Torslanda to Uddevalla via Kalmar:
A journey in production practice in Volvo.

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INTRODUCTION

The development of production systems through the last four decades in Sweden might be confusing to uninitiated readers. Many international and Swedish students of production systems as well as architects, social scientists and general debaters have taken an interest in the subject. The publicity has been extensive [3,12,16] and has been further intensified through the close down (1993) and reopening (1995) of the Volvo Uddevalla plant under the name Auto Nova, a co-operation between Tom Wilkinshaw Racing and Volvo. In some respects the Uddevalla plant is the symbol of the striving to develop humanistic production systems alternative to the assembly line.

The fact that Volvo as well as Saab, the other major car manufacturer in Sweden, have developed both short cycle repetitive production and long cycle parallel production through the last decades does not contribute to the understanding of the direction of the Swedish practice. These two lines of development are often referred to as Lean production [19] and Socio-technical [17] or Reflective production [9]. The latter are two of the most used terms for a humanistic approach to production systems design. I will try to discus this dualism in Swedish automotive industry in the end of this paper.

The history of development of alternatives to the traditional assembly line is long within Volvo. I will do some reflections on this as an architect participating in the development of such alternative production systems. My point of departure is an architect professionally responsible for linking the managers design assumptions into a participatory process where users with different roles in the coming production system take part. Off course this is a long and tedious process where production and quality goals shall be integrated with quality of work issues and spatial design.

Primarily I will focus on two extremes, on one hand The Arendal and Uddevalla plants, on the other hand on the Torslanda plant. These are good examples of the Humanistic and the Lean production approach. I will also briefly mention some additional plants that have properties from both these extremes. To make this kind of distinction is somehow a simplification, but is justified of pedagogical reasons in this paper.

SOME EXAMPLES OF ASSEMBLY SYSTEMS DESIGN WITHIN VOLVO

An early experience from Arendal (1974)

One of the first indications that long cycle assembly could be an efficient alternative to traditional short cycle line assembly arouse more or less by accident. The production capacity of The Lundby truck plant had 1974 reached its capacity limit and an extra 400 trucks/year had to be produced. A new temporary plant was set up at Arendal in Göteborg. To reduce investments in equipment in the temporary plant an experiment with an alternative production system was made. A group of twelve people were to assemble two trucks/day, which was regarded tough. The group was responsible for assembly, materials handling, quality control and correcting defects. The assembly was organised in a two-stage dock with

a possibility to buffer one chassis between the two docks. Air cushion carriers were for the first time in Volvo used to carry and move the chassis during assembly.

Already after a couple of weeks the group performed due to production goals and after four months they had dramatically decreased assembly time. They often finished their two trucks two or three hours before the end of the day. The extra time was used for discussing experiences from that day's production and planning next day's production.

As the Volvo organisation was dedicated to traditional paced short cycle assembly line production and very sceptical to alternatives, they immediately suspected the trucks produced in Arendal lacked in quality. A quality audit was made and showed that the quality was higher in the Arendal plant than in the traditional Lundby plant. This despite the fact that the most complicated trucks, with the largest needed assembly time, were assembled in Arendal. Volvo could not find any theoretical explanation to this and the scepticism against long-cycle parallel group assembly did not disappear. The Arendal plant was closed down in the summer 1977. [8]

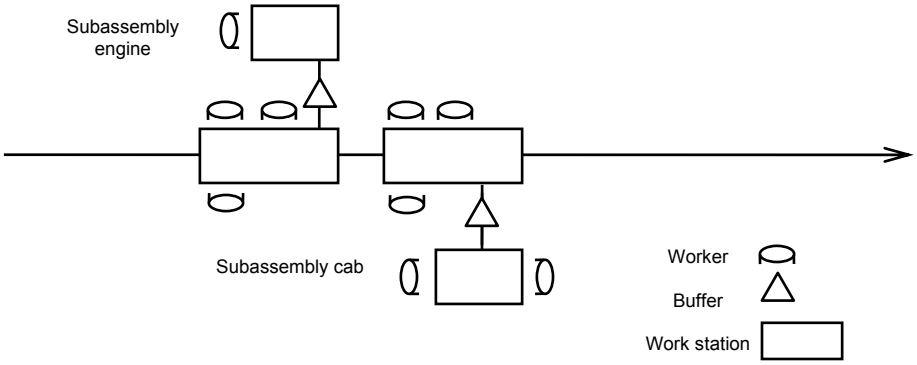


Fig. 1. The production flow pattern in Arendal workshop (1994). After [8]

