production system at Volvo Uddevalla. To investigate this link, I conducted several interviews with REFA experts. It was pointed out that Swedish concepts had been discussed by the REFA, amongst others in context with presentations of Pornschlegel. However, the Swedish concepts influenced the REFA methods only marginally and were not formally integrated into the REFA methods.

associates are able and willing to take on the responsibility of working independently as a member of the team (ibid.).

Similarly to the REFA, the MPS includes an entire operating principle concerned with providing methods of group work, as seen above. The key aspects of group work according to the MPS are similar to the REFA-principles above, proposing for example: "common group tasks within the group, semi-autonomous and self-directed work teams, self training responsibilities, self directed rotation, and scheduled group meetings lead by representative of each group" (MPS 2000:43)

The REFA methods provide far more detail than the description of the MPS tools. One reason for this is that REFA methods are intended for training purposes. Also, REFA methods cover a far greater scope of issues. They range, for example from methods regulating health and workplace safety (REFA 1991a:223f.), formulae to measure work intensity (REFA 1971a:174) to tables relating the height of the worker with the operational position at the machine (ibid.:199), the angles of levers, etc. Although in the operating principle "Safe Work Practices and Environmental Awareness", the MPS lists ergonomics as one particular tool, it does not provide standards as comprehensive and detailed as the REFA-methods.

Despite the consensus based REFA-methods drawing on the support of both management and unions, its training system and its in-depth account and integration of standards, the REFA-methods no longer take the unchallenged position they once occupied. Instead, as pointed out above, standards developed by companies substitute REFA-methods. A view confirmed in an interview I conducted in which one REFA representative stated that the number of workers and supervisors trained in the REFA methods has declined dramatically over the last couple of years. The question arises why the REFA has not further developed REFA-standards for production systems? In this connection, the repositioning of the REFA has to be considered. Two years ago it shifted its training focus on the process organisation to the management of processes (Binner and Lehr 2002:10). Based on a process approach, the REFA-process model focuses on the customer satisfaction approach which is the result of motivated associates and lean business processes (ibid.:11). This model is based on process model previously developed by the automotive production section of the REFA and serves as orientation for the planning, design and controlling taking into consideration branch-specific factors (ibid.). The creation and introduction of process-oriented models represents a distinctly new direction taken by the REFA reflecting the growing importance of lean-production based process models and EFQM-based self audit (ibid.:10) and process audits (ibid.:15). This step signals a repositioning which is also underscored by the current attempts of the REFA to co-operate with the MTM in the creation of a so-called holistic production system. Interestingly, the model the MTM proposes is similar to the MPS and is also based on the Toyota Production System.

4.12 The Mercedes-Benz Production System and the Toyota Production System

In the following part, I will compare the Mercedes-Benz Production System (MPS) with the Toyota Production System (TPS). This comparison focuses three main aspect: structure, intention, approach.

Introduce via the Chrysler Operating System and the DaimlerChrysler Production System, the core principles of the MPS are identical with those of the TPS. According to Thomas, responsible for the production system at DaimlerChrylser (Leiter Produktionssystem), both are essentially concerned with the same topics. (Thomas 2000:8). Although this similarity of both systems is evident in the themes of the five MPS subsystems ("Work Structures and Group Work", "Standardization", "Quality Focus and Robust Processes and Products", "Just-in-time" and "Continuous Improvement"), the MPS is different from the TPS on a number of grounds.

As pointed out above, the structure of the MPS consists of a number of fragments which are grouped into clusters. Hence the MPS does not reflect the highly integrated structure of interrelated elements of the TPS. It is not based on a cause-effect relation. Moreover, whereas Toyota standardised all tasks concerning the number of tasks, their sequence, time limits and results, the MPS focuses on the standardisation of work in areas of direct manual work, taking into particular consideration the specific background of the workforce (ibid.:9). For example, concerning the induction of new staff, the Mercedes-Benz Production System reflects the particular structure of the German workforce which consists primarily of skilled workers and the key role of the apprenticeship system. Subsequently, the induction training described in the MPS is less extensive than at Toyota and is conducted as consisting of a training on the job primarily with the focus on learning the most important issues of work content and what to do, what not to do (ibid.). Toyota, in contrast, recruits predominantly High School leavers. Thus, for example in the assembly, new staff receive a twelve week training. The focus of this training is to learn about standardised work processes, standard work methods, and the concept of continuous improvement.

Another difference between the MPS and the TPS concerns the role of the group speaker. At Toyota, the responsibility of the group speaker is to support and solve processes. According to Thomas, this amounts up to 60% of his time. The role of the group speaker in the MPS is to generally "support the team members", to arrange meetings and to act as a "voice" of the team. Moreover, his function is to integrate the team into daily shop floor decisions and thus relieves the workload of the supervisor so that he has more "opportunity to perform planning and follow-up activities" (MPS 2000:44).

Concerning the influence workers have on standards, in both the Mercedes-Benz Production System and the Toyota Production System, workers are responsible for the design of their work system, their performance and the continuous improvement of their work and work processes (ibid.). In the MPS, a particular function in this process is given to continuous improvement workshops intended to "provide a platform and standards method for operators, supervisors, and engineers to focus and learn about waste elimination methods and activities" (MPS 2000:83). The purpose of integrating teams and various members of staff into continuous improvement workshops is to provide a "cross-functional team to learn and work together" (ibid.). According to Thomas, standardisation of work and processes imposed through the MPS is based on the following criteria: acceptable work content and work organisation are designed to promote group work. The tasks given to groups facilitate an acceptable degree of physical demand, workers with limited abilities can be integrated into the teams and last but not least, ergonomic standards are adhered to (Thomas 2000:8).

Concering the subsystem "Just-in-time", this subsystem has been fully transferred from Toyota. It drives home the need to develop lean structures, which are most efficient within production flow systems controlled by cycles (Thomas 2000:10). Like the TPS, the MPS is based on a pull system which is achieved as each process only produces the amount demanded from the next process (MPS 2000:73). The flow of material is controlled as "the preceding process produces only enough units to replace those that have been withdrawn" (Monden 1983:6). This link is seen by two specific MPS tools: "Withdrawal and Fill-up" and "Order Cards (kanban)". The former defines a standard withdrawal and fill-up system as the "supplier department (material handling) replenishes only what is withdrawn by the customer department" (MPS 2000:75). The signal for replenishment may be in electronically or via a kanban system, defined in the latter tool. The MPS regulates that "(kanban) order cards are attached to container, as material is used, the kanban card is removed and returned to the supplier (or supply department/process) as a refill signal (i.e. permission to produce/convey)"(ibid.). As either a paper or electronic format, the kanban contains information about product type and quantity and required date (ibid.). The kanban system thus controls the inventory levels held. According to the TPS, "the standard quantity of work-in-process is the minimum necessary quantity of work-in-process within the production line: it consists principally of the work laid out and held between machines. It also includes the work attached to each machine" (Monden 1983:155). The MPS does incorporate Toyota's notion of a standard quantity of work-in-process and defines it in tool "Standard-work in process" (i.e. work in progress) as the "maximum stock allowed between two processes or within a process" (MPS 2000:52). The TPS considers the kanban system to facilitate the minimisation of inventory levels. In order to ensure that work in progress is kept a minimum, workers are encouraged to continuously improve potential problems which might bring the flow to a stand still. Thus kanban and inventory levels force workers to contribute to the continuous improvement of processes. This pressure exerted by external structural drivers on the work of actors is less evident in the Mercedes-Benz Production System. Thus the TPS provides a far more explicitly integrated system of regulation. Thus, the difference between the Mercedes-Benz Production System and the Toyota Production System is the pressure external structural drivers such as for example the Just-in-time system, the pull production principle and the kanban system exert on the work of actors on the shop floor. This is also reflected in the difference of the form and function of standard operations. The Toyota Production System contains highly formalised instructions aimed at reinforcing these external structural drivers. The two key documents are the standard operations routine sheet and the standards operation sheet. The former defines the sequence of operations the worker performs, the latter in addition includes cycle time and standard quality. Both documents are highly detailed and formalised and are thus intended to precisely regulate work.

The corresponding document in the MPS is tool "Standard Work Instructions (SWIs)" and to some extent the tools "Process Map" and "Performance Standards". Their purpose is similar to the standard operations documents of the TPS. However, the description of this standard in the Mercedes-Benz Production System is by far not as detailed and formalised as the TPS standards. For example, the purpose of the SWI is defined to "process relevant data for one takt or cycle and station, e.g.: required tool, material to be assembled, value added or non value added elements and times, standards steps to complete the work." (MPS 2000:52). Moreover, the standard proposes that the SWI should include a "sketch of steps (overview) and any key points (quality, safety, signature approvals, etc.) requiring further detail should be included" (ibid.).

These examples show that whereas the TPS provides detailed descriptions, formalised set of standards, the MPS standards are rather vague, as this example showed. The intention of the MPS is thus that it provides standards which are flexible enough to be adapted according to their particular production environment. According to Thomas, our point is not to copy blindly from the Japanese, but to develop our own system reflecting our own identity (Thomas 2000:8).

In summation, the Mercedes-Benz Production System incorporates the major themes of the TPS. Introduced via the Chrysler Operating System and the DaimlerChryslers Production System, there these themes are represented by the five subsystems. The difference between the Toyota Production System and the Mercedes-Benz Production System is that whilst Toyota strictly applies a few principles, the Mercedes-world needs a variety of methods, regulations und descriptions (ibid.:10).

Conclusively, this chapter examined how the Mercedes-Benz Production System evolved from the context of the merger between Daimler-Benz and Chrysler with the purpose of creating a basic order for the production organisaion of all Mercedes-Benz production plants (a basic (MPS 2000:introduction). The MPS does not represent a radically new production system, but similarly to the COS has been modelled upon the TPS.

Challenging the traditional dominance of standards set by the REFA, the introduction of company-specific production systems like the Mercedes-Benz Production System, reflects not only a change in the form and function standards towards describing best practice working routines, but also a change in the role of standard setters. Whereas traditionally standards have been set by professional associations and standard setting bodies, today companies themselves have evolved as the standard setters.

The observations I made during the implementation process of the MPS suggest that there is a difference between what the MPS "preaches" and how actors live the MPS on the shop floor. These findings point out that there is a difference between the theory and practice of the MPS standards, suggesting that despite the introduction of standardised methods and routines, workers continue using their own routines. This aspect, in my view is of particular relevance and for the purpose of analysing the influence of the implementation of the MPS on the actors on the shop floor, particularly in terms of the link between standardisation, control and learning, I conducted two surveys. The findings and implications will be discussed in the following chapter.

5 The results of implementing the Mercedes-Benz Production System

5.1 Introduction

This chapter continues the case study of the Mercedes Benz Production System (MPS) by presenting the results of two surveys conducted. These surveys were not commissioned by DaimlerChrysler. I independently designed, administered and evaluated them during the implementation period of the MPS. Together with the previous chapter, the findings of these surveys round off the case study of the MPS.

The intention was to quantitatively analyse the impact of implementing a standardised production system on the shop floor, particularly how actors on the shop floor perceive standardisation. My prime interest was to examine the link between standardisation, learning and control: do actors confirm that standards increase the degree of control over work processes? How far can actors influence standards? To what extent can actors contribute their own know-how and experience into standards?

First, the function of standardisation to control the work on the shop floor is linked to the alienation image of work. Based on the view that as standards divorce the object of work (the task) from the actors (subjects) on the shop floor, work is no longer meaningful but individual creativity is repressed for the sake of industrial productivity. Consequently, "destroying the meaning of work itself" (James Worthy 1959:70). The purpose of the survey was to examine if this particular image of alienation holds true in the case of implementing the standardised Mercedes Benz Production System.

Second. the impact of standardisation on organisational learning. A key conclusion Adler and Cole draw from the study of NUMMI is that standardisation features as an "essential precondition for learning" (Adler 1993:104). Does Adler and Cole's argument apply in the case of the MPS? To evaluate this, the surveys are intended to examine to what extent standards facilitate organisational learning and the inclusion of the shop floor know-how. And to do so, I operationalised these research intentions into a questionnaire to collect information, primarily from the workforce on the shop floor.

The chapter is divided into three parts. First, a presentation of the research scope, methodology and survey technicalities, timing, administration and questionnaire design, and a brief account of the statistical tools deployed, is given. The MPS questionnaire is included in the appendix.

The second part is the core of this chapter presenting the quantitative results collected in two surveys administered within a period of twelve months during the MPS implementation phase. The final part offers an interpretation of these results.

5.2 Research scope and methodology

To measure the effects of the implementation of the MPS, within the overall duration of the longitudinal study from October 1999 to June 2002, two measure points were fixed for the collection of the quantitative data:

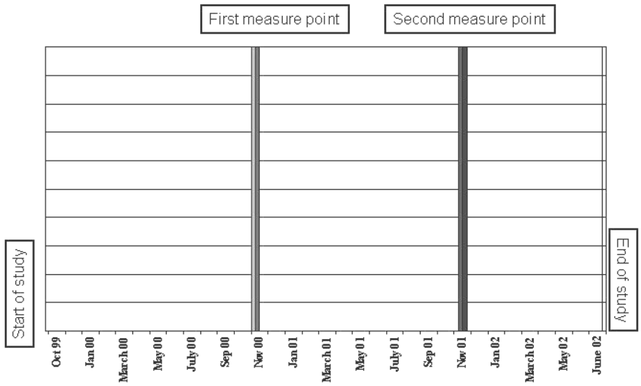


Fig. 5.1. Longitudinal research period of present study and empirical measure points

The first questionnaire was administered in November 2000, immediately after the MPS was introduced on the shop floor. This date was chosen to collect evidence reflecting opinions about work and the production system immediately upon the implementation of the MPS.. The second measure point was set to be exactly 12 months later after more than 50% of the MPS (i.e. 59 MPS tools) had been implemented.

Questionnaires were put in neutral envelopes and sent out to each individual (the selection procedure and sample size will be discussed in due course). For the collection of the returns, labelled MPS-questionnaire boxes were set up at the secretariats of the three selected sub-centres (production departments) and actors were requested to return the completed questionnaires within four weeks. The questionnaire answers were transcribed via excel sheets to be then analysed using all available and relevant statistical functions featured in the Statistical Package of the Social Sciences (SPSS). The same processing procedure was applied for both questionnaire collections. The following part focuses on the research location and sample selection, size and return.

