MANAGEMENT AND NEW PRODUCTION SYSTEMS

THE 3RD INTERNATIONAL PRODUCTION MANAGEMENT CONFERENCE ON MANAGEMENT AND NEW PRODUCTION SYSTEMS

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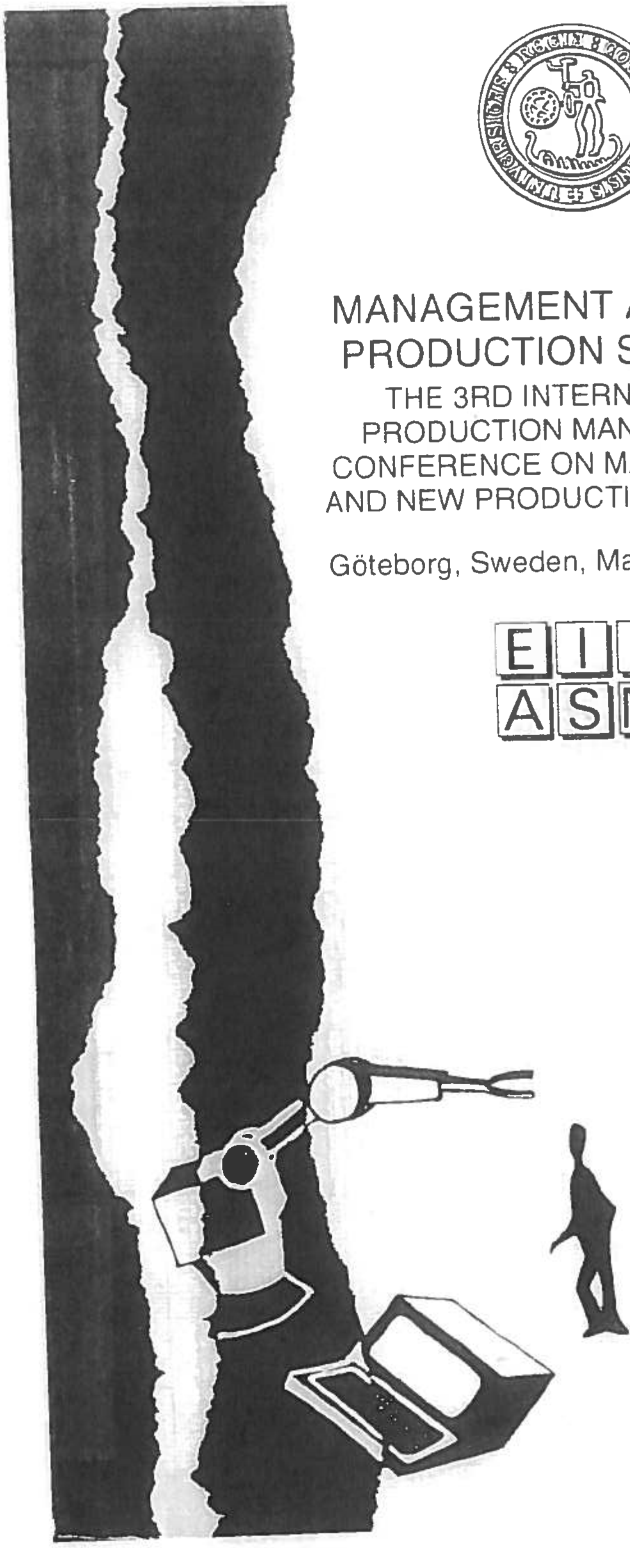

Part 1 (2)

Words of caution should be inserted concerning the interpretation of the results of the presented study. The data are subjective. The participants have given their perceptions of the managers and the job situations. I have chosen to present these informations as indications of objective realities, assuming that the perceptions and descriptions to some extent mirror real leadership behaviours. As a consequence the factors are seen as depicting leadership behaviour dimensions. But a quite different interpretation can also be made; that the perceptions are idiosyncratic and the descriptions mainly reflecting the personality of the perceiver. In such a case the factors and dimensions are to be considered common mental structures people have for perceiving leaders and leadership. The results still rises an interesting question: Why do people in the organization use a category of change in perceiving leadership behaviours, a category that was not applied earlier?

The theoretical position taken in this report is that there exist general leadership behaviour dimensions (leadership style dimensions). The behaviour of the leader is, however, to some extent adapted to the concrete situation, especially the single subordinate or group of subordinates. This means, for instance, that a highly structuring leader is structuring in all situations but that the degree varies somewhat according to the persons involved. Different subordinates thus have real differences in leader behaviour as basis of their perceptions and descriptions. This theoretical view does not exclude personality flavoured, idiosyncratic parts of the variance between leadership descriptions. Thus, when a subordinate describes the leader's style three influences are in action; a. the general behaviour style of the leader, b. the adaptation of the behaviour to the subordinate and c. the subordinate's idiosyncratic way of perceiving the leader's behaviour.