The Kalmar plant (1974)

The Kalmar plant might be the single Volvo plant that is best known and that has contributed substantially to Volvo's image as a humanistic and responsible car manufacturer. The managing director of Volvo P. G. Gyllenhammar was a strong forerunner for humanistic production system and wanted a plant that should communicate this to the market. The final building design and layout was however quite conventional and did not communicate the kind of image that was sought for. Evidence from those who took part in the design process tells that P. G. Gyllenhammar personally intervened late in the project and urged the architect to design a building that looked more like a radically new assembly plant.

Interesting enough the Kalmar plant is quite conventional when it comes to production technology and work organisation.

The so well known star-shaped building plan contained 27 workstations in sequence with intermediate buffers. Originally the concept contained some parallel workstations. This concept was however abandoned and the Kalmar plant came to be a quite traditional line where every workstation had a view through the window. Originally the buffers were not meant for assembly work but in practice the workers met their cars in the preceding buffer and went on working into the following buffer. The assembly line in Kalmar was equipped with very expensive AGVs. These had ergonomic advantages as the workers could ride on them and do the assembly work stationary relative to the car even if the line was moving in a constant pace monitored by a computer. The AGVs also made it possible to tilt the bodies 90 degrees so the workers did not have to do under-up work on the car and also could have comfortable working situations on interior details like the roof.

In 1987 the Volvo 760 model production started in Kalmar. The new model needed substantially more assembly time than the earlier models. The plant had to be extended with a new wing that made the famous star shape asymmetric. Still the limited number of AGVs

available and shortage of space made it necessary to decrease the number of buffers. The computerised product specification system made it however possible to identify every individual car on the line, which made it possible to allow revise of the flow due to variation on the products. In 1989 parallelisation was introduced on some subassemblies and at the marriage point between the engine-axis and body. These changes were made to improve the ergonomic situation but also gave a substantial increase in productivity. [8]

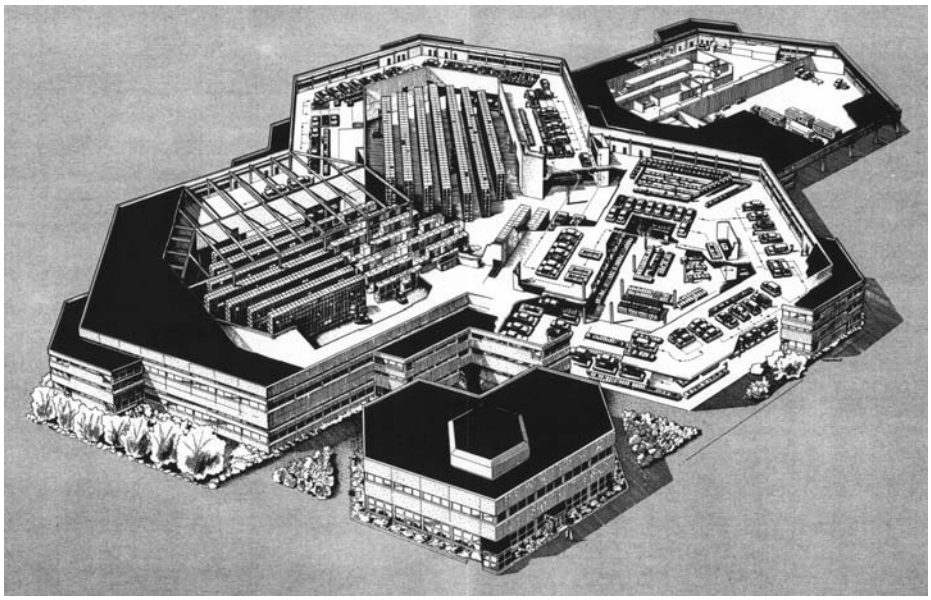


Fig. 2. The layout of the Kalmar plant (1987)

Uddevalla

In early 1985 Volvo management authorised a prospective study concerning the establishment of a car plant in Uddevalla, on the West coast of Sweden. Originally, the plan envisaged a complete car plant with body manufacturing, assembly and painting/finishing plants. A project group was formed to include union representatives in the planning process from its earliest phases. In order to facilitate the new establishment in Uddevalla, Volvo had received permission from the Swedish government to use funds from the company's investment reserves.