The research location was the Mercedes-Benz plant Untertürkheim. As introduced in the previous chapter, it consists of decentrally organised production centres. The empirical research was conducted at one of these centres, henceforth referred to as Z. Its objective is to manufacture and assemble components for passenger car power train units. Z consists of a number of sub-centres (equivalent to departments) such as quality management, production maintenance, controlling and communications, including three production sub-centres (in the previous discussion on MPS audits introduced as A,B,C). Each sub-centre is hierarchically organised as follows:

- One head of department (management level 3 – E3)
- Depending on the size of the sub-centre:
  - between 4 - 6 team leaders (management level 4 – E4)
  - between 9 – 26 supervisors (Meister: management level 5 – E5)
  - between about 350 – 1100 workers (including direct, indirect and temporary workers)

Overall the entire population of the three sub-centres consists of a workforce of around 2.000. Based on the returns achieved by previously conducted company-internal surveys at the DaimlerChrysler plant Untertürkheim and Z, the expected return rate for the present questionnaire was less than 50%. To generate a statistically acceptable return then, the questionnaire sample size (n) was set at a level of 643 representing around one third (33.6%) of the entire population at Z and was partly randomly selected from a stratified sub-sample of the population (Remenyi, Williams, Money and Swartz 1991:195). Looking at its structure, he sample includes:

- All management levels from E3 – E5
- 90% of all workers (including direct, indirect and temporary workers)

The following pie chart shows the sample composition in detail:

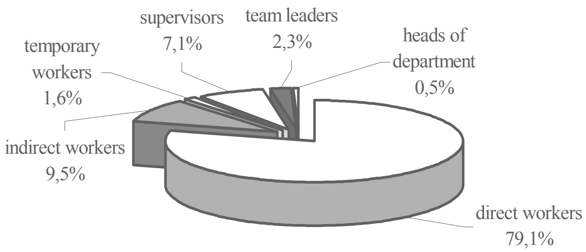


Fig. 5.2. Sample composition according to hierarchical groups

The number of actors drawn from each of the sub-centres was determined on the basis of its size. The sample size therefore mirrors the relation in terms of staff numbers between the three sub-centres, thus 60% of the sample size consists of members of A, and 20% each from sub-centres B and C, respectively. Moreover, the composition of the sub-centres regarding percentages of direct, indirect and temporary workers were considered in the sample size. As already pointed out above, whereas the sample size includes all management of the three sub-centres, the 90% segment including direct, indirect and temporary workers had to be randomly drawn. Once the sample size was thus determined, the questionnaire was sent out. During both survey waves, the same sample size and population was used. The following part presents an overview of the returns and some statistical evaluations regarding underlying implications.

Of the 643 questionnaires sent out twice, at the end of the first survey period in November 2000, 28.5% were filled out and returned; one year later in November 2001, the return rose to 39.5%. The implication being that the interest to contribute to the survey increased from the first to the second wave. This interest was primarily evident as during the second wave, management gave workers around 15 minutes during the working hours to fill out the questionnaires, thus ensuring a higher number of returns. Despite this support for the MPS survey, of those returning surveys, only 83 actors participated in both survey waves. This implies a low degree of consistent interest in the MPS survey. It is difficult to ascertain the reasons and hence any explanations are speculative. Nevertheless, one possible reason might be that because surveys are frequently conducted at the plant Untertürkheim including at the production centre Z, candidates are thus less willing to participate especially if they do not receive sufficient feedback as to the results of these surveys.[1]

The statistical analysis showed that the degree of willingness to participate in the survey depends on the departmental affiliation. Evaluations of this study reveal that for example, amongst those individuals answering twice, staff of B is significantly higher represented. This also applies to associates of C. In contrast, staff of A are significantly higher represented amongst those who never answered.

In addition to the relation between level of participation and the department, there is statistical evidence that there is also a link between the willingness to participate and hierarchical level. The least willingness to respond is seen in the sample segment of the workers, whereas supervisors and team leaders are more likely to respond.

An explanation for this difference is often deduced from the nationality of the workers and their ability to read and write German as a foreign language. This possible explanation was tested in the present survey. However, statistical evaluation only confirmed a slight bi-variate relation. This is insufficient to proof that German as a questionnaire language, represented a potential participatory barrier. The questionnaire language did therefore not influence the willingness to participate.

[1] In addition staff fluctuations, transfers to other plants or production centres, retirement cases and absenteeism during the period the survey was administered, offer possible explanations.

5.3 Statistics

An adequate operationalisation, a translation of the research objects into an empirical system was conducted (Gediga 1998:12ff, Borg und Staufenbiel 1997). In the present study this has been done using a quasi-experimental design (Bortz und Doering 2002). Whereas an experimental design draws on randomly selected groups, the quasi-experimental design uses natural groups.

Regarding the test design, based on the classical test theory, the attitude of individuals is measured according to scales (Lienert und Raatz 1994). To measure attitudes and opinions, first a pool of items was created. Using the Varimax method (Pawlik 1968), these items were then pre-tested and a reliable questionnaire design was developed. The intention was that the total scores of these designs could be used as a probability variable for further calculations. Depending on the distribution of this probability variable, a range of parametrical and non-parametrical tests, such as the t-test, the chi^2-test (Chi Square Test), regression analysis, variance analysis, the H-test and other statistical tests were conducted (Bortz et. al. 1990, Büning und Trenkler 1978, Fisseni 1990) Cronbach's Alpha was used as a reliability measure.

In practice the basic approach was to get actors to rate verbal statements (items) on a symmetrical scale of six levels ranging from verbal statements of agreement, to verbal statements of disagreement, as presented in the detailed account of the MPS questionnaire design below. The reason for choosing six levels was to prevent individuals from merely ticking the middle to the scale.

Concerning the structuring of items, deploying factor analysis (Backhaus et. al, 2000) highly correlating items were summarised. Where necessary, after z-transformations, these items then were used as a basis for the calculation of the total scores. The purpose was to thus create stochastically independent item groups.

To understand this rather technical procedure, it is useful to show how this was conducted in practice, exemplified by one set of items grouped together under the heading "Information und Communication".

The questionnaire section "Information and Communication [I+C]" consists of three individual statements which actors should evaluate according to the six level scale, mentioned above. The first item consists of the statement "I am well informed by my boss" and each actor rates the degree to which he agrees with this statement using the six level scale. The remaining two statements are:

"The flow of information between and the communication with other teams is good"
"I am satisfied with regular communication meetings"

For each individual questionnaire returned, the total score is calculated by adding the total scores of each of the three items. In order to calculate this total score correctly, according to classical test theory, a calculation of the parameters, especially the degree to which each item is representative of the entire test result is necessary. Moreover, calculations should also establish the degree to which each item is answered in line with the direction of the overall trend, in this particular case represented by an arithmetic mean of 7,2 and a median of 7,0.

Thereafter, the reliability of the test was established, that is the extent to which one research objective is expressed by the item in the test. For the present study, this is indicated by a Cronbach Alpha of 0,7875 (for the entire survey) and according to statistical convention is hence acceptable.

Regarding the statistical calculations of the parametrical test, such as the t-test, the developed probability variable should be (nearly) normally distributed. Although it is acceptable to use the Kolmogorov-Smirnov Test to compare how this distribution compares to the normal distribution, statisticians commonly agree that the t-test used in the present study offers an equally acceptable test measure (Büning 1991).

Summarising, in accordance with classical test theory, for the analysis of the results, a barrage of statistical calculations were conducted to provide a statistically sound evaluation. The following gives a detailed presentation of the quantitative measuring tool, the MPS questionnaire.

5.4 The MPS questionnaire design and content[2]

The choice to collect quantitative evidence through a questionnaire was determined by the fact, that this instrument represents a standard requisite used to conduct surveys throughout the DaimlerChrysler AG. Every year, one so-called associate survey is conducted via a questionnaire. As associates are thus familiar with the administration of questionnaires, the decision was made to deploy this type of measure also for the MPS survey. Before drafting the questionnaire, the internal associate survey designs of 1998 and 1999 were analysed. Their basic structure, such as the clustering of items into different sections and the personal data section at the end were also adopted for the MPS-survey. However, as the research goals of the general associate survey and the MPS survey differ, substantial changes as to the content and scoring scales were made. Regarding the latter, a variety of coding schemes were used, primarily drawing on a 6-level interval scale.

Table 5.1. 6-level questionnaire interval scale

Completely agree	Mostly agree	Tend to agree	Tend to disagree	Mostly disagree	Completely disagree
01	02	03	04	05	06

This scale does not provide a central dimension, as is the case with scales based on sets of odd intervals, thus so-called hidden abstentions, caused by individuals consistently marking the middle of the range, were avoided. In addition to this scale, where appropriate both nominal, ordinal, and ratio scales were used.

After having drafted a first MPS questionnaire, it was tested by two groups each consisting of 10 workers and one supervisor (E5). Based on classical test

[2] For the entire copy of the MPS questionnaire, see appendix.

theory discussed above, total scores were developed. The final design consisted of a set of 85 items, grouped into seven main parts. The following part discusses these parts and items in detail and relates their purpose to the research goal.

Preceding the actual questionnaire, the purpose of conducting the questionnaire was briefly introduced in a cover letter to associates which also assured that upon conclusion of the research, participants would receive feedback regarding its results. It also contained an explanation how to fill out the questionnaire and explicitly stated that the unanimity of each actor was considered to be of prime importance and any data collected was subject to confidentiality.

The questionnaire then commenced with the first part, "Information and Communication" It contains six items and is primarily concerned with measuring the degree of satisfaction with the flow of information, and the degree of staff involvement in the suggestion system, asking, for example, about the number of suggestions made and the time it takes for them to get implemented. The underlying reason for posing these questions was to establish if, after the implementation of the MPS, communications, the flow of information and the rate of participation through improvement suggestions changes.

The second part, "Leadership and Management" consists of five items such as, attempts to rate the relationship between superiors and associates, focusing on determining factors such as the frequency of communication, behaviour, autonomy and feedback. This part of the questionnaire relates to the MPS tools provided in the first operating principle, "Leadership" and serves to evaluate the effect of implementing these.

The third part is divided into two groups of items. The first set contains items focusing on the "Co-operation within the team", the second set contains items focusing on the "Co-operation between teams". Altogether this part consists of 12 items.

Regarding the first set, the co-operation within the team is measured according to participation, integration, agreements, usefulness of team development and general satisfaction with the communication within the team.

The second group of items, measure the co-operation between teams at work. Overall this set of items is intended to measure the degree to which individuals are aware of their role within the overall production organisation, asking, for example, about the need to co-ordinate work with other teams, the knowledge about the tasks other teams have to perform, and if the individual's work is appreciated outside the team. It also intends to measure the degree of responsibility for indirect tasks and the actor's awareness about the location of his work within the production flow (for example, asking actors about the awareness of immediate upstream and downstream work processes within their area of work). The items presented in these two groups, related to the MPS operating principle "Work Group Organizational Structure", thus measure how the implementation of the MPS affects team work. The expectation being that the implementation of MPS tools improve the rating results of these items, reflecting an overall improvement of team work through the implementation of the production system.

The fourth part, "Know-how and experience" measures the importance of the know-how and experience of workers within the production process. Specifically, the two items establish to what extent superiors and planners consider the know-how and experience of workers, and to what degree individuals feel that their know-how and experience is actually incorporated into production standards. Both questions then assess the relationship between standardisation and tacit knowledge. They are thus intended to measure the degree of organisational learning facilitated through the implementation of the MPS.

The fifth part "Quality" consisting of three items primarily focuses on quality awareness of individuals and within teams and asks actors to rate their ability to influence product and process quality. This set of items links to the MPS subsystem "quality and robust processes and products", however, unlike the detailed MPS tools listed, the questionnaire is rather intended to measure results based on the general quality awareness of individuals. This choice was made, as the prime intention of the questionnaire is to ascertain the impact of the implementation of the MPS on the work on the shop floor rather than providing an assessment of the changes of quality management specifically.

The subsequent, sixth part "Own Work" consisting of altogether 27 items is by far the most extensive part of the entire questionnaire. It is sub-divided into four parts covering the following themes:

1. Factors influencing work load such as physical and mental challenges of work, time pressure and an item asking actors to rate the progressive aspect of work load (i.e. has the work load increased over time)
2. Potential work improvements based on a list of 9 suggested items ranging for example from job variety, working environment, pay, and qualification.
3. Job satisfaction: how satisfied individuals are with their work
4. Autonomy in terms of ability to independently solve problems of work load / work pressure
5. Motivating factors based on a list of 12 items including for example, pay, team work, responsibility, working environment, management, relationship with colleagues and training and qualification opportunities.

Regarding the improvement and motivational factors, actors were asked to assess the items. Based on these results, the items were ranked. The interpretation of the results is based on the changes in these ranks. Thus potential improvements and motivational factors are indicators as to the effect of MPS on work. To elucidate, if, for example, in the first questionnaire the need to create more varied jobs as an item was rated high, i.e. individuals signalled that their jobs were too monotonous and in the second questionnaire, this item received a lower rating, signalling that job variety has improved, a potential relation between the degree of job variety and the implementation of the MPS can be deduced.

The seventh part of the questionnaire consists of 20 items measuring the opinion of actors about the Mercedes-Benz Production System, asking for example about how they rate the influence of MPS on career opportunities, if it will be successful, its influence on the motivation of staff, and how staff perceive the management support MPS receives.

Moreover, two sets of items invite individuals to evaluate its expected results as set out in the MPS goals (safety, quality, delivery, cost and morale) and its potential effects on work for example, cycle time, work content, qualification opportunities, jobs and control over work. A concluding open question invites actors to give their personal comment about the MPS.

The questionnaire concludes with a final section "Personal details and statistics" asking details about: age group, gender, educational background, training, type of contract, sub-centre affiliation, hierarchical level (for example worker or manager) and length of sub-centre affiliation.

5.5 Significances

In accordance with statistical conventions, using the t-test, the significance level was set at 5% based on a 95% confidence interval. All results with significance values of 5% and less are therefore considered significant and are denoted as Alpha throughout the text. In order to account for results which are just outside this range and are therefore also significant but slightly less so, a second band of results falling in the range between 5% - 10% was included. Results indicating an Alpha outside this range (Alpha > 10%) signal that no changes in the rating of items, in the opinion of individuals, has occurred. These results however, are important as they provide additional context to the significant results. Where appropriate then, the following presentation of results considers both, results which reveal a change in opinion and results which indicate a consistency of opinion. The indication whether the results have a positive or negative sign are drawn from the median difference (MD). Unless specified, all trends are positive.