The stance taken here is that the behavioural style of the leader is paramount in the description.

The Possibilities of "Lean Production" - A Comparison between Different Production Flow Concepts in the Automotive Industry.

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The book "The Machine that Changed the World" (ref. 1) has focussed attention on how efficiency can be increased in line production and seeks to prove that the moving line has a greater potential than is exploited in today´s mass production. The need has arisen to put forward empirical evidence, based on Swedish experience, to show that efficiency can also be improved when other production systems are used. There are several reasons for these efficiency gains. The new Swedish alternative production system is dismissed in the book as a failure, in spite of the fact that the authors have not visited the Swedish factories, even less examined them. Nor is any evidence presented to support the correctness of the approach. A basic tenet of this paper is that Volvo's Swedish Uddevalla Plant (hereafter referred to as Uddevalla) represents a breakthrough in production systems for the final assembly of automobiles. In section one we briefly sketch two different planning philosophies; the one in use when Uddevalla was projected is examined more in detail. Section two consists of a discussion of three production concepts as they apply to the final assembly of automobiles, viz. Mass Production (Neo Fordism), Lean Production (Toyotism) and Reflective Production (as intoduced below). In this connection, we also analyse the notion of Lean Production. Section three amplifies the analysis of different production flow concepts for final assembly and in particular addresses the issue of new mechanistic and organic production flow concepts as alternatives to conventional line assembly. Section four reports the implications for management. The text is based on practical production engineering work in connection with the introduction of new production flow concepts. In section five we spell out some conclusions and summarize.

1 TYPES OF SOCIETY AND PROJECTION APPROACH

1.1 Types of society

North American society has a particular historical relation to the automobile industry; the cradle of Mass Production stood at Ford's moving line. Japanese society is interesting for the automobile industry of today; both management and the moving line have been made more efficient and efficiency has also been improved in the relations within the automobile manufacturer and to its suppliers and markets - Lean Production.

The relation that Swedish society has to the automobile industry has its origin in special preconditions in the labour market; work content in the new industrial production processes has been developed to agree with human preconditions, both physical and intellectual. This has led to the development of completely new production systems which can replace division of labour in societies where people's capacity as thinking creative beings is exploited. This is important from the point of view of recruitment, for example.

The origins of these differences in preconditions for the realization of new production systems lies partly in the contrasts between societies. One important factor is that industrial relations on the North American labour market continue to build on the classical conflict between work and capital and therefore phenomena connected to solutions based on mutual understanding have no great effect. In Scandinavia the situation is different; solutions arrived at in an atmosphere of critical, distanced, mutual understanding are regarded both as being able to bridge immediate conflicts and also as conducive to results that exceed those that would otherwise have been possible. This gives new thinking excellent preconditions.

North America, Sweden and Japan have also developed differently in relation to their markets. In contrast to the North American, both the Swedish and Japanese automobile industries are strongly export-oriented. The Swedish automobile industry, as opposed to the Japanese, consists of low volume production aimed exclusively at the luxury class.

Manufacturing in Sweden has been successively complemented by factories in other countries, because of marketing restrictions. The North American automobile industry manufactures for the home market; it has acquired factories in other countries and focuses on the markets around these factories. The Japanese automobile industry produces for both domestic consumption and export, but has also established manufacturing in the countries where the markets are. When plants have been established the production system dominating at the time has been used; this has meant that the majority of these Japanese plants have line production systems.

Japanese automobile manufacturers have, for reasons of market restrictions, established a number of plants in foreign countries. In this connection they have taken with them their own production concepts and created "copies" of Japanese production facilities outside Japan, so-called transplants (ref. 2). When Swedish plants have been established abroad, alternatives to line production was introdused in plants with too small production volume for paste line assembly, among other places in South East Asia. Volvo has thus gained some practical knowledge of alternative production systems, albeit on a small scale.

1.2 Projection and planning ideals

The projection and planning of new factories in Sweden takes place largely along the lines of the following model. The prevailing approach for factory layouts - the moving line - is supported by an institutionalized, rectilinear projection technique. It is thereby assumed that the track from start to finish is a straight line. Behind this lies the assumption that there is one correct way to solve the problem (figure 1). This means that the task of reaching the goal does not start until the goal has been fixed and operationalized, in line with the accepted proposal for a solution. This can be very efficient, the goal has really been correctly understood and formulated.