Early on in the preliminary study both Volvo management and the unions itemised their respective goals in the project. Ellegård [3] has documented this phase of the project in extenso. The "vision" of the respective parties is capsuled in the following phraseology: "a holistic approach to an efficient workplace with human qualities for the manufacture of quality products" and "technology, process information and environmental aspects shall be well integrated in the complete plant". Ellegård itemises the ambitions for the Uddevalla plant in the following terms: Finest quality, highest reliability of delivery, maximal cost-efficiency, excellence in personnel development, streamlined administration with few hierarchical levels, and a personal "manufacturer" for each unit produced.

The final assembly plant

After some deliberation and discussions relating to the concession to operate, Volvo chose in January of 1986 to confine their plans for Uddevalla to a final assembly and finishing plant.

The preliminary proposal for the layout of the new plant had many characteristics in common with the Kalmar plant, but not as advanced. Assembly was, for example, to be performed at 150 different stations, located along the walls of the plant. Assembly was to be organised according to the same principle as a line, but would involve assembly in docks. That is to say, bodies would be assembled standing still. Furthermore, the team at each dock was expected to leave a perfect unit to the next team along the line. Differences within the project group in respect of production technique preferences, which had been implicit in the

earlier discussion of goals, surfaced into the open light here. The project group included both individuals imbued with the production ideals of Taylor and Ford and exponents of the socio-technical approach to work and view of the role of workers in production. The latter proposed parallelisation as a means to diminish the losses that line assembly entailed and they also introduced longer task sequences and buffers to achieve a greater measure of autonomy for both individuals and groups of workers. Thus, proponents of the socio-technical approach were dissatisfied with the proposal currently under consideration. Two features were particularly criticised: the very brief work cycles envisaged, and the fact that line workers were to be held responsible for quality although the conditions under which they would be working afforded no real opportunity to ensure quality. [11]

The project continued as two parallel projects, one by the existing in-house production design group and one led by a production engineer with a socio-technical approach in co-operation with a research group from Chalmers University in which I participated. The two groups had to prove the efficiency of their designs continuously through the project. A more detailed description of this process can be read in [11].

After a long design process the socio-technical or reflective approach came to realisation. The design process was not straight forward as neither the theory nor the practice were available to design a production system that should meet both high humanistic and efficiency performance goals.

The finalised Uddevalla plant was divided into six parallel assembly shops, so called product workshops. The product workshops are grouped in two buildings there a test workshop form the centre for three product workshops.

The layouts were different in the two buildings. In the first started building the automobile was assembled in two stages and the body was moved between the two stations. The group seize was seven workers and normal cycle time 100 minutes. In the later building the body was not moved during assembly work. At the close down, a group of nine workers circulated between the two stations and the normal cycle time was 80 minutes.

The sub assemblies were integrated into the work station system. In the early workshops the workers did both body and subassembly while specific workers did subassembly in the latter workshops. The individual differences were however large. Two female workers choose to assemble the entire car by themselves. [8]