The presentation of results is divided into two parts, commencing first with results for the entire production centre Z, and in a second step individual results of sub-centres A, B and C. The section is rounded off with an analysis and interpretation of the results.

5.5.1 The general trend of results at Production Centre Z

Overall, it is interesting to see that at Z, outcomes of only nine different items of the questionnaire reveal that significant changes in opinion between survey one and two occurred. The results of the remaining items did not change during the period. The main findings are as follows.

5.5.1.1 MPS improves integration of shop floor know-how and experience into standards and decisions

The first finding concerns how actors rated the impact of their know-how and experience on both decisions and standards. It becomes clear that individuals are convinced that their know-how and experience is integrated in decisions made by both planners and superiors (Alpha 1.0%). Moreover, actors also overwhelmingly confirm that they reckon that their know-how and experience is more integrated into standards (Alpha 0%).

To understand the implication of these results it is interesting to consider how they relate to other items. Although the assumption being that a greater degree of inclusion of know-how and experience is associated with an increasingly intellectually demanding job, results did not confirm this link: actors did not confirm that the degree of intellectual work content did increase (Alpha 37%). Similarly, individuals neither confirmed that the overall demand of the job has risen (Alpha 52%). These findings are also confirmed as actors rejected that their job demand and content have indeed increased (Alpha 3%, MD –10%).

This is interesting insofar as it raises the question regarding the relation between MPS, job content and inclusion of know-how and experience. As the outcomes above show, the MPS is not seen as additional burden on the job of actors, it does not increase job demand and content. Instead, the results suggest a relation between the decrease in job demand and content and the implementation of the MPS. At the same time though, findings also show that the know-how and experience of actors are increasingly included in decisions on the shop floor and have also more influence on the standards set. Actors do not perceive this extended influence they thus have as an additional burden on their job. This is confirmed by the findings above, that the general work load has not increased. Obviously, one cannot deduce that these changes occurred primarily as a result of implementing the MPS. One has to consider this link in relative terms, acknowledging the impact of factors other than the MPS on these results. For example, changes in product, production schedule or team rotation might have contributed to these results. However, the findings confirm Adler and Cole's notion that standardisation facilitates the inclusion of the tacit knowledge. In the case of the MPS, the degree of standardisation introduced through the MPS has contributed to both an inclusion of the tacit dimension (know-how and experience of individuals) and a reduction in the work load. Standardisation contributes positively to an integration of the shop floor know-how and experience and at the same time decreases the general work load in terms of job content and demand.

The question whether actors want this extension of their responsibility in the standard setting process, can be assessed by looking at the ratings of what factors motivate actors and what improvements actors consider necessary for their work. Interestingly, these findings show no significant changes. There are no significant changes evident that individuals' wish to improve job variety and monotony (Alpha 19%), job demand (Alpha 63%) and participation in the decision making process (Alpha 75%).

At the same time there are also no significant changes in the rating of a total of 12 motivational factors, with "Task variety" as a motivational factor ranking sixth (Alpha 45%), "Right to participate" ranking fifth (Alpha 50%), "To have responsibility" ranking second (Alpha 37%). These results reflect on two aspects. First, they show that actors perceive job variety less important a motivation factor than responsibility and participation in the decision making process. Second, the inclusion of know-how and experience in decisions and standards is part of the general motivational factor "Right to participate". By increasingly contributing their knowledge, the extent to which actors participate in the decision making process has been extended. Does this affect overall job satisfaction though?

Interestingly, actors did not confirm significant changes in overall job satisfaction levels (Alpha 72%). That means, individuals perceive that their know-how and experience is increasingly incorporated into the decision making process and into standards, yet at the same time they are not more satisfied with their job: increasing inclusion of tacit knowledge does not coincide with an increase in overall job satisfaction. Thus motivation is not significantly determined by the inclusion of the tacit knowledge alone, as will be seen when looking at the ranking of motivational factors.

Do actors associate their ability to influence standards and decisions with the implementation of the MPS? The fundamental assumption underlying this link is that the increasing number of standards introduced through the implementation of the MPS has provided individuals an opportunity to include their opinion and knowledge into the standards. Thus, to some degree, a relation between the positive results regarding the increased inclusion of the tacit knowledge and the individuals' perception of the MPS should exist. The significant results regarding the actors' perception of the MPS are: first, the number of individuals who know about the MPS has increased significantly (Alpha 0%). This was expected, as implementation activities intensified during the period between the two surveys and all staff has had a certain amount of contact in their work with the MPS, be it through training, workshops or audits. Second, as already discussed in detail above, MPS has been associated with a decrease in work demand (Alpha 3%). However, this decrease in the level of demand has neither coincided with actors rating that the MPS has decreased work content (Alpha 53%), nor their rating that the MPS has increased the degree of control at work (Alpha 87%).[3]

It is interesting to see that no other significant changes are evident at Z. This in itself is nevertheless important. For example, although the tacit knowledge has played a more significant role at work, at the same time individuals neither affirm that they have a more positive impression of the MPS (Alpha 75%), nor do they consider that the MPS significantly influences their personal career chances (Alpha 22%) and improves their motivation for work (28%). These results then show that the perception actors have of an increasing inclusion of their know-how is not linked with their impression of the MPS and the career opportunities and motivation function they associate with it.

To resume so far, the Z results suggest that since the implementation of the MPS commenced, the know-how and experience of individuals has increasingly shaped the decisions of superiors and planners and has also been more incorporated into standard. Regarding its effect on work, actors do not consider that their overall job demand, and specifically the mental demand of their work has also increased. Neither do results confirm that there is a relation between this increased tapping of shop floor know-how and job satisfaction levels or changes in the ran-

[3] The remaining significant results observed at Z were primarily due to shift in opinion at B, and are discussed in this context below.

king of motivational factors. Overall then, the standards introduced through the MPS have helped making work easier. Standards are not associated with the alienation image of work but the findings show that individuals perceive standards in terms of working routines which help them to ease their work. This view is underscored as actors do not perceive standards to represent fixed rules, but instead regard them as temporary best practice solutions which individuals can improve. By thus improving standards the know-how of the individual is integrated into the standards and, this know-how is then shared with other actors, as they learn and adapt the new standard. Insofar then, the results affirm that the tacit know-how of actors is tapped through the setting of standards and hence standards provide a framework for sharing this know-how and represent a platform for organisational learning.

Up to now, the presentation and analysis of the results has focused on the results on the individual worker. A next step then is to ascertain what significant changes there are regarding team work.

5.5.1.2 The MPS improves the co-operation in and between teams

Particularly, where communication between teams was evaluated, the flow of information between teams has improved significantly (Alpha 2%). Communication between teams occurs in a variety of ways, the question is: do the findings indicate what type of information has increasingly been transmitted? Indeed, one aspect of communication has improved considerably: individuals have become aware of the tasks of other teams (Alpha 1%). These outcomes show that the awareness horizon of actors now goes beyond their own tasks and those performed within their own group. Instead of this limited or insular view restricted to their immediate working environment, individuals have learned about the responsibilities of others. They are therefore also more able to understand their own job function within the overall production. The results therefore point towards a shift in the individuals' perception from considering their work in isolation, to an awareness of how their work is integrated into the entire production process chain.

This shift has affected the awareness of the actors but has it also improved the relations between teams? Surprisingly, results do not confirm this link. An increase in the degree of co-operation between teams (Alpha 94%) has not occurred. That means, even if individuals have learned more about the tasks and job their colleagues perform, social interactions and the relationships between teams have not necessarily improved at the same time (Alpha 57%), and neither have colleagues increasingly shown appreciation for the work of members of other teams (Alpha 52%).

One explanation why actors know more about the skills members of other teams perform, is that the integration of shop floor know-how has intensified the communication between teams, particularly related to quality issues. Findings confirm that the discussion about quality has intensified during team discussions (Alpha 10%). As it is an issue that concerns all teams, it has also featured more prominently in the communication between teams. In other words through the communication about quality, individuals have learned more about the skills and responsibilities members of other teams perform. As mentioned above this has contributed to the individuals' broader understanding of their role and the role of others in productions. The causes why the discussion about quality has intensified can be linked to the actual goals of the MPS, to improve: safety, quality, delivery, costs and motivation. To reconstruct this causal chain: one key objective of the MPS is to improve quality. Through the implementation of the MPS, quality in turn receives more attention and features more prominently in team discussions and in conversations between teams. Through the communication between teams, actors learn more about the skills and responsibilities of their colleagues. They therefore receive a more comprehensive picture of the entire production process and are also more capable of understanding their own role within this overall picture. At the same time, their level of participation in production decisions increases and their know-how and experience is increasingly integrated into production standards.

Although one has to point out that the survey findings of centre Z reflect the opinions of actors in three production departments at one location only, and are therefore not representative of the entire production plant Untertürkeim, nevertheless one has to acknowledge that the key result of these findings is that individuals rate that their know-how has been more integrated into decisions and standards. Thus they have more influence over the decisions about their work and working processes. At the same time, team work and the flow of information have significantly improved. These positive findings are also being confirmed when looking at the ratings of motivational and improvement factors.

5.5.1.3 Changes in ratings regarding necessary improvements

Part five of the questionnaire contains items intended to measure aspects of work in general. One specific item lists a number of improvements. Individuals are asked to evaluate how necessary these improvements are for their work. Actors rate each suggested improvement and the results are presented in the form of a ranking list. The bar chart below shows the findings of these rankings for the two survey waves. The top bar shows the findings of the first survey in 2000, the bar below shows the findings of the survey 2001.

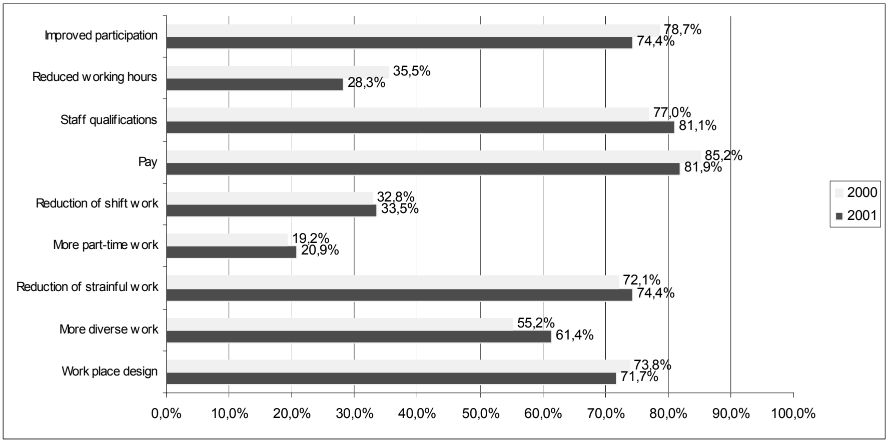


Fig. 5.3. MPS survey results: Question V.A. Suggested improvements of work

These percentage results are ranked, as presented in the table below.

Table 5.2. MPS survey results: ranking suggested improvements of work

Suggested improvements of work	Rank in 2000	Rank in 2001
Improved participation	2 (78.7%)	3 (74.4%)
Reduced working hours	7 (35.5%)	7 (28.3%)
Staff qualifications	3 (77.0%)	2 (81.1%)
Pay	1 (85.2%)	1 (81.9%)
Reduction of shift work	8 (32.8%)	6 (33.5%)
More part-time work	9 (19.2%)	8 (20.9%)
More diverse work/ less repetitive work	6 (55.2%)	5 (61.4%)
Reduction of strainful work	5 (72.1%)	3 (74.4%)
Improved work place design and working environment	4 (73.8%)	4 (71.7%)

The first column gives an overview of all items, the second and third columns shows the rankings based on the percentage results (in brackets) for the two surveys in 2000 and 2001 respectively.

First of all, there are no significant changes of the ratings. In both survey waves, pay received the highest number of positive scores (85.2% and 81.9% respectively). That is, actors think that pay is the most important factor which needs to be improved. In 2001, this figure was closely followed by the need to improve staff qualifications (81.1%), whereas in 2000, the second most significant improvement perceived regarded the issue of participation (78.7%). A consistent fourth place in the ranking was scored by improvements in work place design and working environment (73.8% and 71.1% respectively). The lowest ranks were relatively consistently represented by issues linked to working time such as improvements regarding part-time work (19.2% and 20.9% respectively), improvements of work based on the reduction of shift-work (32.8% and 33.5% respectively) and a general cut in working hours (35.5% and 28.3% respectively).

To sum up, overall individuals confirm the need to improve pay, participation and qualification opportunities. The least likely factors actors think need to be improved are changes in working times or the reduction of shift work.

5.5.1.4 Changes in motivating factors

Similar to the ratings regarding necessary improvements to work, part five of the survey also included an item asking individuals to evaluate different motivating factors. Actors rate to what extent they are motivated by each item. The bar chart below shows the findings of these rankings for the two survey waves. The top bar shows the findings of the first survey in 2000, the bar below shows the findings of the survey 2001.