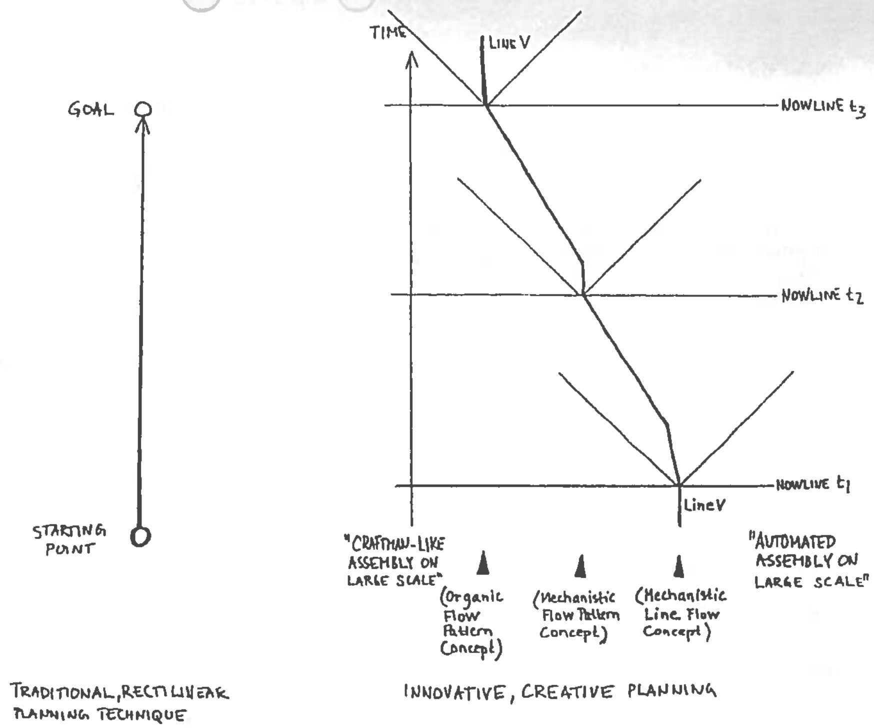

Figure 1. *The left diagram illustrates the traditional, institutionalized projection technique with its rectilinear relation between starting point and goal. The right diagram illustrates how the vision of a final assembly plant can change over the course of a planning period. The diagram is based on time-geographical principles. The development is related to the passage of time (vertical axis) and a dimension of which the extremes are "automated assembly on a large scale" and "craftman-like assembly on a large scale" (horizontal axis). Such variables as work amount, total number of workers involved in assembly, the worker's personal knowledge, the development of this knowledge, and control of the pace of flow, whether determined mechanicalt, or by the worker himself, are central elements in this dimension. In the right diagram the position at the times of certain important decisions are indicated. By the point in time of "now t_1" the different possibilities are indicated by the top of the angle, touching the "nowline" at t_1. The line V illustrates how a project can move within the range of the angle as time passes. At the decision point indicated by the "nowline" at t_2 another angle has been drawn to show the further possibilities of the project. The same holds for the "nowline" at time t_3. The diagram thus illustrates, by the line V (in principle, not in detail) how solutions to fulfill the goals in the planning of an assembly plant can change in the direction away from automation to increased individual worker control (ref. 3).*

By employing consultants and applying this projection ideal, industry paves the way for competence waste. The consultants build up a unique competence about the factory and about its preconditions, but since they do not belong to the permanent organization they leave and take their competence with them, at exactly the time when it is needed most - when the idea is to be realized.

New thinking and creative projection and planning mean rather that guidelines are set for where proposals for solutions are to be found, based on one's position at the start, "now". The possibility is then created to take advantage of alternative solutions that may appear during the work, and which can provide better preconditions for attaining the goals set (figure 1).

During the projection of Uddevalla the creative projection model was applied, which meant that two conflicting approaches existed side by side for a long time, until the proposal for a solution in one of them proved to be superior. This puts great demands on the ability of the project leaders to handle conflicts that may arise during the projection. It is necessary to realize that the essential fundamentals must be maintained. Sooner or later one proposal for a solution must be chosen, in accordance with one of the paradigms - but the choice must be made when several factors indicate just one of them. It is not sufficient for one factor to point in a certain direction. There is a risk that the worst result will be achieved if only tradition points to one of the proposals (ref. 3).

2 ALTERNATIVE PRODUCTION CONCEPTS

2.1 Lean Production

The notion of Lean Production as presented in "The Machine that Changed the World" (ref. 1) covers a broad range of activities including product design, supply of parts, manufacturing processes, and marketing of products. Manufacturing processes in the case of automobiles include welding and painting of bodies, and final assembly. In this paper we focus on the notion of Lean Production as it applies to the final assembly of automobiles. Lean Production, we read (ref. 1):

> -"....is lean because it uses less of everything compared with Mass Production – half the human effort in the factory, half the manufacturing space, half the investment in tools, half the engineering hours to develop a new product in half the time. Also, it requires far less than half the needed inventory on site, results in many fewer deficiencies, and produces a greater and ever growing variety of products."