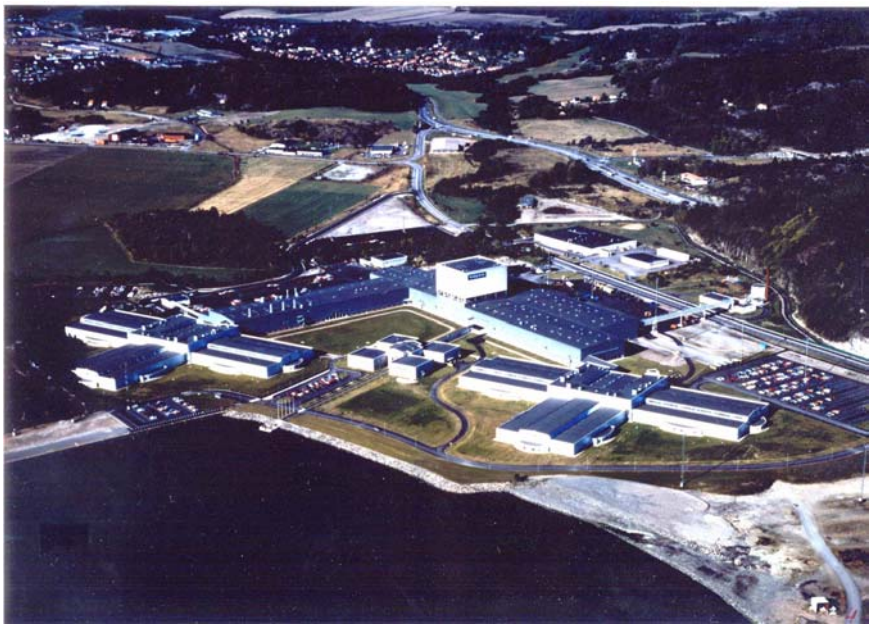
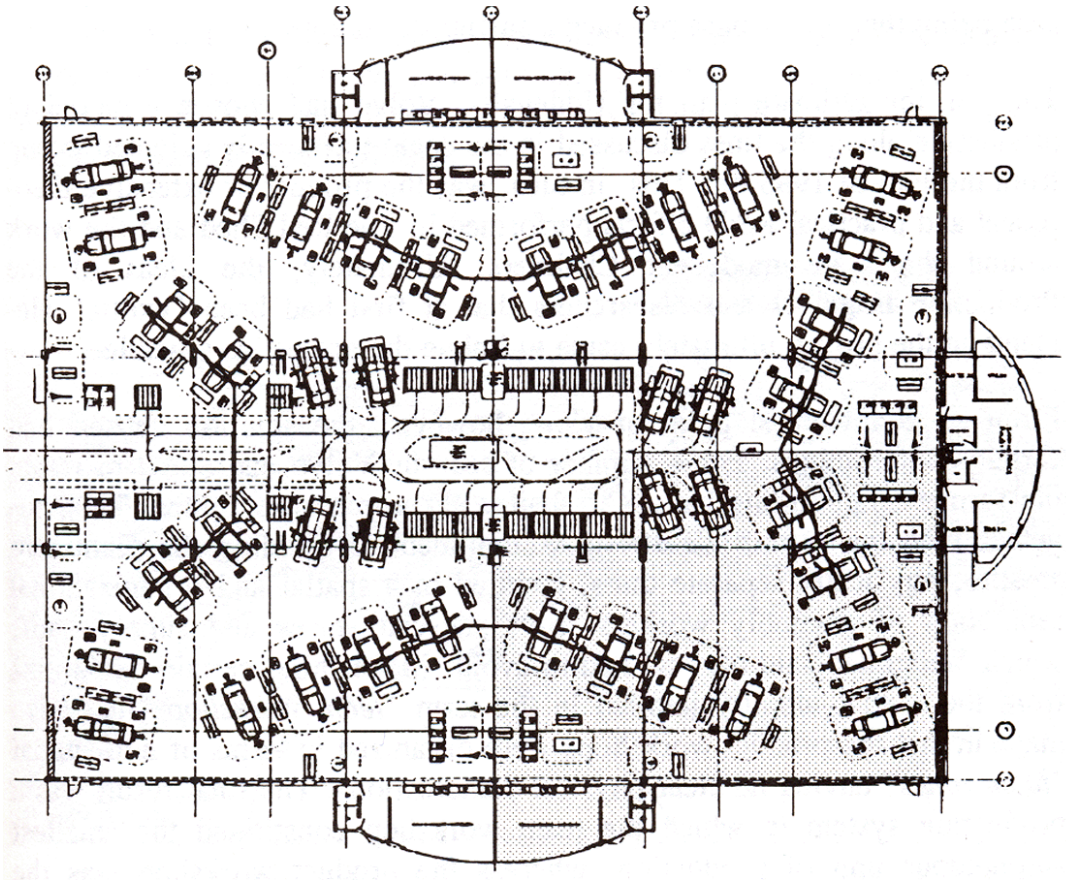


Fig. 3. Aerial view of the Uddevalla plant as build. The two trifoliate buildings, each containing three product workshops, face the sea. Between them, the office building, and behind them, a converted sheet-metal hall used for material stores (1989)



The layout of a product workshop as it was at the start-up of the plant. HMS Maskinkonsult AB. [11]

The Torslanda plant 1985 and after

Torslanda is Volvo's major plant and the plant with the highest production capacity. It was originally build in the sixties and is a complete plant. This means it has body-shop, paint-shop and final assembly which was one of the reasons why the old relatively bad functioning Torslanda plant was spared in 1993 and Uddevalla and Kalmar was closed down. Torslanda became the only remaining Swedish car assembly plant within Volvo.