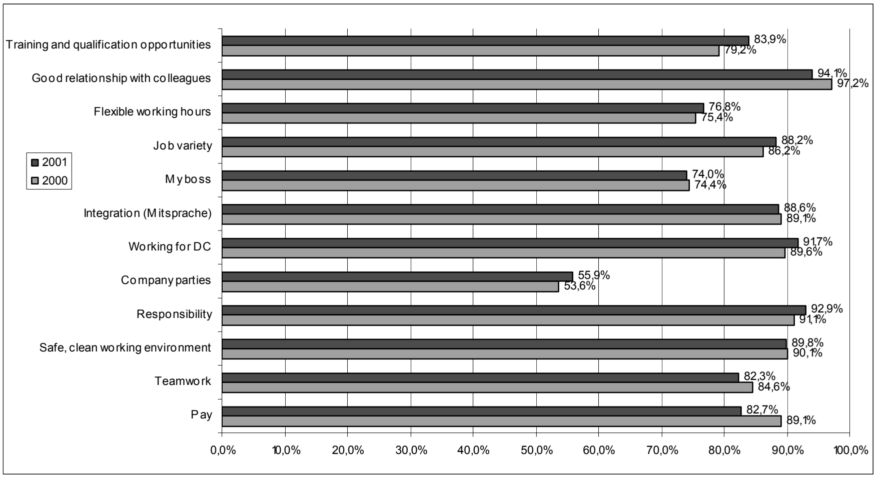


Fig. 5.4. MPS survey results: motivating factors ranking

Based on the percentage scores received (in brackets), the items are ranked as shown in the table below:

Table 5.3. MPS survey results: ranking motivating factors

Motivating Factors	Rank in 2000		Rank in 2001	
Training and qualification opportunities	8	(79.2%)	8	(83.9%)
Good relationship with colleagues	1	(97.2%)	1	(94.1%)
Flexible working hours	9	(75.4%)	10	(76.8%)
Task variety	6	(86.2%)	6	(88.2%)
My boss	10	(74.4%)	11	(74.0%)
Right to participate	5	(89.1%)	5	(88.6%)
To work for DC	4	(89.6%)	3	(91.7%)
Company parties	11	(53.6%)	12	(55.9%)
To have responsibility	2	(91.1%)	2	(92.9%)
Clean and safe working environment	3	(90.1%)	4	(89.8%)
Teamwork	7	(84.6%)	9	(82.3%)
Pay	5	(89.1%)	7	(82.7%)

The first column lists the motivational factors, the second and third columns show the rankings based on the above percentage results (in brackets) for the two surveys in 2000 and 2001 respectively. For example, how important is "my boss" a motivational factor for the actor, similarly, how important is "pay" or "teamwork" for the actor as motivational factors.

The overall trend does not show any major changes in the ranks which factors received. The overriding motivating factor in both waves was the good relationship with colleagues (97.2% and 94.1% respectively) followed by responsibility (91.1% and 92.9% respectively) and a safe, clean working environment (90.1% and 89.8% respectively). Moreover, individuals are increasingly motivated by working for DC (89.6% and 91.7% respectively).

Regarding the lowest ranks, social events like company parties (53.6% and 55.9%) and flexible working hours (75.4% and 76.8% respectively) are perceived least likely factors influencing the motivation of actors. Interestingly, this is also true of the boss as a motivating factor (74.4% and 74.0% respectively).

5.5.1.5 Assessment of the MPS goals

In the questionnaire, the sixth part asking actors specifically to evaluate the MPS, contains two items regarding the expected results of the implementation of the MPS and the influence of the MPS in general.

The MPS is a goal oriented production system. The five goals it intends to achieve and improve are: safer processes, better delivery and quality, lower cost and morale. The question is, how do individuals rate that the MPS actually achieves these goals? The MPS questionnaire then asked actors to rate this question. The bar chart below shows the findings of these rankings for the two survey waves. The top bar shows the findings of the first survey in 2000, the bar below shows the findings of the survey 2001.

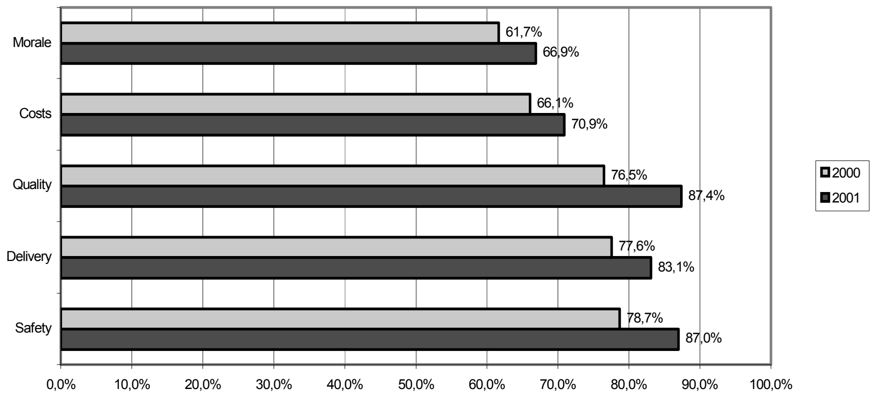


Fig. 5.5. MPS survey results: MPS expected results according to goals

As above, the results are ranked in the table below with the corresponding percentage figures given in brackets.

Table 5.4. MPS survey results: ranking MPS expected results

MPS expected results according to goals	Rank in 2000		Rank in 2001	
Morale	5	(61.7%)	5	(66.9%)
Costs	4	(66.1%)	4	(70.9%)
Quality	3	(76.5%)	1	(87.4%)
Delivery	2	(77.6%)	3	(83.1%)
Safety	1	(78.7%)	2	(87.0%)

Whereas in 2000, individuals stated that the MPS primarily achieved the safety of processes (78.7%), in 2001, quality (87.4%) was considered to be the most significant goal which actors thought had been achieved through the implementation of the MPS, followed by an improved delivery.

The least likely goals individuals suggested that the MPS achieved was to cut costs and to improve motivation (morale). This is interesting, for as seen when looking at the evolution of standardisation, a key function of standardisation has been to provide economically efficient solutions. Actors however, do not associate the MPS with lower costs, at least not during the initial implementation stages. One explanation might be that similar to the demands posed on companies when they introduce quality management systems, the initial implementation process of a production system takes up additional resources and time needed to implement standards. It would be certainly interesting to see, if this perception of individuals changes once the MPS has been fully implemented and the full advantages of standardisation can be seen.

A second point worthwhile remarking is, that the goals least associated to be achieved through the implementation of the MPS is an improvement in the level of motivation. In line with the above results then, although staff is contributing more of their know-how and experience to standards, the findings show that there is no indication that this extended inclusion into the standard setting process motivates them. Insofar, the MPS is not seen to achieve a higher level of motivation.

5.5.1.6 Expected influence of MPS

In addition to the evaluation of the goals of the MPS, actors were asked to rate five factors. The bar chart below shows the findings of these rankings for the two survey waves. The top bar shows the findings of the first survey in 2000, the bar below shows the findings of the survey 2001.

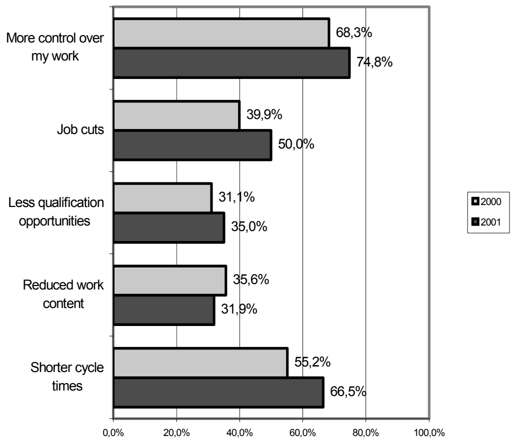


Fig. 5.6. MPS survey results: MPS influence

The results are ranked in the table below with the corresponding percentage figures given in brackets.

Table 5.5. MPS survey results: ranking MPS influence

	2000		2001	
More control	1	(68.3%)	1	(74.8%)
Job cuts	3	(39.9%)	3	(50.0%)
Less qualification opportunities	5	(31.1%)	5	(35.0%)
Reduced work content	4	(35.6%)	4	(31.9%)
Shorter cycles	2	(55.2%)	2	(66.5%)

Significantly, there has been no change in the rankings, the results then show a constant perception. In both survey waves, more control was rated as the most likely influence of the MPS on work (68.3% and 74.8% respectively) followed by shorter cycles (55.2% and 66.5% respectively). Whereas, on the one hand the influence the MPS is least likely to be associated with is less qualification opportunities, on the other, job cuts are rated as a more likely result of the influence of the MPS.

Summarising the trends at Centre Z, the results of the MPS surveys show that the implementation of the MPS has insofar succeeded that associates have become aware of the existence of a formalised production system. Most significantly though, the findings show that the know-how and experience of staff play an increasingly important role. Particularly, superiors and planners draw more on the information provided by staff where decisions are concerned. In addition, staff provides more input on the standardisation process, thus extending the degree of autonomy and freedom they have at and over their work organisation. As the influence of the individual's knowledge on the organisation of work has risen, as much there is also evidence that the communication in terms of the flow of information between teams and different working areas has improved substantially. Overall then the findings for Centre Z show that the implementation of the MPS has resulted in an improvement of work: despite leading to a higher degree of standardisation at work, associates do have an influence over the content of these standards, as they are increasingly able to bring in their own know-how and experience to their work organisation.

Before drawing general conclusions, what are the results at the individual sub-centre level? More specifically, to what degree are they in line with the overall Z results? Is there perhaps evidence, that the implementation of the MPS has had different effects on the sub-centres? To develop an understanding of the MPS at the individual sub-centre level, the next part of this chapter focuses on a detailed analysis of the MPS survey of each of the three sub-centres.

5.5.2 Sub-centre results

The results of the three sub-centres raise the possibility of addressing a question regarding the effect of standardisation, which I have so far neglected in this discussion of the results: can quantitative results confirm the general assumption that standardisation leads to a greater harmonisation in the opinion and perception of actors about processes, such as the flow of communications ? Indeed, the results of all three sub-centres confirm such a trend.

As remarked in the presentation about the questionnaire design above, the MPS questionnaire consists of six parts: information and communication, leadership, co-operation in teams, co-operation between teams, know-how and experience, quality, work and the implementation of the MPS. Adding the scores of all items of each part, an average rating score for each of these six parts can be calculated. It is then possible to compare average scores of, say information and communication at A, with the scores of B and C. A diagram helps to visualise these differences, as shown here:

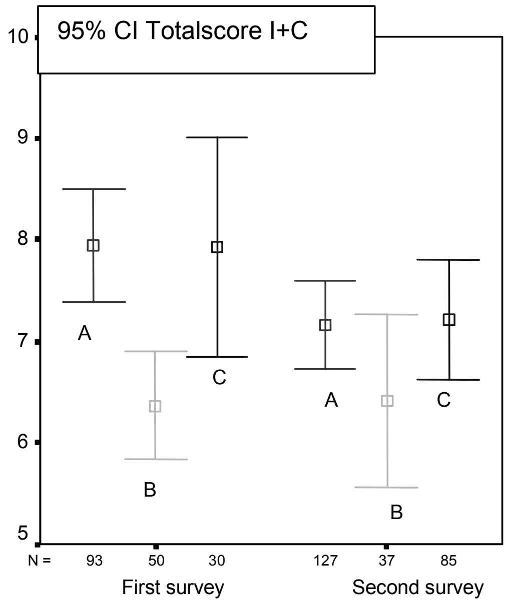


Fig. 5.7. Total scores items in the section "Information and Communication"

This graph shows the results of the three sub-centres regarding all items listed in the MPS questionnaire part or item cluster "Information and Communication". On the x-axis, denoted as "First survey" and "Second survey" are the two measure points at which the MPS surveys were conducted. In the first survey, 93, 50 and 30 individuals participated in A, B and C respectively (N = 93, 50, 30). In the second survey, 127, 37 and 85 individuals participated in departments A, B and C respectively (N = 127, 37, 85). On the y-axis are the total scores. To explain, actors rate items on a six-level scale, ranging from "completely agree" to "completely disagree", as presented in detail above. Each of these six scales corresponds to a number, for example if individuals tick the most positive rate "'completely agree", the item receives a score of 1; if on the other hand the actor ticks the most negative score "completely disagree", then the item receives a score of 6. The scores of each item cluster of the survey are then first added and then divided by the number of total items, thus calculating an average score. The lower this score, the more positive the cluster is rated. The higher the score, the more negative the cluster is rated. The y-axis then represents the range of possible average scores within a confidence interval of 95%.

The vertical lines refer to the range of scores of each department (the so-called confidence interval), the little square in the middle represents the arithmetic mean of these ranges. The lower the value the little square denotes, the more positive the individuals rated all items in the cluster information and communication.

Taking a look at the results of the first MPS survey wave, with a median score of around 6.3, B rated the level of information and communication as good, whereas the scores of the other two sub-centres were considerably higher, i.e. more negative, both at median scores of around 8. Moreover, their ranges also showed a greater variance. So in general, actors at B were more satisfied with the level of information and communication than individuals of the other two sub-centres. However, this situation improved. When looking at the second survey, the median score of B remained stable at 6.3, whereas the scores of both A and C decreased, that is, they improved to a median score of around seven. Thus, the rating of the level of information and communication has converged towards a common score in all three departments. The opinion of actors about the level of communication and information has converged towards one common trend (statistically denoted by a median score of around 6.3 to 7).

But what does this trend reveal about the question as to the effects of standardisation? Well, the results show that through the implementation of the MPS, the flow of information and communication has firstly improved (the median ratings have improved) and second, the level of these ratings of all three sub-centres has converged towards one common, nearly homogenous level. This shows that standardisation has indeed evened out differences in the level of information and communication between sub-centres and has thus contributed to a greater degree of homogeneity which is also reflected in an increasingly homogenous rating level. To provide an analogy, before standard ingredients are introduced, burgers in Rome, Berlin and New York taste different. Mr Agnelli thinks the burger tastes salty, Mr Schremp suggests it tastes hot, Mr Ford states it tastes spicy. Once standard ingredients are introduced, the burgers taste similar, if not the same. This homogenisation of taste is also reflected in how the three gentlemen rate this taste, Mr Agnelli, Mr Schremp and Mr Ford all think the burger now tastes spicy. The standardisation of the ingredients goes hand in hand with a harmonisation in the opinion of how he burgher tastes. The analogy fits the case of the MPS survey results: the implementation of the MPS has led to a standardisation of processes, hence leading to greater harmonisation. This harmonisation is also reflected in the convergence of opinion of how individuals rate these processes. Interestingly, this convergence trend is not only perceived in the above example about mean scores of items in the "Information and Communication" part of the MPS survey, but also is also evident in other parts of the MPS survey. A particularly close convergence of ratings has occurred in the items listed under the MPS questionnaire part assessing the integration of actors' know-how and experience. All three sub-centres converge around a median average of 6.5, reflecting that actors in all three sub-centres have perceived a significant improvement regarding the inclusion of know-how and experience. A similar, though less remarkable trend is also perceived in the convergence of leadership ratings (median range between 10 - 11) and internal team co-operation (median range between 12– 3.8).

Obviously, there is trend of a convergence of opinion in the three sub-centres. This concerns particularly the opinion individuals have about communication and information, leadership, internal team co-operation and the inclusion of know-how and experience. Actors have become more satisfied with these areas.