This and similar statements in the book seem to imply that the main objectives of Lean Production are high productivity , high product quality and high capital turnover. It should be noted that these objectives are today shared by virtually all automobile manufacturers, regardless of their production concepts. What is specific to Lean Production, then, is not the goals pursued but a high degree of goal attainment. Hence, the three objectives listed will be referred to below as "production objectives" rather than "Lean Production objectives".

The expression Lean Production is also used in another sense, however, viz. to refer to a specific production concept introduced by Japanese automobile manufacturers. In this sense, Lean Production is characterized by the means used to attain the goals mentioned above rather than with the selection or attainment of goals. When Lean Production is discussed, it is often unclear whether it is the objectives (the first sense) or the methods (the second sense) that is meant.

As noted by Berggren et al. (ref. 2), there is no systematic discussion in Womack et al. (ref. 1) of goals based on employee concerns such as quality of work issues. To remedy this imbalance, one might introduce the expression "generous production" to describe production systems that satisfy employee aspirations.

For present purposes, "generous production" will be defined in terms of three objectives, namely, high autonomy, meaningful work content and adequate ergonomics. It is debatable whether these objectives are as universal as the three objectives associated with Lean Production, i.e, whether they are considered important irrespective of the production concept adopted. We may nevertheless define generous production as production conducive to the attainment of these objectives.

It will be argued in this paper that alternative production concepts may be as economizing as the Lean Production concept and in addition more generous. One such alternative, which we have called "Reflective Production", will be presented in the next section.

We now turn to a comparative analysis of Lean Production in this sense and three other production concepts. The analysis is based on the simple model depicted in the figure below.

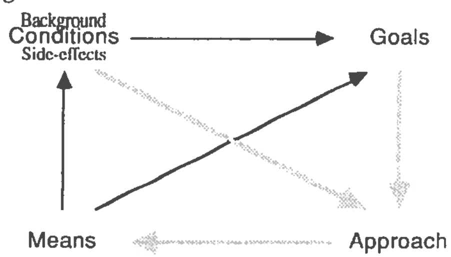

Figure 2. *A model for analysis of production concepts.*

A production facility is here regarded as a goal-oriented system. Goal attainment is jointly determined by prevailing conditions and means employed. Since the effectiveness of the means varies with existing conditions, they have to be adapted to the conditions. On the other hand, the means chosen may have certain side-effects ; i.e., they may modify the existing conditions. It may happen that conditions created by certain means reduce the effectiveness of these same means, so that the system becomes "self-contradictory" or "self-defeating". Conversely, the means may create conditions favourable to the effectiveness of these means; in this case the system is "self-sustaining".

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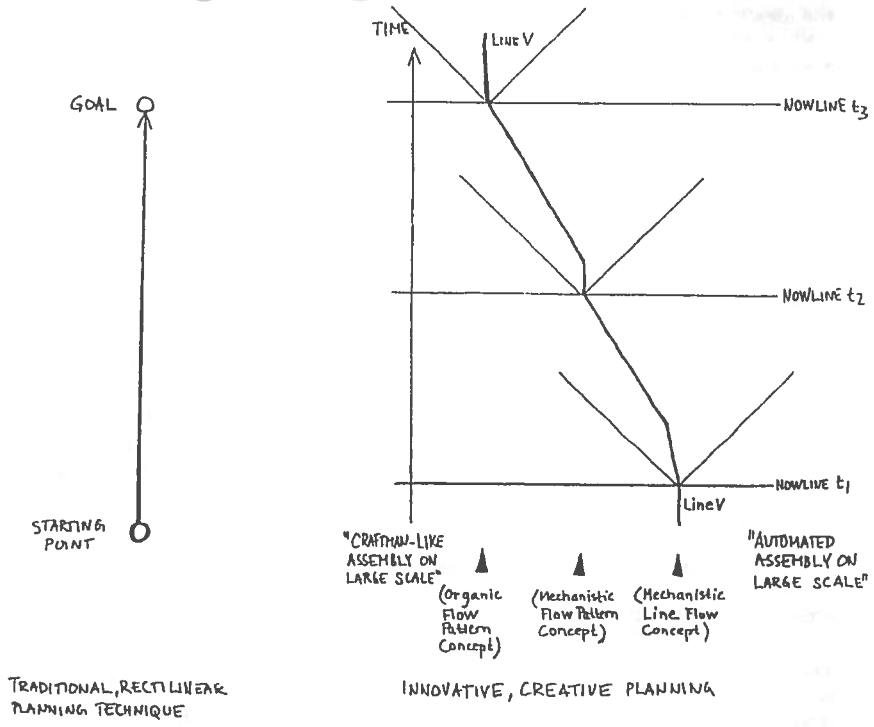