In the eighties the production system was basically a traditional assembly line with short cycle assembly. The absenteeism was high and so was personnel turnover. The plant also had quality problems and the adjustment work after the cars had left the line represented a problem. The plant also presented severe work environment problems like muscle and nerve problems in arms, neck and upper body and other ergonomic problems. The Torslanda plant was not an attractive workplace.

The plant had two separate lines for the Volvo 200-series and the 700-series. The 200-series was however on its way out and new models should be introduced in the plant. Difficulties to interest young people to work in industry and the current problems in the plant caused Volvo to look for new concepts for production. Despite the scepticism in Torslanda to the Uddevalla concept some of the experiences gained in Uddevalla was taken up, though not fully understood, in a new production project with the name TC 90. TC stands for Torslanda C-plant. [11]

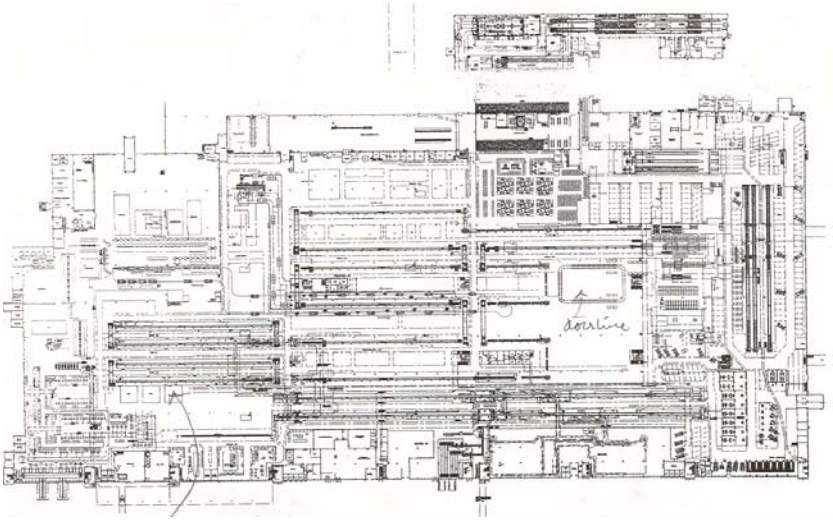


Fig. 4. The Torslanda plant with two assembly lines. The more than 200x300-meter building was virtually just one large open space (1985) [11]

TC 90

The idea was to abandon the traditional line assembly and set up eight so called functional workshops. Such a workshop for engine/axis assembly had already been in use for a while as a workshop for assembly of doors. These two workshops had been in production parallel to the line and integrated in the assembly flow.

Different technology and work organisation could be used in different workshops. The PUR station was already, of work-environment reasons, a fully robotised station and the door workshop had stationary assembly of the whole sub-assembly by one group. Some workshops like final assembly would probably have been a short serial assembly line. The material should be fed from the perimeter of the building to every workshop in a JIT manner and sub-assemblies and bodies should be transported on an internal road system between the workshops.

The material-handling concept would make the whole area around the plant into a large warehouse and transport area. The outside of the building would have large roof preventing any light to enter the workshops. This design of the building could be accepted in the existing assembly-line plant as the worker's possibility to move around and get a glimpse of a window was restricted by the production system anyhow. The workshop concept however gave the opportunity to less dependent work and freedom to take breaks. Usually so called product work-shops in industry take advantage of the more autonomous work and design the work-shops with higher environmental qualities like windows with a view and maybe even a possibility to go outside for shorter breaks. Nothing of this kind was considered here. [11]

In a student project at the Chalmers University, described in [11,15], we suggested to consider these possibilities which would need a redesign of the material handling system. This was looked into by the Volvo project group and found to be an improvement.