There is then an interesting parallel between the intention of standardisation to harmonise processes and the findings which show that individuals share the same positive opinion about these results.

After the presentation of this overall trend of converging opinions, I will now move on to the presentation of the main results of the individual sub-centres.

5.5.2.1 Sub-centre A

At sub-centre A, the flow of information between working areas has improved significantly (Alpha 1%). This improvement also coincides with greater satisfaction of staff with regular communications (Alpha 4%). Thus both group-internal communications and the communication between teams have improved at this sub-centre.

Coinciding with these improvements are the results regarding the internal team co-operation. On the one hand, they confirm that actors are more integrated into groups (Alpha 3%), on the other that team agreements are more adhered to (Alpha 8%). These results concur with, and perhaps relate to, the positive effect caused by team training; for, results show that staff is increasingly satisfied with the results of team training (Alpha 6%). Regarding the topics groups discuss, the issue of quality has become more important (Alpha 1%), a result which I believe is linked to a greater level of quality awareness (Alpha 1%) individuals now signal. However, associates at A not only affirm improvements regarding internal teamwork, but the co-operation between teams has also improved significantly, particularly in terms of knowing about the tasks members of other teams perform (Alpha 5%).

Regarding work and the individual, in line with the significant trend perceived at centre level, A staff confirm that their know-how and experience is increasingly heard by superiors (Alpha 1%) and features more prominently in actual standards set (Alpha 1%). Interestingly, associates also confirm that the time needed for implementing staff suggestions has decreased significantly (8%). Thus actors at A not only feel that they can increasingly influence decisions but their suggestions are also implemented faster. So how does staff at this sub-centre perceive the MPS? In line with the trend at the centre Z, they do not believe that work has become more demanding through the introduction of the MPS (Alpha 6%). In addition, individuals perceive that MPS receives sufficient management support (Alpha 1%), at both sub-centre and centre level.

The implementation of the MPS at A has had specifically a positive effect on issues of teamwork (in and between groups) and the flow of information and communication.

5.5.2.2 Sub-centre B

As already pointed out above, B differs in comparison to the other two sub-centres insofar, as overall results of the first survey wave revealed in general a far more positive picture. It is particularly important to keep this in mind, as any negative trends evident in the second survey are relative to these. For example, during the first survey wave, results showed that actors were less likely to be afraid of speaking about their mistakes to their boss than in the other two sub-centres. However, the result of the second survey did not confirm this trend. Instead, the scores suggest that individuals are now more likely to be afraid of talking about their mistakes to their boss. (Alpha 4%, MD – 43%).This result also impacted on the overall results of Z (Alpha 4%, MD–22%), but has neither been confirmed in A or C.

The same care has to be taken when considering the result that actors at B have increasingly linked the MPS to job cuts (Z: Alpha 9%, B: Alpha 1%), a result neither evident at A and C.

In connection with this result, unlike the overall trend at Z, it is furthermore interesting to see that individuals at B do not confirm that their know-how and experience is given more attention by superiors and thus shapes departmental decisions (Alpha 23%). Yet they affirm that their shop floor know-how is increasingly incorporated into standards (Alpha 7%). Interestingly, in the overall Z results and also the results of the other two sub-centres, the two items linked with the inclusion of know-how and experience both improved significantly, whereas in the case of B, staff only confirm a growing influence on standards they have, but not on decisions made. Thus, one cannot assume that the inclusion of the tacit knowledge goes parallel with an increase in the degree of influence actors have on decisions. Although associates might feel they are increasingly able to influence standards, this does not mean that they are also increasingly able to influence departmental decisions. The inclusion of tacit knowledge into standards is independent from the degree of influence it has on the decision making process.

About issues of work, B scores suggest a change in the amount of indirect tasks: results show that the responsibility for indirect tasks has decreased (Alpha 7%), at the same time results also show that work pressure has eased as time is perceived to represent less of a pressure at work (Alpha 9%). Work has then become less stressful in terms of time pressure and demand associated with indirect tasks.

Interestingly, associates believe that the MPS is less likely to succeed (Alpha 3%) at the same time though they also affirm that MPS contributes to better quality of processes and products (Alpha 11%). Associates also confirm that in addition to increasingly associating the MPS with job cuts (as discussed above), the MPS is also seen to lead to shorter cycle times (Alpha 6%).

It has to be stressed once more, that these results have to be seen in relation to the extremely positive rating of the first survey wave. Yet, one should not underestimate the fact that overall B results show a trend that individuals have become more critical regarding the implementation of the MPS.

Insofar, the results of B are, compared to the results of the other two sub-centres, slightly more pessimistic. During the implementation of the MPS commencing between the two survey points, staff opinion has changed, reflecting an increasingly more critical attitude. This change is particularly evident in terms of how actors rate the impact of the MPS on their work. The findings of the second survey show that work cycles and job cuts are now being associated with the implementation of the MPS. The heart of this negative trend is that the MPS is increasingly perceived as a rationalisation tool. Overall then, the results of B reveal that through the implementation of the MPS the level of skills needed has been reduced. As a result, workers also become increasingly replaceable. This links up neatly with the second effect associated with the implementation of the MPS, job cuts. In a sense then at B, workers are afraid of losing their jobs. This is perhaps also implied by the findings that workers are increasingly afraid of speaking about any mistakes they made, particularly with their superiors. One has to qualify these findings and it would be somewhat wrong to overrate these results and to attribute these critical implications exclusively to the implementation of the MPS, other potential factors such as a decline in customer demand for the product produced at B or the reluctance of workers to move to B's new production location represents factors which might have affected the survey findings.

5.5.2.3 Sub-centre C

Significant results at C overall reveal a positive perception of the implementation of the MPS. The key areas of perceived improvements are leadership and team work. Regarding the former, individuals confirm that superiors increasingly consider the opinion of associates particularly through the intensified use of the staff feedback tool (Alpha 2%). The inclusion of the opinion of staff is also underscored as actors rate that their know-how and experience has become more important for decisions made by superiors and planners (Alpha 5%). Moreover, the general trend at Centre Z is also extended to the individuals' impact on standards: associates at C express that the impact of their know-how and experience on standards has intensified (Alpha 10%). However, actors do not perceive this extended influence they have as affecting the job demand in a negative manner. On the contrary, results reveal that individuals' rate that job demands has decreased (Alpha 5%). This suggests that the contribution of know-how and experience are not considered an additional burden on the work. The results so far reveal that at C, the relationship between associates and superiors and the importance to the actors' opinion have improved. But what role does teamwork play in this context?

In line with the trend of improved teamwork perceived at A, actors at C also rate that the internal team co-operation has improved significantly. Coinciding with the fact that the know-how and experience of the individual has gained importance for superiors, individuals in teams too, are more likely to express their opinion freely (Alpha 2%), a result which can be directly attributed to the effect of team training, which associates state has become more useful (Alpha 11%). Staff also rate that occasions aiding the social intercourse C have also become more important for staff motivation (Alpha 5%): sub-centre events or parties like open days offer in addition to team trainings, additional occasions where staff can meet and socialise. Not surprisingly then, the negative trends signalled at B, particularly regarding an increased level of fear of speaking about mistakes, are not confirmed by actors at C.

The implementation of the MPS at C has lead particularly to improvements regarding the social aspect of work: individuals rate team work and leadership more positively. Moreover, sub-centre events and parties have contributed to motivate staff. The social aspects at work, such as improved team work and the relation

between staff and superiors, and outside work, such as staff parties and team training events are the dominant improvements at this centre.
The differences found at the individual sub-centre level can be summarised as follows.

At sub-centre A and C there is a positive perception of the MPS, whereas the results of B offer a slightly more critical picture. The effect the MPS has at sub-centre A is primarily an improvement of the work in and between teams, but also a better flow of information and communication. At B, staff is more critical about the implementation of the MPS, and associate it with a cut in cycle time and job cuts. At sub-centre C, changes in trend can be summarised in terms of improved social environment, as social relations in teams and between individuals and superiors have improved significantly.

Interestingly, the result of all three departments point towards the improved inclusion of tacit knowledge at work. Associates at A and C affirm that their know-how and experience shapes decisions made by superiors and planners to a greater extent, also findings of all three sub-centres affirm that the shop floor knowledge influences the content of standards more. At the same time, this inclusion is neither associated with an increase in the work load i.e. job demand, nor with an increase in the level of stress caused by mental work.

It is also significant to point out that no changes occurred regarding stress levels and job satisfaction. As already discussed with regard to the overall Z results, the implications are that there is no relation between job satisfaction and the inclusion of tacit knowledge.

5.6 Analysis and interpretation

Concerning the research intention to examine the link between standardisation, learning and control, the findings do not confirm that the standards introduced through the MPS contribute to actors being alienated from work.

On the contrary, at Z shop floor know-how and experience has been more incorporated into the decisions made, especially as superiors and planners draw more intensively on the know-how and experience of their staff. This points towards regarding standards as routines to reduce the degree of instability of both products and processes.

Regarding the standard setting function, those responsible for setting standards were since Taylor's days, Industrial Engineers but also planners. They had the power to set and control standards, and the workers had the responsibility to accept and keep to these standards. In contrast, as the empirical study showed, actors now have more influence over the setting of standards and the decisions made by planners and superiors. Instead of relying on the knowledge accumulated by planners and engineers, the results show that these planners and superiors are now increasingly relying on the opinion of staff on the shop floor. Their decisions thus incorporate what Polanyi has termed, the tacit dimension. By drawing on these practical insights, decisions are made closer to the actual root of the problem. Moreover, the control once exclusively exercised by Industrial engineers, planners or superiors in general, is now being shared and most importantly, is no longer perceived in terms of control over people, but is now understood to denote a control over the stable running of processes. The responsibility to ensure and control this process stability, is now shared by both superiors and staff. Insofar then, associates have received more freedom to contribute and voice their opinions, and by being encouraged to take part in the decision making process, staff have also gained more responsibility. This responsibility is not only limited to the inclusion of the individuals' know-how in decisions, but also extends to the actual standards set and used in production: actors confirm that their experience and know-how to a greater extent shapes standardisation. This change shows that Taylor's notion of the division of work has been undermined. As discussed in detail above, historically the actual standard setting process had been a prerogative of the Industrial Engineers, or the management. Actors on the shop floor were not included in the setting of standards. Instead, they had to accept standards given to them regarding how long they should take to perform certain tasks and how to perform them the best way. As stressed throughout the study, this separation of mental and physical work contributed to the alienation of workers from their work – work for them became meaningless. The findings of this study indicate that this situation has changed, not through changes as those called for by the labour process debate, but, through the introduction of a standardised production system. Although, the MPS had been created and implemented using a top down approach, the results confirm that individuals can influence standards used on the shop floor. Thus, and this is significant, the introduction of standardisation has both led to a greater degree of control of processes and at the same time, through the inclusion of their know-how and experience, has given actors greater freedom to define their own work. Standardisation is then not perceived as a top-down control instrument leading to a renaissance of Taylorism. Instead, the empirical survey shows that the know-how and experience of workers on the shop floor has influenced standards. The implementation of the MPS which with its 92 methods has undoubtedly contributed to a greater degree of standardisation of work and work processes. It represents a framework in which individuals are able to determine how their work processes should be regulated.

Moreover, the empirical findings show that the inherent controversy underlying the concept of standardisation, can be reconciled: standardisation, such as introduced through the implementation of a production system, leads to a greater harmonisation of processes, but this harmonisation is achieved by including the opinion and contributions of the workers on the shop floor: the contradiction between the need to regulate processes and the need to account for the individual human at work can be reconciled by offering individuals the opportunity to contribute their know-how and experience into the standards set. This can be only achieved, if standards are treated as temporary best standards and actors are encouraged to improve these standards continuously. The results of this present study underscore this relation, particularly the results pointing at an improved continuous improvement process at A.

Workers are also more satisfied with their work and the overall situation of work on the shop floor has improved. However, the result does not confirm this link: the inclusion of the tacit dimension does not coincide with more job satisfaction or a higher job demand. The degree of the inclusion of know-how and experience in decisions or standards is not perceived to impact on the work itself. The results thus reveal that the inclusion of tacit know-how is neither associated with a more motivated workforce, nor with a more demanding job.

The implementation of the MPS has had an effect on standardisation and control insofar as it encouraged the inclusion of the shop floor know-how and experience in decisions and standards. Thus, individuals received a greater degree of control in terms of how their work is organised through standards. This shows that the link between standardisation and the image of alienation has been eroded. Instead, through the inclusion of tacit knowledge actors have more control over their own work. Yet, the findings show that this greater degree of influence is independent from the motivation levels of individuals: the inclusion of tacit know-how does not at the same time lead to an increase in the motivation levels of individuals. What this inclusion of the shop floor know-how into standards however has done is, it has contributed to organisational learning. For one, the flow of information and communication between individuals and superiors, and also in teams and between teams has improved significantly. Learning takes place as actors express their know-how and experience. The forum in which they do this is either in conversations with superiors, within the team or between teams. Results show that all three channels of communications have increasingly played a more important role. Individuals were able to learn more about the know-how and experience of superiors or colleagues and vice versa.

Interestingly, results at Z do provide input as to the content of learning insofar as actors stated that they have become increasingly aware of the tasks their colleagues perform and that one key topic frequently discussed in teams has been quality. This shows that control has been delegated from the realm of the purely specialist staffed quality department, to the teams on the shop floor. This finding shows that with regard to the responsibility for quality, the MPS does not continue to follow the Taylorist division of mental and physical work, but instead delegates the quality responsibility onto the shop floor.

One result of extending the quality responsibility on the shop floor, might be that particularly teams at A, have also gained a better understanding of the context of their work. Thus, the communication between teams and the awareness about the responsibilities of colleagues in other teams has improved significantly.

Moreover, the dimensions of control and learning can be linked to an improved social climate witnessed in C. Parallel to the implementation of the MPS, the social aspect of work improved considerably: team training and social events improved contributing to an improved social atmosphere at work. At the same time, leaders received more feedback from their staff and team work improved. One possible explanation being that the standards regulating team work and leadership have contributed to this improvement.