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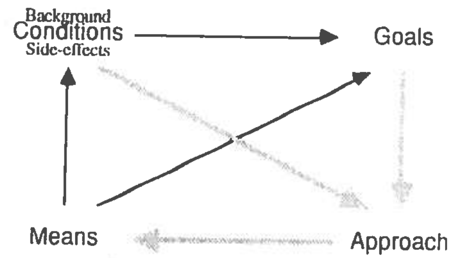

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The choice of means, finally, reflects some basic approach to the design and/or management of a certain type of production facility. This approach should ideally be based on a thorough understanding of given conditions and goals as well as of causal relations between conditions, goals, and means.

During the last decade, the traditional concept of Mass Production on assembly lines has been strongly criticized. This criticism reflects different points of view and addresses different areas of concern, including:

-Productivity and quality.
-Monotonous work tasks and absenteeism.
-Capital turnover.

The predominating line assembly production concept appears rational in that material flows are well-defined, a familiar material feeding technique is available etc. Internationally, the predominating trend has been to refine the line assembly concept to address these areas of concern. Some common methods to improve upon line assembly are quality circles, team work, just-in-time principles, extended subassembly, product standardization etc. Some of these improvements are sometimes referred to as Lean Production.

In Sweden, for reasons other than purely of productivity, attempts have been made to design assembly concepts based on the special relation on the labour market and on the value system in the population. This has led to efforts to upgrade industrial work. Technically, the direction is based on the idea of highly parallelized material flows that enable autonomous work teams to assemble objects independently. As a concomitant of this parallelization, the work tasks assigned to groups and individuals will comprise a larger number of work operations. This implies longer work cycle times requiring extended worker competence. On the other hand, new competences are also generated by the extended work content. The work teams are given responsibilities so that they can meet demands on quantity and quality.

2.2 Mechanistic and organic production flow concept in Sweden

Besides traditional line assembly, there exist two other fundamental production flow patterns for increasing production flow efficiency, which we shall discuss below (ref. 4 and 5).

1 Mechanistic flow pattern with centralized mechanizing functions are characterized by large differences in the degree of mechanization in the process (assembly and materials handling).

2 Organic flow pattern with successively decreasing mechanization and maintained/expanded sorting capacity from the beginning of the process to finished automobile.

An organic flow pattern meets the demands for efficient exploitation of space, flexibility, disruption in sensitivity and worker control of the flow to a greater extent than a mechanistic flow pattern. The organic pattern does not preclude adaptation of the degree of mechanization.

In a mechanistic flow in line assembly, specific work tasks will move between work stations for reasons, among others, of balancing. Components that are identical or have a connection with characteristics in the automobile will not always be assembled at the same stations for each individual automobile. This means that the assembly work is characterized by a number of additive sequences without any apparent logical connection. In the organic flow pattern a team assembles the complete automobile and the work groups control their production flow. The product's inner logic appears obvious, and the worker can correct faults directly, immediately after detection (the adjustment frequency thus will be lower because, among other things, better understanding, ref. 4 and 5).

The fact that considerable productivity losses are built into line assembly is frequently overlooked. This is mainly due to the natural human variation in working pace, the sensitivity to disruptions, the difficulty of balancing the work operations, and the need for extensive inspection and adjustment of the objects assembled (ref. 4, 5, 6, 7, 8, 9 and 10).

In addition, the products have become more complex and the number of product variants has increased. This has greatly enlarged the number of different components that have to be displayed along the assembly line. This, in turn, leads to, e.g., space shortages along the line and material handling problems when a line with conventional materials feeding techniques is used.

The fragmented work, where the individual's working pace is controlled by the movement of the assembly line, has led to high personnel turnover, a high level of absenteeism, and has undermined the sense of responsibility for product quality.

Both the work and its description have become fragmented in the case of line assembly, the main reason for this being, of course, the line itself, but also the way of describing the product and organizing the pre-production work (ref. 11).

2.3 Learning in mechanistic and organic flow concepts

Mechanistic and organic flow concepts require different competence. This in turn closely relates to the underlying principles of learning. There are two essentially different ways of learning; the dominating instrumental mechanistic method and the organic functional method. These methods include the organization of ideas and purely technical dimensions such as material flows and assembly instructions. Let us take a closer look at some important dimensions in each.