The TC 90 project was however not competed as strong indications came from top management to try to adopt the Uddevalla solution even in Torslanda. A project was set up together with the Uddevalla research group. The name was confusing enough Ergonomi 90. [11]

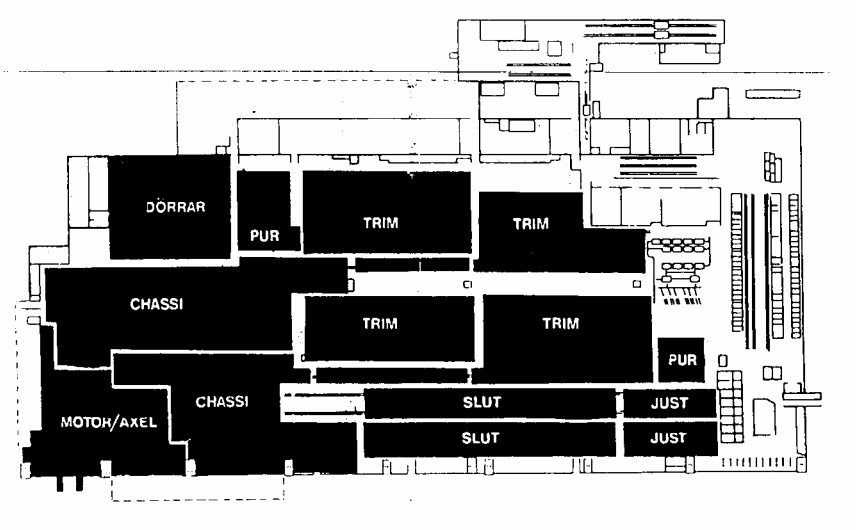


Fig. 4. The planned layout for the assembly plant divided into functional workshops.

Ergonomi 90

The project called for exploring on the basis of selected Volvo models, the technological and administrative feasibility of introducing complete-car assembly into the final assembly plant at Torslanda. The analysis included studies of material handling and flows, studies of layouts for a team workshop, studies of the process of conversion from line assembly to complete-car assembly, and whether complete-car assembly could be accommodated in existing facilities at TC, given the production goals set for the plant. Yet another objective was to co-ordinate the developmental work with the Uddevalla plant, so that assembly work in both plants might benefit.

The team workshop developed by the production engineers consisted of two identical team zones grouped symmetrically on either side of an axis. The team area took the shape of a truncated half-ellipse, with the assembly stations located along the base. Shelves of parts and accessories occupied the periphery, and the inner portion of the area was devoted to pre-assembly work. The shelving and car assembly stations on the peripheries, with lower pre-assembly stations in the centre, gave the area spatial definition.

A number of such team workshops were arranged in a circle around a common material "market", from which assembly workers could gather necessary parts and material for subsequent assembly, with the shelving along the periphery of the team workshop serving as intermediate stores. The parts and accessories for each unit (car) - wheels, tires, fuel tank, not to mention the body itself - would be delivered from a transport corridor running along the periphery of the circle. Some control functions would be performed along the corridor, and some space was allocated to administration and staff.

The project was however quite controversial as it went on parallel with TC 90 and was far more radical than the Torslanda organisation might be able to handle. It was however decided to convert Torslanda into a Uddevalla like production. [11]

The NMT-project

When the Ergonomi 90 project became official it replaced the TC 90 project and was taken over by the Torslanda organisation. The production technology researchers left the project and only the architects from the Ergonomic 90 project stayed. The experimental workshop at Arendal was replaced by a product workshop inside the Torslanda final assembly plant. As the project group for the production workshop basically lacked technological competence the project soon turned into a sort of democratic experiment rather than a production technology project. In the main project however spatial implications of the layouts from Ergonomic 90 was investigated. A successive transformation of the Torslanda plant from traditional line assembly to long cycle group assembly in seven parallel workshops was investigated. The transformation was made step by step through transferring production from line into assembly workshops. The scenario was to do the whole transformation in full

production on all units. The original hole-car assembly concept deteriorated however more and more and concepts where minor parts of assembly work was done in parallel docks while the more important parts of assembly were done on assembly line occurred.