Obviously, one has to qualify all these empirical findings, particularly when considering the that the observations conducted during the MPS audit have shown that there is a discrepancy between what is practised and what is preached: one the one hand there are written standards, on the other there are actors on the shop floor who have established their own, personal working routines. Although the survey findings confirm that the know-how and experience of the shop floor are increasingly included in the standards, the findings cannot confirm if and how these standards are actually practised on the shop floor. The findings do not show how much influence the actors have over the standards and if their colleagues in turn adopt these standards.

Also, the findings have to be seen in relative terms insofar as one has to point out factors other, than the implementation of the MPS itself which might have contributed to the positive results. Apart from the economic situation which as certainly affected the results, one has to point out that A, B and C produce three different products which vary in customer demand. At A, the "cash-cow" is produced, and the pressure to achieve the ordered output is high. Also, team work and components of the MPS, such as Just-in-time management and continuous improvement processes are already well established and have been practised before the introduction of the MPS.

At B, the customer demand for the decreases slightly and currently a new product is being developed and tested which will eventually replace B's current product. Because the new product is in the testing and development phase, there is uncertainty as to production numbers to be produced, and the technologies and machinery to be deployed. These uncertainties obviously affect the job prospects of actors at B.

At C, an old product is currently phased out, parallel the production start up of a new model is underway. With the new product, new machinery is being introduced. The department takes this opportunity to improve its team work. Thus the findings have to be qualified because parallel to the implementation of the MPS, team work activities were intensified through team trainings and regular team meetings. This has to be taken into account when considering the results, particularly the positive ratings of team work at C.

A general factor one has to consider regarding the findings is that during the initial starting phase of project, the motivation and activity levels are high. In the case of the MPS, the implementation of MPS standards on the shop floor was pushed by management. Thus the MPS became a subject not only discussed during team meetings but from the beginning, the responsibility for the implementation of the MPS was delegated to actors on the shop floor. Actors were, to some extent at least involved in the implementation process. However, it remains to be seen if this involvement continues after the MPS is fully implemented by the end of 2002.

An obvious limitation that has to be pointed out is the research scope. The findings have to be qualified insofar as they give a portrait accompanying the MPS implementation process at merely three departments of one production centre of the multi-plant DaimlerChrysler corporation. I do acknowledge that this represents a limitation of the single case study approach (Yin 1998). On the one hand this approach facilitates to draw a detailed and coherent portrait of one particular part of the company (Dalton 1959, Dyer and Wilkins 1991), on the other this limited local perspective does not permit an analysis of the correlation between globalisation and the creation of company-wide production systems, a significant aspect I pointed out in the case of the TPS. Neither does one case study alone allow the researcher to infer general conclusions about the reception of the MPS throughout the DaimlerChrysler corporation. Extending the research scope to an international level, Mercedes-Benz production plants outside Germany should be consolidated into the research. One particularly interesting extension would be to conduct a comparative analysis between the MPS and the COS, thus incorporating actors of both companies into a survey population.

Finally, the findings are based on two collection points within the period of twelve months. In order to examine if the trends perceived are sustained, more measure points are necessary. Useful are two or three measuring points, one in November 2002, almost at the end of the MPS implementation phase, but also at two or three points thereafter, in November 2003 and November 2004. Also, to extent the research scope, other production centres at the plant Untertürkheim could be included.

Summarising, the empirical analysis shows that the implementation of the MPS has caused changes in the organisation of work, particularly the issues of control and learning. Most significantly, the results refute the claim that standardisation is merely a control tool, implemented from the top down and reaffirming the classical picture of alienation of work. Instead, the tacit dimension, the shop floor knowledge expressed through the know-how and experience of workers is more incorporated in both, not only in the decisions made by planners and superiors, but also into the writing and adoption of standards. To this extent, the view of standardisation proposed by Adler and Cole is confirmed by the findings, as standards are not considered fixed one best way solutions, but allow that staff by bringing in their know-how and experience to refine standards. This inclusion of the shop floor wisdom coincides with improvements in the efficiency of the channels of communication and information. These are essential tools aiding associates to contribute their knowledge and hence facilitate the spread of tacit know-how through the organisation: organisational learning takes place. By encouraging staff to contribute their ideas, to some extent then, actors regain the control over process standards.

Parallel to thus strengthening the role of the actors on the shop floor, results also point at changes supporting the importance of teamwork within the context of standardisation. As individuals are able to contribute more to decisions and standards, the team as a forum for discussion has been strengthened, particularly concerning discussions about quality. The team then has become increasingly responsible for ensuring and controlling the quality of products and processes, a major goal of the MPS.

Thus put it in a nutshell, the empirical results show that through the implementation of the MPS, the role of the tacit dimension, the flow of information and communication, the role of the team and the relationship between individuals and superiors have improved. These findings however, have to be considered with care particularly as the MPS does not represent an isolated factor which has led to these results, but the economic situation and the particular production circumstance in each department have to be taken into account. Qualifying these findings, one must not disregard the observations presented in the previous chapter which point towards a more critical view of the influence the MPS has on the shop floor.

6 Conclusion

6.1 Research questions revisited

Steeped in the tradition of the industrial sociology debate on production systems in the automotive industry, this study intends to contribute to this discussion by examining the role of standardisation in production systems. In the wake of the current trend in the automotive industry to implement standard production systems, and exemplified by the specific case of the Mercedes-Benz Production System (MPS), the focus was placed upon examining three major aspects: first, the driving forces underlying the process of standardisation; second, the changing forms and function of standardisation; and third, in terms of control and learning, the influence of standardisation on the work of actors on the shop floor.

I approached the analysis of the driving forces of standardisation and the changing forms and function of standardisation from an historical-genetic perspective. Exemplified by the rise of quality management systems, I pointed out the key driving forces in the process of standardisation and the evolution of the form and function of standards from product parts to entire company processes. Viewed as a process of institutionalisation, I also examined the role standard setters play therein.

On those grounds, the introduction of standardised production systems in the automotive industry was analysed covering the history of production systems from the beginnings of mass production with the rise of Taylorism and Fordism, to the evolution of the Toyota Production System; the deliberately anti-standardisation oriented reflective production system of Volvo Uddevalla, right up to the current trend in the automotive industry to introduce standard production systems.

To examine one specific standard production system which is currently being implemented in detail, I presented a case study of the Mercedes-Benz Production System (MPS). In the first part of this case study, I analysed the process towards creating the MPS, its implementation process and the influence of organisational structures aiding this process. I also gave an account of the MPS-audit system, and based on my observations, the role of the auditor and reactions towards the audit on the shop floor were discussed. I also contrasted the MPS with existing standard methods of work, such as the REFA, and compared it with the Toyota Production System.

In the second part of this case study, I focused on the influence of standardisation on the work of the actors on the shop floor, particularly in terms of learning and control. To do so I, conducted two surveys. My main concern being to examine the influence of standardisation on the issues of learning and control and thus to

evaluate to what extent the argument of Adler and Cole holds true in the case of the Mercedes-Benz Production System.
I shall now proceed to present the conclusions drawn from my research findings. For this purpose, this final chapter is divided according to three major questions raised: First, I shall commence with the conclusions from my findings about the driving forces of standardisation. Second, the focus will be on the findings about the rise of production systems in the automotive industry. Third, I will present my results of the changing forms and functions of standardisation in production systems. Based on the quantitative findings of this study, in the fourth part, conclusions drawn about the link between standardisation, learning and control will be given. In the final part of this conclusion, I shall present an outlook upon future research issues which arise from the findings of this study.

6.2 The driving forces of standardisation

The research I conducted has shown that the historical evolution of standardisation is a process primarily driven from three directions: the state, companies, and customers. Thus, a number of key driving forces exist. From the perspective of the state, warfare and the protection of national economies drive the standardisation process. From the perspective of the company, outsourcing activities, the need to control internal processes, cost factors and globalisation drove the introduction of standards for parts, products, processes and also skills. From the perspective of the consumer, demand, quality and health and safety issues influenced the process of standardisation leading to the rise of mass production and the introduction of quality standards. In the following, I résumé these findings.

Concerning the influence of the state on the process of standardisation, the need to supply the US military with identical weapons drove the development of interchangeable parts in the early nineteenth century.

In the twentieth century, the two World Wars brought the urgency of national and international standardisation to the forefront. On the one hand, standardisation emerged as a technique of interchangeability, on the other it contributed to the conservation of the scare resources and raw materials available during the war times. Also, the differences between weapon and supply management between the Allies pointed at the significance of having common standards between interfaces to co-ordinate processes. This resulted in an influx of academic activity in the areas of operations research for materials management, value analysis and statistical methods such as linear programming and sampling methods to regulate the material flow.

During times of peace, national interest and politics also drove the process of standardisation. During the 1970s, a vast range of different quality standards existed. The difficulties of companies to reconcile these, different, often contradictory standards, raised the necessity to create a standardised model for quality management systems. The findings show that this standardisation process was driven by the political influence, particularly by the British government under Margaret

Thatcher. Britain had already adopted NATO standards as British National Standards and by doing so pledged to use their system of quality management as a "prototype" for the ISO 9000 series. The motivation behind this stand was to establish a counterbalance to the dominance of the label "Made in Germany".

Moreover, with the adoption of the British quality standard as an international standard, Thatcher also intended to raise the awareness of British managers for the quality of products and the advantages the British industry could achieve against their rival competitors when adopting standard quality assurance and management systems. The political interest exerted by the British shows that on a political level, standardisation serves to protect national industries and by pressing for the acceptance of a national standard as a world-wide standard, nations can exert political dominance.

Regarding the role of companies in the process of standardisation, there are two major driving factors: outsourcing activities and control in context of globalisation.

Companies have increasingly outsourced the production of parts and components to suppliers. Manufacturers are thus no longer solely responsible for producing all parts of one particular product. However, they continue to be obliged to ensure that their products fulfil the quality requirements. As a consequence, new contracts between manufacturers and suppliers were introduced asking suppliers to perform quality inspections and thus to pledge a zero defect guarantee. The quality liability shifted from the manufacturers to the suppliers. To ensure that suppliers delivered the correct quality, the introduction of a standardised quality management system was inevitable. This need also drove the development of quality management systems. Through its inclusion in contractual clauses, it became the key to both the process reengineering of German supplier firms and one of the major instruments for making new supplier relationships tolerable within the German liability law in the late 1980s.

Second, companies use standards to reduce the variety of processes and approaches. As processes become more transparent, individual deviations were more "visible" and could therefore be detected more quickly. The aim of these standardised systems is to contribute to a simplification and economisation of management functions, particularly as companies pursued globalisation strategies and set up international multi-plant organisations. Thus globalisation and control of global operations are key drivers in the process of the development of standards. Standardised operating procedures aid the co-ordination of manufacturing processes of global operating companies. As processes are thus simplified, it is less time consuming and complicated for management to comprehend processes and to manage various international locations. Global standards therefore ease the controlling of multi-plant organisations and, with the help of bench mark studies, facilitate direct comparisons and evaluations concerning the productivity between international locations, which can then readily be conducted. Also, differences in production capacities are levelled out as the standardisation of processes facilitated the moving of products between plants. Through the introduction of global-standards companies can reap the benefits of exploiting both the economies of scale and the economies of scope. This occurs as company-wide standards make it cheaper to produce a range of related products at different international locations and this in turn provides a base for the economies of scale a company can reap, as the average production cost per unit thus decreases.

Concerning the customer as being the third driving factor in the process of standardisation, manufacturers realised the economies of scale and scope, the price of products decreased and subsequently consumer demand is stimulated. Hence a virtual cycle is established. However, price alone does not determine market demand: customer demand and satisfaction depends upon the quality of products produced. From the perspective of the company, to satisfy customers and to ensure continued customer relations, companies have to produce products of adequate quality. Thus, standards regulating product specifications evolved which listed the quality requirement products had to fulfil. These standards are primarily introduced by national standard setting institutions. Consumer test services also provided research and comparison on the quality of goods. Independent, non-profit product safety testing and certification organisations issue standards for materials, test the manufacturers' compliance with those, and award marks for quality compliance. For customer complaints, ombudsmen in companies were made available and data banks, which started recording the number of complaints lodged against a particular entity, were set up.

However, customers not only demanded that products were of adequate quality, but that products also guaranteed safe usage by the customer. Thus health and safety standards for products, and also for processes, work and the environment, were developed. Regarding products in the pharmaceutical, foods and food additives sector, to protect consumers, quality became regulated by government certification through federal law. Thus a range of quality standards was then developed. These ranged from the development of standard labels for hazardous substances, standard health and safety regulations at work, ergonomic standards for the workplace, and standards to control the level of toxic emissions, such as for example standard limits of emission levels of vehicles.

6.3 The evolution of production systems in the automotive industry

The history of production systems begins with the introduction of standardised parts for arms heralding the end of the period of craft production in America. First, identical parts for weapons were traditionally manufactured by hand and subsequently tools and machines for the production of standardised parts, such as jigs, gauges and milling machines were developed. This marked the transition from the craft production period to the rise of mass production. The foundations of craft production and the importance of the all-round skilled worker were no longer sufficient to ensure the standardisation demands posed on the arms producers.

The American machine tool industry bridged the inherent gap between the production of arms and the production of consumer durables. In order to be applied in a range of production circumstances, standards had to be documented. Plans and drawings of parts in scale were produced and thus the standardisation in the American System resulted in the formalisation of parts' specifications. Whereas before, craftsmen used their inherent knowledge of the parts' shape and size, detailed drawings now documented the exact measurements, angles and other specifications of the part to be manufactured. I pointed out that with the emergence of mass production, those concerned with the production of parts were no longer involved in the product design process itself, instead, formally drawn up plans provided guidelines of the design of parts: a step towards reducing the skills and the influence of the craftsman on the shop floor. The role of the craftsman was eroded with the rise of Taylorism. Skills and work became highly standardised.

It was Henry Ford's achievement to combine Taylorist principles with technological advancement. This led to the rise of the first formalised production system in the automotive industry, Ford's system of mass production was first applied at the Highland Park plant in 1914. Based on the research findings, it is evident that mass production represents the first formalised production system. Its key components are: technical and process standards, work standards and social standards. Ford deployed and refined the system of jigs and gauges and not only introduced new technical standards of car parts (such as wheels), but also entire complex parts, such as transmissions. Moreover, by developing the moving assembly line, Ford extended standardisation to production processes which thus determined the work places and work content. The rhythm of the line determined the speed and rhythm of work. Ford deployed Taylor's *Principles of Scientific Management* to regulate the sequence and timing of tasks.