The instrumental mechanistic method rests on the assumption that the final results is the sum total of all component parts. Demands for standardization in combination with rationalization results in the replacement of meaningful names by codes adapted to machines. The parts are thus assigned a mainly numerical code suited to computer systems. For this reason, and through there being so many model variants, the number of parts seems enormous and impossible to overview.

The organic functional method for learning on, the other hand, rests on the assumption that the automobile is understandable when its the functions are known. Thus there must be adequate names in use for materials and components (ref. 4 and 5).

Transferring this organic idea to material handling techniques, the basis must be the automobile. This is important for the assembly workers but even more so for the materials handlers, who in their practical role must be professionals at choosing the correct materials. The product functions are normally realized through a number of physical parts (components) being related to each other (fitted) with predetermined quality (precision) and fixed to the automobile body. Using these wholes as a basis, it is possible to describe the automobile in terms of functional material groupings which are related to assembly. This means that functions, assembly and the position of the material can be taken into consideration at the same time (ref. 4 and 5).

2.4 Reflective Production - a concept for production system design and running

The introduction of parallelized assembly with extremely long work cycles changes the work content from being controlled outside the work process, towards team controlled flows connected to more complicated tasks, where the worker makes important decisions together with his co-workers on, for example, work pace and how exactly the task is performed. To make this possible in Uddevalla, for example, it was necessary to introduce a radical change of various technical and administrative subsystems. The assembly must be totally reorganized on the basis of formalized knowledge from the shop floor.Final assembly with considerably greater work content can then be achieved. Today's information technology allows completely new possibilities in this respect.

The new assembly concept has to be used in a wider sense on the shop floor. It must not only include the assembly itself, but also the preceding phases, i.e. quality control of the fitting itself, materials and mental and physical structuring , and the subsequent phases, i.e. final inspection, any necessary adjustment and further inspection (ref. 4 and 5). This new concept of extended assembly work, calls for workers' own reflections.

In a traditional Mass Production system, production is thus planned in advance down to component level by people other than the workers. The forming of the job is thereby divorced from the workers´ practical concepts.

Humanization in the Lean Production sense then becomes a question of replacing assembly with other activities. In Reflective Production, on the other hand, the work itself becomes intellectualized and thereby meaningful.

Established empirical knowledge of grouping and restructuring work tasks is also a basic precondition for the realization of efficient and humane production systems in the future. Such a total reorganisation leads to other

conclusions regarding industrial work than those accepted today. Work content, factory layout and investment in equipment will be chosen differently; manual, intellectual and machine resources will be exploited more effectively than today.

Production thereby becomes reflective in the performance itself. Reflective Production does not however stand in opposition to the goals of Lean Production. Reflective Production is based on the human specifications with regard to abilities and preconditions, which dictates the design of technical and administrative preconditions on the shop floor. Reflective Production builds on a system design of which the basis is knowledge of the basic specifications for both man and product. These preconditions then give unambiguous relations to both the market and supplier.

In order to nuance the debate around Lean Production we have introduced the concept of Reflective Production. Such Reflective Production has today been realized on the shop floor, in the organization of the preconditions for production and in the design of information systems. In the future this will influence the activities of design and pre-production.

Reflective Production is something radically new for applications in the automobile industry. Reflective Production does not mean a return to pre-industrial handicraft. Toyotism is the result of a long conscious refinement of mechanistic thinking (a refinement of the moving line). Effects that Neo Fordism and, to a certain extent, Toyotism have resulted in on the factory floor, have produced the preconditions for the development of Reflective Production. By Reflective Production we here refer to production related activities. In its application, compared to Lean Production, Reflective Production is a considerably more advanced concept.

Let us summarize: Both Lean Production and Reflective Production have a holistic view of the production that takes into account not only the assembly work and the technology structure, but also the relationships of product design and market demands to the organization of work. Product design will influence not only the production process, but also the ease with which service and repair activities can be performed. The Japanese vision of a holistic strategy makes it natural for designers and production engineers to work as a team in planning and implementing product changes and new products. It is also natural for them to seek views from assembly workers. This is a natural view also for those who advocate Reflective Production.

There are a number of distinguishing characteristics for Reflective Production. Reflective Production is based on the assumption that both human and product specifications are known and can be realized in practice. Reflective Production started on the floor and is spreading upwards in the organization and outwards to supplier and market. Reflective Production thereby rests on a solid empirical base.

The mechanistic stepwise flow concept

This system consists of eight production steps in series. The number of parallel channels varies between the steps and lies between one and six. This means that some parts of the system function in the same way as the line described above. The production steps are separated by intermediate dual-purpose buffers. First, the buffers compensate for variances in working pace in the steps and for variances due to different assembly objects having different assembly times. Second, the they sort the assembly objects, so that the sequence of objects is maintained throughout the system even if the objects overtake each other in production steps with parallel channels. This is necessary because of requirements from the materials feeding system.