A downturn on the market and new management both in the top of the company and in Torslanda had turned the project into more and more traditional solutions. In 1990 the development workshop was closed down and in January 1991 the project was ended by publication of a so-called red book that described a rather conventional production system with only some solutions from Uddevalla. In reality not even this was realised but the Torslanda plant was renovated as a traditional assembly line with some innovations in line with the state-of-the-art in Lean Production. [11]

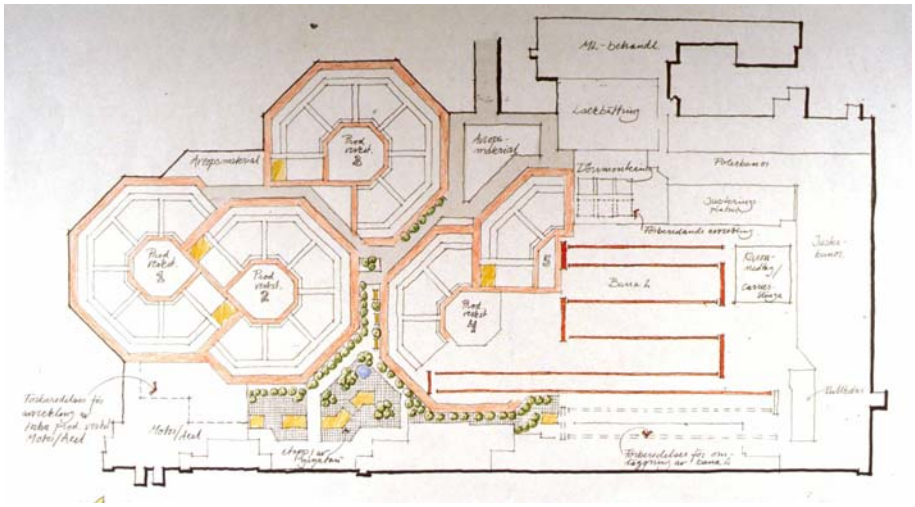


Fig. 5. Fourth step in a tested step by step conversion of the assembly line into product workshops. The entire line 1 is dismantled, and has been replaced by workshops. Personnel and service facilities are started. Old engine-axis and door assemblies still remain. [11]

SUMMARISATION OF THE CASES

It might be interesting to look at the development of production systems in Volvo from the point of view of quality of work as well as efficiency of production. The two extremes are Traditional Mass production systems and Reflective production systems. Lean production systems is a modernisation of traditional systems with some properties in common with Reflective production systems.

Quality of work

Quality of work contains a number of aspects. I suggest that a system that offers professional meaningful work is better in this respect than those that only can offer unskilled or semi-skilled work. The aspects that signify professional work are control over methods, time and quality plus the responsibility to plan ahead and the knowledge needed to reflect on work done. It also contains a professional language including theories, concepts and rules. Quality of work also means good ergonomics, appropriate working tools and a good physical working environment. If we look at these aspects it is clear from table 1 below that Reflective production systems are superior in this respect.

Something like professional assembly work first occurred in the temporary Arendal plant. Compared with the traditional line assembly at Lundby the assembly work in Arendal turned into something quite different. The group of twelve was responsible for the whole product and could when assembly time went down also plan their next day work. There were people in the group assigned to materials handling, control and correcting defects but the group's total work content was basically the entire truck. The actual cycle time was 240 minutes. As a whole the assemblies work in Arendal had very little in common with the repetitive short cycle work their fellow workers did in Lundby. It took almost twenty years before the Tuve (1991) truck assembly plant came close to what was achieved in Arendal.

The so hailed Kalmar plant could not present a work situation much different from traditional assembly line work. The cycle time in Kalmar was substantially larger than in a conventional line assembly, 20 to 2 minutes, but basically it was a paced assembly line with its limitation in work content, high dependencies of the technical system and very little possibilities to influence quality. The big improvement was on the physical environment. All workstations were located at the perimeter with large windows. The assembly workers had nice designed rooms for pauses at the facade. The ergonomic situation was dramatically improved compared to a traditional line assembly.

The Uddevalla is however the most radical example of Reflective production in Volvo. This plant was in all its aspects a humanistic production system. The cycle time was in general 480 minutes but one team of two female assembly workers assembled the entire car by themselves. Planning, quality control, corrections and development of methods were responsibilities of the team.

The spatial consequences and preconditions for different production concepts are interesting. In Kalmar the managing director realised the importance of spatial design and urged the architect to give the plant a visual image different from traditional plants. Group work with intellectual property demands however other physical conditions than in detail controlled short cycle repetitive work does. One needs an overview, space for planning and intellectual work plus a noise-level, a lighting quality, cleanliness and a proximity within the workshop that are similar to that of an office environment. The smallest possible scale of a serial assembly line is enormous compared to a 42 parallel product workshop assembly like in Uddevalla. [5] The long work cycles also make buffers unnecessary that make more of the space eligible to assembly work. The amount of parts displayed to the assembly workers are also less in parallel assembly than in serial assembly. [8] Altogether this makes a Reflective production system more space efficient and allow and furthermore benefit from having a more humane spatial scale and design.