Standardisation in the Ford's system of mass production extended from the shop floor to the social sphere of the workers. The 5$ day is an example of how Ford used the monetary incentive to coerce workers to adapt his social ethics. Due to the labour surplus, workers had no choice but to conform to Ford's social vision and to accept and adapt to the living standards he envisaged as the American way of life. Ford's system of mass production did then not only erode the control of workers over their work, but also penetrated into the workers' private spheres, affecting their control over their private, social and cultural areas of life.

The second major production system which emerged in the twentieth century was the Toyota Production System (TPS). It represents the next major step in the evolution of production systems after Ford's system of mass production. At its core is the intention to constantly improve processes and standards with the goal of reducing any form of waste, be it faults or unnecessary movements at the workplace. Thus standards are constantly refined. The organisation of work in teams, the standards regulating operations, the kanban system or the pay system, all contributed towards this continuous improvement process.

In its idealised form, kaizen activities drive a learning spiral between shop floor - experts and the shop floor. Insofar, the dynamic process of standardisation is internally generated. By contributing to the refinement of standards, the know-how and experience of each actor is integrated into the standards of the TPS: the individual worker is thus able to set best practice standards and hence can influence existing standards. Standards in the Toyota Production System represent specifications about how processes are to be structured which are then assessed and improved by workers. Hence, initial TPS standards provide an input, an improvement opportunity which then allows the worker to bring in his know-how and experience to refine them. As a result of the inclusion of the know-how and experience of the workers in standards, this knowledge is shared and hence the TPS contributes to the creation of an "evolutionary learning environment" (Fujimoto 1997). Today though, this idealised form of kaizen has changed and the standard setting process at Toyota today has become dominated by experts (Shimizu 1999). This implies that the tacit know-how and experience which once represented a key ingredient in the continuous refinement of standards at Toyota, has been replaced by expert knowledge.

The third main production system which can be distinguished is the reflective production system of Volvo Uddevalla. It emerged as an alternative to the traditional system of mass production and the Toyota Production System. Instead of deploying an extensive system of standards to regulate production processes and resources, Volvo relied on the individual worker and teams to organise their work introducing a system of standards intended to regulate and control the work according to their individual best way. The reflective production system offered the workers the opportunity to decide on the extent of work content and thus their individual cycle time: work was structured and organised around the individual skills of the worker.

Moreover, instead of following standards regulating the number of tasks workers have to perform, the reflective production system offered workers the possibility to complete the assembly of a car and thus encouraged the creation of holistic and functional tasks. As a result workers gained a holistic view of their work. Thus, Uddevalla did away with two key factors traditionally associated with mass production: short cycle times and highly repetitive work.

Today, in the wake of the increasing importance of globalisation strategies, automotive manufacturers (and also their major suppliers) standardise their production systems and interfaces with suppliers to level out national and plant-specific variations. The introduction of explicit, formalised production systems marks a shift away from local, idiosyncratic solutions and informal experience-based routines. They thus represent a system of formalised routines. This rapid and rather drastic revision of the production system orientation shows that the Swedish inspired production concepts, exemplified by the reflective production system of Volvo Uddevalla has not had a long-lasting effect on the attitudes and thinking of the majority of automotive manufacturers and has not influenced company-specific production systems. Instead, with the introduction of standardised company-level production systems, a distinct step in the process towards implementing the universal principles of "lean thinking" as propagated by the MIT-study is taken: the Toyota Production System is taken as an exemplary model thereof and a majority of Western automotive manufacturers use it as a standard reference model for their own production system.

There are key differences concerning how companies approach the issue of standardisation and its form and function within their production systems. Some companies stress the significance for organisational learning and the continuous improvement of processes, whereas the issue of standardisation in other production systems is less prominent or is even rejected (Jürgens 2002). Insofar, a number of variations of the Toyota Production System exist.

The case study about the Mercedes-Benz Production System exemplified how a company-specific standard production system is created and implemented on the shop floor. Its content confirms the close affiliation to the Toyota Production System which has been used as reference model for the Mercedes-Benz Production System. The difference between the two production systems is that the TPS relies upon the pressure of external structural drivers, such as the Just-in-time system, the pull production principle, and the kanban system, to regulate the work of the actors on the shop floor. Through the continuous improvement process these external structural drivers are interrelated with the work of the actors on the shop floor. For instance, the TPS considers the kanban system to facilitate the minimisation of inventory levels. Thus kanban and inventory levels force workers to contribute to the continuous improvement of processes. This pressure exerted by these external structural drivers on the work of actors is less evident in the Mercedes-Benz Production System.

6.4 Changing forms and functions of standardisation in production systems

The table below shows an overview of the resume drawn from the study of the changing forms and functions of standardisation. In the first column, the main steps in the historical evolution of the organisation of work and production systems is shown, ranging from the pre-industrial period craft production period until today. The second column shows what form standardisation has taken, and the third column shows the function of standardisation during the respective period.

In the period of craft production, through the tradition of the journeyman and the apprenticeship training, the various skills needed to work as craftsman in a trade were standardised. During the apprenticeship training, each apprentice was taught these skills of the trade. Skills encompassing a wide range of tasks the craftsman had to perform, including administrative tasks, the planning and organisation of his work. The function of standards then was to pass on the traditional skills and customs of the trades.

During the early mass production period, the forms and functions of standardisation changed and focused on providing technical norms for products and parts. Thus standards specifying the dimensions of nuts and bolts, gauges and jigs were introduced. With the technological evolution, the need to introduce standards regulating the design and manufacture of products arose. At the dawn of mass production, standardisation focused on the provision of technical norms for parts, tools and machines. The function of standardisation was to provide for the production of large number of identical and interchangeable parts and products needed to support the mass production of products.

Table 6.1. The changing forms and functions of standardisation in context to the historical evolution of production systems in the automotive industry

Historical Period	Forms of standardisation	Functions of standardisation
Pre-industrial period	Skills	To pass on traditional craft skills: journeyman tradition and apprenticeship training also through the establishment of the cloth show
1850 Early mass production	Technical standards/norms for: parts, tools, jigs and gauges, machines	Interchangeability of parts and foundation of mass production
1911 Taylorism	Task content and performance, task sequences, selection of workers	Scientific management and management control over shop floor
1914 Fordism	Work, material flow processes (assembly line), social standards, wages, quality inspection	Economies of scale through mass production, control of production processes, quality and social aspects.
1942 - 1992 Toyotism	Dynamic standardisation: standardised operating routines, external processes	Waste elimination, continuous improvement of processes, integration of shop floor know-how and experience into standards
1989 - 1993 Volvoism	Apart from standardised material flow, no standards to regulate working processes	Individualism, holistic learning, long cycles, extended work content
2002 Today	Standardised processes: formalised, best practice methods, routines and processes, audit systems	Co-ordination and control between interfaces within companies and between companies and suppliers

As expansion towards mass production continued, the organisation of labour and work called for reorganisation. Subsequently the focus of the forms and functions of standardisation shifted from technical norms, to providing standards for work processes. This occurred primarily though the introduction of Taylor's *Principles of Scientific Management*. Thus the work content, work methods and work sequences became standardised.

Ford deployed Taylor's standards of work. Moreover, through the introduction of the moving assembly line, the forms and functions of standardisation encompassed production and work processes. With the introduction of Ford's set of living standards, standardisation came to include social aspects. At the same time, standards to provide for the quality of products were introduced. These contained standards for the inspection and quality control of products. Thus the climax of standardisation was reached as the forms and functions of standardisation encompassed technical norms of tools, machines and parts; mechanical standards regulating the production flow, work routine and process standards, living standards and quality standards. The function of standardisation was not only to control product process, but also the worker within the production process and beyond, in his social realm.

Rooted in this system of mass production, the development of new production concepts in Japan gave rise to new forms and functions of standardisation. Standards became more dynamic as the Japanese integrated the principles of mass production and the American systematic approach towards quality control and assurance into their own production organisation. The function of standards was to eliminate waste, and through the continuous improvement process to integrate the shop floor know-how into the standardisation process. The function of standards being to present temporary best practice solutions which are then subjected to the continuous improvement by workers on the shop floor. Also the kanban system and the Just-in-time system represent external processes used to regulate the work of the actors on the shop floor. Standardisation thus has a key function in Japan, as the findings about the Toyota Production System have shown. Its form and function is primarily concerned with providing highly interrelated process standards.

The findings have also shown that standardisation played a less significant role in attempts to humanise production, such as in the reflective production system at Volvo Uddevalla. Instead of exploiting standardisation for the co-ordination and regulation of production processes, the organisation of production processes, work content, methods and routines were determined by the individual worker and teams. Thus the degree and scope of standardisation at Uddevalla was relatively low and primarily encompassed the organisation of the materials supply system and ergonomics.

Concerning the forms and functions of standardisation today, the Japanese influence is evident as standards are used to regulate increasingly complex processes. Also, parallel to this evolution of standardisation, the need to check the correct implementation of standards evolved. This gave rise to the introduction of standard auditing procedures. Standardisation thus encompasses standard systems and standard audits of these systems. As a result of this extension of the forms and functions of standardisation, a growing formalisation of the regulatory layers within companies has occurred. As validation, internal and external audits are conducted resulting in a reworking of inspectorial institutions.

6.5 The effects of standardisation on the actors on the shop floor

Focusing on the case study of the Mercedes-Benz Production System, in the following, I résumé these findings based on the observations and surveys I conducted.

As pointed out above, from an historical examination conducted, I concluded that audits are used to control the implementation of standards. This is also the intention of the MPS-audits. However, in the light of my empirical observations made during audits, this control function is not realised. Instead, the findings show that

through the introduction of MPS audits, new motivational structures emerge, particularly as auditees develop their own audit strategies.
This applies in case where self-evaluations for the preparation of audits are conducted. It shows that it is important for actors to be seen to comply with performance measurement system on the one hand, while keeping as much autonomy as possible, on the other. Audits thus offer scope for opportunistic behaviour and secondary, wasteful (i.e. non value-adding) activities. Thus, despite the regulatory control underlying audits, actors adapt tactics to undermine this control aspect of audits.

The influence actors hence have on the audit outcome is not restricted to the tactics of the auditees alone but also extends to the role of the auditors. Although auditors aspire to be "neutral" and are selected primarily from quality management departments on the ground of their extensive experience with quality management audits, my findings show that quality auditors lack shop floor experience and knowledge regarding issues concerning production.

Moreover, based on the observations I collected whilst working on the shop floor, I concluded that, although actors are aware of the existence of MPS tools and methods, they continue using their own individual methods which they have tried out and refined. This shows that despite the existence of the MPS and the intention to control its implementation through audits, the organisation of work on the shop floor is still being largely determined by commonly practised, informal shop floor routines. I showed that the goal of standardisation to reduce the variety of methods used on the shop floor and to introduce common standard methods and routines. At the same time though traditional methods and routines which workers initially developed and have been using since continue to be used. Informal shop floor know-how and practice continues to determine how processes and routines on the shop floor are performed. These observations have to be considered in connection with the conclusions drawn from the two surveys I conducted.

Based on changes in statistical significances,[1] the opinions of workers on the shop floor collected during my two surveys at centre Z in 2000 and 2001, show that during the course of implementing the MPS:

1. Actors on the shop floor exert more influence on the decisions made by planners and superiors (Significance: alpha 1%).
2. The know-how and experience of actors on the shop floor is more included in standards (Significance: alpha 0%).
3. Communication and the flow of information within and between teams has improved (Significance: alpha 2%) this has resulted in a more holistic view of work of actors on the shop floor.
4. A good relationship with colleagues, responsibility and a safe and clean working environment are the main motivating factors of actors on the shop floor.

[1] Using the t-test, the significance level was set at 5% based on a 95% confidence interval. All results with significance values of 5% and less are therefore considered significant and are denoted as Alpha. Results with a significance value exceeding 5% are considered less significant.

Pay, staff qualifications and participation, are the most important factors in need of improvement.

5. Actors expect that the implementation of the MPS leads to more safe and stable processes and better quality, but is least likely to improve motivation levels. Also, actors expect the MPS to increase the degree of control over their work, and to decrease the cycle time.

Most importantly, the conclusion drawn from the first two surveys shows that standardisation facilitates the inclusion of the know-how and experience in decisions and standards. Actors do not perceive this added responsibility as an additional burden on their work: workers did not confirm that the degree of intellectual work content increased (Alpha 37%), nor did they confirm a rise in the workload (Alpha 52%). By improving standards, the know-how of the individual is integrated into the standards, this know-how is then shared with other actors as they learn and adapt the new standard. Insofar then, the results show that the tacit know-how of actors is tapped through the setting of standards and hence standards provide a framework for sharing this know-how and represent a platform for organisational learning. As the shop floor know-how is also included into the decisions made by planners and superiors, actors have more influence over the organisation of work on the shop floor.

Concerning the improvement in the communication and flow of information within and between teams, findings show that actors have also become more aware of the tasks of other teams (Alpha 1%). The awareness horizon of actors now goes beyond their own tasks and those performed within their own group. Instead of this limited or insular view restricted to their immediate working environment, individuals have learned about the responsibilities of others. They are therefore also more able to understand their own job function within the overall production. The results therefore point towards a shift in the individuals' perception from considering their work in isolation, to a more holistic understanding of their role in the entire production process chain. One explanation for this is that quality played a more significant role in discussions (Alpha 10%). As one key goal of the MPS is to improve the quality of products and processes through the implementation of the MPS, quality in turn receives more attention and features more prominently in team discussions and in conversations between teams. Thus actors learn more about the skills and responsibilities of their colleagues. They therefore receive a more comprehensive picture of the entire production process and are also more capable of understanding their own role within the overall picture.

Regarding the influence of the implementation of the MPS on motivating factors, the overriding motivating factor in both survey waves was the good relationship with colleagues, followed by responsibility, and a safe, clean working environment. Regarding the lowest ranks, social events like company parties, and flexible working hours are perceived least likely factors influencing the motivation of actors. Interestingly, this is also true of the boss as a motivating factor

Concerning the factors of work in need of improvement, the findings show that no significant changes of the ratings occurred. In both survey waves, pay received the highest number of positive scores in. That is, actors think that pay is the most important factor which needs to be improved. In 2001, this figure was closely followed by the need to improve staff qualifications whereas in 2000, the second most significant improvement perceived concerned the issue of participation. A consistent fourth place in the ranking was scored by improvements in work place design and working environment. The lowest ranks were relatively consistently represented by issues linked to working time such as improvements regarding part-time work, reduction of shift-work, and a general cut in working hours.