Because of the varying number of parallel channels, the cycle time varies between 3 and 20 minutes (80 min. is possible in some parallel areas). In the parallel areas, the work organization is a team with six workers in each. Quality control and mechanical adjustment are performed both by the work groups in the production steps and in a separate adjustment area at the end of the production flow.

Materials feeding is a combination of four methods. So-called variant materials are picked in kits from local storage, basic materials (the same on each automobile) are delivered in batches for 12 automobiles to the work stations, small materials are fetched by the assemblers on requirement and finally, some materials are fed to the system in sequence deliveries.

The organic flow concept

This is a parallel system consisting of 50 parallel assembly teams, each responsible for the assembly of complete automobiles. The teams are grouped in product work shops. Each team has about eight members, performing inspection, mechanical repair, instruction, production planning, cleaning, production engineering tasks etc. The number of produced automobiles demanded of each group is related to the number of workers present and the automobiles' work load. Substitutes when members are ill are therefore not needed. The cycle time is normally approx. 100 min., but can vary depending on how the group distributes the work. In the extreme case a complete automobile can be assembled by two workers. Each team has four automobiles standing still and accessible for assembly. Assembly adjustment is done directly by the worker in the course of assembly. There is a spokesman in each team, a position that rotates among the team members.

The materials are delivered in kits from a centralized picking store. A number of minor subassemblies, as well as some that requires heavy equipment, are included in the kits. The main subassemblies, however, are built by the teams in the team.

	Line Flow	Mechanistic Flow	Organic Flow
Balancing loss (%) (ref. 6)	30 (ref. 12)	15	5
Handling loss (%) [1]	25	20	15
System loss (%) [2]	80	30	20
Total loss (%) [3]	135	65	40
Throughput time base object (h)	6	16	7
Possible working-up at collective and individual level (min) [4]	0 0-15 [5]	20-60 20-60	unlimited [6] 15-100
Space requirement (m^2/automobile/year) [7]	0,6	0,6	0,4
Size of repair area (m^2/automobile/year) [8]	0,2	0,2	0,1
No. of hand tools and mechanized equipment per assembly minute	1,6 (ref. 13)	1,6	0,6
No. of material supply units per automobile displayed for the workers	5000	1800	1500

Figure 4. *Comparison between three fundamentally different production flow concepts. The figure is read downwards. Uppermost in the table is shown a loss analysis. Then follow representative key factors. For example, the space requirement in the mechanistic stepwise flow concept is dependent on the demand for autonomy (20-60 min. working up) and maintaining sequence which means large buffer areas between the eight production steps. The results here are in good agreement with the results from earlier studies (ref. 4, 5, 6, 7, 8, 9 and 10).*

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1 The time taken for the workers to fetch and handle tools and materials.

2 Inspection and adjustment during and after the assembly process.

3 The losses are in relation to the required assembly time, which is the same in all three cases and is equivalent to 100 %. In the case of the line, the reported total time used is thus 235 %. The assembly time needed is dependent on product design. Only time from the point when the worker has the component in position for assembly until the component has been fitted is included.

4 Two different limiting factors are the limits imposed by the system, and the fact that the worker himself can not over-achieve more than to a certain extent; at least 20 % should be allowed (ref. 7).

5 On a line working-up always takes place at the expense of ergonomics, more materials handling etc. Working up of time is here, in fact, not permitted. In practice, however, it is permitted within foreman areas.

6 In parallel systems with administrative autonomy the possibility to work up is regarded as unlimited at the group level since the group plans for itself (a group controls/performs the assembly of complete automobiles). How much working up is possible at the level of the individual is dependent on how the group distributes work/free time.

7 Measured from layouts of three typical systems and includes both assembly and storage areas. Normalization has been made with regard to the stipulated autonomy and other pre-conditions in each case.

8 Measured from layouts of three typical systems and includes both mechanical and paint repair.

	Lean Production (Toyotism) v. Mass Production (Neo Fordism)	Reflective Production v. Lean Production
Productivity:	LP clearly superior.	RP potentially superior, but yet to be officially recognized.
Product quality:	LP mostly superior.	RP potentially superior.
Capital turnover:	LP clearly superior.	No significant difference.
Work autonomy:	Probably no significant difference.	RP clearly superior.
Work content:	LP possibly superior.	RP clearly superior.
Ergonomics:	Probably no significant difference.	RP clearly superior.

LP = Lean Production.
RP = Reflective Production.