The actors perception of the MPS show that the most likely goal, the MPS will achieve is the safety of processes, followed by quality and improved delivery. The least likely goals individuals suggested that the MPS achieved was to cut costs and to improve motivation (morale). This is interesting, for as seen when looking at the evolution of standardisation, a key function of standardisation has been to provide economically efficient solutions. Actors however, do not associate the MPS with lower costs, at least not during the initial implementation stages. One explanation might be that the initial implementation process of a production system takes up additional resources and time needed to implement standards. Concerning the expected effect the MPS has on their work, in both survey waves actors rated that the more control the most likely influence of the MPS upon their work, followed by shorter cycles and job cuts. The least likely influence of the MPS is to lead to less qualification opportunities.

Conclusively, although the findings show that actors have more influence on standards and decisions on the shop floor, they perceive the implementation of a standard production system as a measure to rationalise processes, causing processes and work to become more controlled, cycles to be cut and potentially threatening their jobs. On the other hand, the findings show that despite the introduction of the MPS, actors continue using their own methods and work routines. This implies that through the inclusion of the shop floor know-how and experience, the standard routines and methods proposed by the MPS will be influenced and improved. Thus formalised standards set forth in the MPS provide a framework for continuous improvement and organisational learning.

6.6 Outlook

In the following I shall give an outlook concerning future issues which arise through the research conducted in this study.

With the Western automotive industry predominantly looking towards Japan for inspiration concerning how to organise their production processes, future research has to examine the implications of this over-fixation with Japan. One particular focus thereof has to be the change in the nature of the idealised form of the kaizen process at Toyota. Instead of the learning spiral between shop floor and experts and the inclusion of the tacit knowledge into standards, today experts regulate work processes and set standards at Toyota. Thus the tacit know-how and experience which once represented a key ingredient in the continuous refinement of standards at Toyota, has been replaced by expert knowledge.

A second future research issue I would like to raise being the effect the introduction of standardised production systems has upon suppliers. Delivering components and parts to a range of different manufacturers, suppliers are faced with a growing number of different standards they have to fulfil. These demands on suppliers are intensified as manufacturers introduce different standard production systems. Will suppliers be subsequently forced to reorganise their production around different key account client lines? This would not only lead to a reorganisation of the production processes of suppliers but would have repercussions also upon tier two and tier three suppliers. Future research, particularly in the area of networking structures, as driven by Jürgens (2000), Sydow (1999, 2001), and Milberg and Schuh (2002), particularly the issue between internal and external networking partners, such as for example between automotive manufacturers and suppliers, but also between small and medium sized enterprises (SMEs) is necessary to trace the evolution of production systems beyond the actual manufacturers.

A third outlook from this study concerns the role unions have taken and will take in the future of the evolution of standard production systems in the automotive industry. To trace the role, unions and works councils have taken as institutions in the process of standardisation and also their role in institutionalising standards to protect the working conditions on the shop floor needs to be addressed.

Historically, unions have defended their acquired rights particularly through their fight for standards regulating workers health and working conditions. Particularly during Taylorism, unions insisted on the application of time and motion studies to curb the threat of "speeding up" (increasing the speed of the mechanically controlled assembly line).

In Germany, time and motion studies became regulated in the collective bargaining agreements between employers and unions (as reflected in the Steinkühler pay agreement of 1982, Jürgens, Malsch, Dohse, 1993) and are thus subject to integration of works council representatives (co-determination). To prepare union representatives for their role in the decision making process, they underwent the Industrial Engineering training as offered by the REFA and hence learned the methods and work practices of the Industrial Engineers at first hand. The intention to control the standard setting function of the Industrial Engineers (time and motion standards) by both employers and worker representatives, was particularly evident in the industrial nations in the West (less so in Japan). The influence of the Industrial Engineer to control and improve speed and standards at work gradually declined and instead became a key concern in the conflict between management and unions. Defending working standards regulating time and working conditions, management accused the unions of creating inflexible working structures which inhibit the company from competing, particularly in an increasingly global environment. Thus, for management, the methods and principles of the TPS, discusses in the lean production debate in the early 1990s represented a welcome opportunity for deregulation. This role of unions in the process of standardisation, and their influence on the changing form and function of standardisation, in my view, deserves future research attention.

Thus, the continuing influence of the Japanese production methods, the growing importance of experts in the standard setting process, and the growing importance of network structures and the implications of the introduction of company-wide standardised production systems for suppliers, and the role of works councils and the unions in the planning stages of new standard production systems, all create continuing issues for the industrial sociology and labour policy debate about the social implications of the role of standardisation in production systems of the automotive industry.

Appendix

MPS Employee Survey

MPS Employee Survey

I. Information and Communication	Completely agree	Mostly agree	Tend to agree	Tend to disagree	Mostly disagree	Completely disagree
1. I am well informed by my boss.						
2. The flow of information between and the communication with other teams is good.						
3. I am satisfied with our regular communication meetings.						

A) Within your division, how many improvement suggestions did you submit last year? (please state number) ☐

B) If you have submitted improvement suggestions, have they been implemented?
Yes ☐ partially ☐ No ☐

C) How long did the implementation take?
Less than three months ☐ Up to six months ☐ Up to one year ☐
Up to two years ☐ Longer than two years ☐

II. Leadership behaviour and management	Completely agree	Mostly agree	Tend to agree	Tend to disagree	Mostly disagree	Completely disagree
1. My boss regularly talks to me and my colleagues.						
2. My boss takes me seriously.						
3. I can speak about mistakes without being afraid.						
4. My boss encourages me to take on responsibility and to act self-responsible.						
5. My boss uses feedback as management tool.						

MPS Employee Survey

IIIa. Cooperation within the team	Completely agree	Mostly agree	Tend to agree	Tend to disagree	Mostly disagree	Completely disagree
1. During team meetings, everyone says what he/she thinks.						
2. Everyone is integrated into the team and is part of it.						
3. Decisions made by the team are followed through.						
4. Team building has helped us.						
5. All in all, I am satisfied with the results of our team meetings.						

IIIb. Cooperation between teams

1. I have to coordinate my work with colleagues of other teams.						
2. I know what tasks colleagues of other teams perform.						
3. My colleagues of other teams appreciate my work.						
4. The cooperation with colleagues of other teams is good.						
5. I am also responsible for maintenance tasks.						
6. In the production flow, I know who performs tasks before me.						
7. In the production flow, I know who performs tasks after me.						

MPS Employee Survey

IIIc. Know-how and experience	Completely agree	Mostly agree	Tend to agree	Tend to disagree	Mostly disagree	Completely disagree
1. My know-how and experience in production is important for and listened to by planners and other responsible managers.						
2. My know-how and experience in production is integrated into standards.						

IV. Quality

1. Quality is an issue we talk about in our team.						
2. I know our quality standards.						
3. I am able to influence the quality of our products.						

V. Own Work

1. The physical work puts a strain on me.						
2. The mental work puts a strain on me.						
3. The time pressure puts a strain on me.						
4. The demands on the skills I need to perform my job have increased.						

MPS Employee Survey

V.A. The following areas should be looked at in future to improve your work and your working conditions:	Completely agree	Mostly agree	Tend to agree	Tend to disagree	Mostly disagree	Completely disagree
- Work place design/ improved working environment						
- More diverse work / less repetitive work						
- Reduction of strainful work						
- More part-time work						
- Reduction of shift work						
- Pay						
- Staff qualifications						
- Reduced working hours						
- Improved participation						
V.B. I am satisfied with work						
V.C. I can find my own solutions to reduce stress and strain from work						
V.D. The following points motivate me:						
- Pay						
- Teamwork						
- Clean and safe working environment						
- To have responsibility						
- Company parties						
- To work for DaimlerChrysler						
- Right to participate						
- My boss						
- Task variety						
- Flexible working hours						
- Good relationship with colleagues						
- Training and development opportunities						

MPS Employee Survey

VI. Introduction of the Mercedes-Benz Production System (MPS)

1. Have you heard of the the MPS?
Yes ☐ No ☐

2. Will the MPS give you new career opportunities?
More likely ☐ Less likely ☐

3. Do you think the MPS will be successful?
More likely ☐ Less likely ☐

4. Which of the following results, do you think are likely, once the MPS has been implemented?	Completely agree	Mostly agree	Tend to agree	Tend to disagree	Mostly disagree	Completely disagree
- More stable processes						
- Improved delivery						
- Improved quality						
- Reduced costs						
- Staff issues are more important						
- No new results						

5. Will the MPS improve your personal motivation ?
More likely ☐ Less likely ☐

6. Do you think that the introduction of the MPS has increased the demands on you and your work?
More likely ☐ Less likely ☐

MPS Employee Survey

7. The introduction of the MPS will have influence in terms of:	Completely agree	Mostly agree	Tend to agree	Tend to disagree	Mostly disagree	Completely disagree
- Shorter cycle times						
- Reduced work content						
- Less qualification opportunities						
- Job cuts						
- More control over my work						
8. My overall impression of the implementation of the MPS is good.						
9a. I think the MPS is sufficiently supported by management						
9b. I think this will also be the case in the long run						

10. Your personal opinion about the MPS?

MPS Employee Survey

VII. Personal details statistics

1. Which age group do you belong to? Up to 20 years old ☐ 21 – 30 years old ☐ 31 – 40 years old ☐ 41 – 50 years old ☐ above 50 years old ☐

2. You are… male ☐ female ☐

3. What is your educational qualification? (Please mark your highest qualification or equivalent) Primary school (6 years) ☐ Leaving at 16 (9 years) ☐ GCSE/O-Levels (10 years) ☐ A-Levels (12/13 years) ☐

4. You finished your professional training as: Apprentice ☐ Supervisor ☐ Industrial Engineer ☐ Graduate of University/University of Applied Sciences ☐

5. You have a temporary contract ☐ permanent contract ☐

6. In which department do you work ? Department A ☐ Department B ☐ Department C ☐

7. You are: E3(Head of department) ☐ E4(Teamleader) ☐ E5(Supervisor) ☐ White collar employee ☐ Worker ☐

8. You have been working at this centre since: 19___ 200_

Thank you very much for your participation!

Glossary of terms, symbols and abbreviations

3K	Kitanai (dirty), Kitsui (stressful) and kiken (dangerous)
A4	DIN Norm for standard paper size
AAM	Alliance of Automobile Manufacturers
AG	Aktiengesellschaft
AGV	Automatic Guided Vehicle
AIAG	Automotive Industry Action Group
ANS	American National Standard
ANSI	American National Standards Institute
AQL	Acceptable Quality Level
ASQC	American Society for Quality Control
AT&T	American Telephone and Telegraph Co.
BBB	Better Business Bureaus
BMW	Bayerische Motoren Werke
BNS 5750	British National Standard
BSI	British Standards Institute
CAMI	Joint venture between Suzuki and GM
CCS	Civil Communications Sections
CD	Compact Disk
CEN	Comité Européen de Normalisation
CEN/TC	Comité Européen de Normalisation / Technical Committee
CEO	Chief Executive Officer
CIP	Continuous improvement process
CNC	Computer numerically controlled
COS	Chrysler Operating System
DC	DaimlerChryler
DCPS	Daimler Chrysler Production System
DIN	Deutsches Institut der Normierung
DIN EN ISO 9000	Deutesche Institut der Normierung European Norm International Standard Organisation
DM	Deutsche Mark
E5	Ebene 5
EDP	Electronic data processing
EFQM	European Federation of Quality Management
EPS	(Opel) Eisenach Production System
EU	European Union
FAKRA	Fachnormenausschuss Kraftfahrzeugindustrie

FMEA	Failure Mode Effects Analysis
GBR	Gesamtbetriebsrat
GHQ	General Head Quarter
GM	General manager
IEC	International Electrotechnical Commission
IFAN	Internationale Föderation der Ausschüsse Normenpraxis
IFT	International Automotive Task Force
ISA	International Federation of the National Standardizing Assocation
ISO	International Standards Organisation
ISO/TC	International Standards Organisation / Technical Committee
ISO/TS	International Standards Organisation / Technical Standard
JIS	Japanese Industrial Standard
JIT	Just in time
JMA	Japan Management Association
JSA	Japan Standards Association
JUSE	Japanese Scientists and Engineers
KVP	Kontinuierlicher Verbesserungs Prozess
MD	Median
MDS	Mercedes-Benz Development System
MIT	Michigan Institute of Technology
MPS	Mercedes-Benz Production System
MTM	Methods Time Measurement
NASA	National Aeronautics and Space Administration
NATO	North Atlantic Treaty Organisation
NC	Numerically controlled
NSBs	National standards body
NSCC	United Nations Standards Coordinating Committee
NUMMI	New United Motor Manufacturing Inc.
PDCA	Plan, Do, Check, Act
PMI	Post merger integration
PSA	Peugeot Citroen S.A.
PWS	Production Work Shop
Q101	Quality standards 101
QM	Quality management
QMC	Quality management centre
QS	Quality standard
R&D	Research and development
RADAR	**R**esult, planning and developing of **a**pproaches, **d**eploying approaches, **a**ssessment and **r**eview of Approaches

REFA	Reichsausschuss für Arbeitszeitermittlung Today REFA - Verband für Arbeitsstudien und Betriebsorganisation
REZEI	Reorganisation der Zeitarbeit
ROQ	Return on quality
RPS	Rastatt Produktionssystem
SDCA	Standardise, Do, Check and Act
SPC	Statistical process control
SPSS	Statistical Package for the Social Sciences
SQC	Statistical Quality Control
SWI's	Standard work instructions
TPS	Toyota Production System
TÜV	Technischer Überwachungs Dienst
TVR	British Sports Car Manufacturer
UAW	United Auto Worker Union
UK	United Kingdom
US	United States
US MIL-Q 9858	United States Military Quality Standard 9858
USA	United States of America
USD	United States Dollar
VDA	Verein Deutscher Automobilhersteller
VDA-QMC	Verein Deutscher Automobilhersteller Quality Management Centre
VPK	Verkehrstechnische Prüfungskommission
VW	Volkswagen

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