Figure 6. *Comparison between different production systems for final assembly of automobiles (with the degree of design of Swedish vehicles) with regard to economic and human goals. Note that the comparison is simplified and automobile manufacturers with low production volumes can not easily achieve the high degree of design that Lean Production in its most extreme application assumes (high volume manufacturers have even better preconditions for exploiting suppliers' competence in respect of design and development work).*

For those who are used to thinking conventionally, for instance in terms of line assembly and/or in terms of "zero-sum" labour-employee relations, many features of modern, highly parallelized final assembly systems look paradoxical.

Some examples of these paradigmatical paradoxes are:

-In long work cycle parallelized production, work cycle durations of two hours or more have already proved practically realistic, and by applying Reflective Production this can be achieved without compromising product quality or total assembly time required.

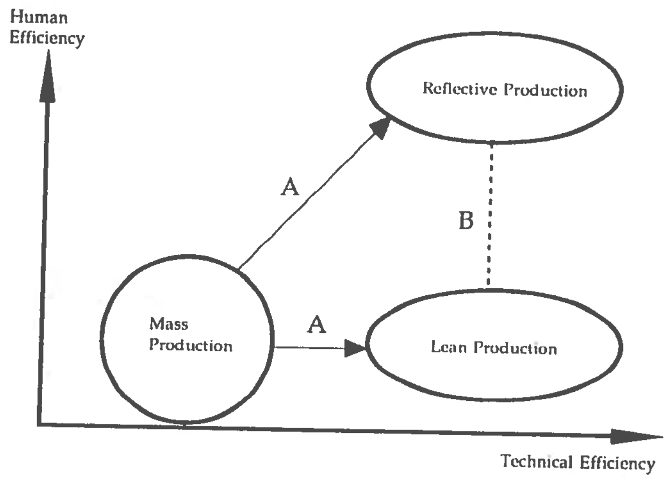
-With organic production, it is possible simultaneously to enhance productivity and quality of work. These production concepts, properly designed, are compatible with or conducive to reduced space requirements and buffer storage volumes.

-It is our opinion that highly parallelized production flow patterns will, for example, be compatible with methods such as "just-in-time principles" and the requirements of high delivery precision.

The assembly work in the new production systems advocated here is a qualified profession using advanced information technology and other "hi-tech "features (most on a small scale). In some aspects there are similarities with craftsmanship but it must not be misinterpreted in the sense that old-time production technology is used.

This new profession is acquired by a new occupational learning based on a new assembly-oriented product structure (ref. 11) and supported by advanced materials feeding techniques (ref. 8, 15 and 16).

In order to realize these new production systems it is necessary to project facilities so that possibilities and experience can successively be introduced. This is the reason why it is important not to rely just on conventional methods and thinking. Realizing theese new systems has in practice proved to lead to considerably different demands on the preconditions for production and thereby also for production management.



A = 1970 -1990.
B = 1990 -2010.

Figure 7. *Schematic summary of the different production systems' relation to human and technical efficiency, which represents the long term exploitation of human potential and technical facilities. Productivity, quality and humanization are then a consequence of the production system chosen. If we include social aspects in human efficiency the distance between Reflective Production och Lean Production further increases.*

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MANAGEMENT A
PRE-CONDITIONS FOR LONG CYC
SOME FINDING

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1 Introduction

Earlier research in Sweden had shown that the combination of high production flow, a multitude of material to supply and assembly of medium or large sized products would have been impossible without line assembly. The use of parallel material supply is problematic because of the need for space for the material containers at the work station, which means extra cost for transportation, buildings and capital tied up in material. Furthermore it had been found that the design of the product was a very important dimension - and in some cases the only determining factor for the way in which the material supply and work operation were organized (ref. 3).

We have shown that the formulation of detailed production system specifications requires the participation not only of labour but of production engineers as well, and it is then perfectly possible to combine higher productivity with meaningful work content. Experience from such system changes has been communicated at the international level only to a limited extent. The uniqueness of each system makes transfer of experience difficult. There have been several failures when transferring experience from one system to another, usually because the local conditions have not been taken in account (ref. 5 and 6).

A possible conclusion is that production systems which are very similar to each other are probably not optimized since the products have proved to be so very different. The reason for keeping unmodified, "simpler" systems may be ignorance about the content of "the technology shelf" or the inability to establish the close cooperation needed for refinement of the system. The long tradition of close cooperation between management and labour in Sweden has greatly facilitated experiments with new production systems and work organization (ref. 9).

To some extent the limited production volumes (compared to those of many competitors) have improved flexibility in the Swedish production systems. our experience has shown that it is extremely important to specify exactly the performance requirements of the new systems. In order to understand and be able to meet these requirements, it is necessary to describe clearly and communicate the overall goals among the parties involved.