The Uddevalla plant is the most obvious example of how the professional assembly work is accompanied by a building design that is appropriate for this kind of work and also communicate something else than a traditional assembly plant does. The described development projects at Torslanda shows however that even extremely large scale plants can be converted into Reflective production units if some efforts are made on the redesign of the space.

Table 1
Work related aspects on Reflective production, Lean production and Traditional Mass production with Volvo examples. [5]

Uddevalla 1989			Torslanda 1985
	Arendal 1974	Kalmar 1974	
Tuve 1991	Borås 1978	Torslanda 1998	

Reflective production	**Lean production**	**Traditional Mass production**
⟵		⟶
Economic goals with social preconditions	Economic goals	
Large work content		Low work content
High autonomy		Low autonomy
Planning within the group		Pre-planned production outside group
Large possibility to influence quality		Low possibility to influence quality
Superior ergonomics	Ergonomic efforts	Bad ergonomics
Space efficient		Space consuming
Possibility to small scale spaces		Large open space solutions

Production efficiency

The most important quality of a production system is however its efficiency in terms of productivity and quality. In this case I will compare mainly the Uddevalla plant with assembly line production. Engström et al have, in several papers, questioned what they find, simplified measures of efficiency that are dominant in writings on Lean production. [5,14] There is no room for this discussion in detail here but I will present some empirical figures from Engström et al on the efficiency of the Uddevalla plant. It is important to note that the

plant was probably not fully trimmed at the time of the close down. The work pace in Uddevalla was measured to 115-130% higher than the standard time for the assembly line. The average cycle time was 80-100 minutes. The two above mentioned female workers that had 350 minutes cycle time worked at a pace of 105-115%. A subassembly for doors was measured and the empirical data showed that the assembly time in Uddevalla was lower in all but one case [9]. A part of the explanation to this might be found in another empirical study done by Engström et al of assembly in Volvo and Saab [6]. This study shows significant lower losses related to materials handling, balancing and system in parallel systems than in serial flow systems. The measured figures are 40% losses compared to 135% losses relative to an ideal system without losses [18]. As we see above there was an early experience of this efficiency of parallel systems in Arendal where the stipulated work was done faster that estimated. Another example is The Volvo bus plant in Borås with three parallel assembly stations where the productivity suddenly went up to 26% higher than on assembly line and with superior quality. [8]

Reflective production systems on one hand and Mass production systems and Lean production systems seem to relate to variations in different ways. Variations both in systems behaviour and man performance that are build into the serial systems tends to add up and give extended losses [9]. Variants in the products are preferably avoided in serial systems, as they also tend to add up and cause unbalances and quality problems. The cure to this is high degree of design of the product that cause large design and construction costs. With very large production this represent an affordable problem, as the development cost per unit will be reasonable. A serial system therefore can perform efficiently with high product quality under certain conditions.

Reflective production systems on the other hand are designed to accommodate variations. With long cycle times, extended work content and overlapping competence within the group, variations in man performance and products does not influence efficiency in the same way as in serial systems [6]. These systems also take advantage of the workers intellectual capacity to replan production, make corrections on line and trouble-shooting whenever needed [3]. Reflective production systems are designed to accommodate variations of all kinds. This make them especially suitable to low and medium volume production with relatively low degree of design of the products and the design and development costs have to be kept within reasonable limits.] The flexibility of reflective production systems can however be exploited even in large volume production and have potentials for higher quality and productivity in addition to the proved superiority in work content, autonomy and ergonomics. [5]

Table 2.
Characteristics of Volvo final assembly plants [5,8]

	Arendal 1974	Kalmar 1974	Borås 1987	Tuve 1981	Uddevalla 1989	Tuve 1991	Torslanda 1985	Torslanda 1998
Number of assembly workers/workstation system	9	8	9	6	7-9	10	2	2
Number of vehicles/work-station system	3	4	3	2	4	2	1	1
Number of work-stations in parallel within a work-station system	1	1-4	1	1	2-4	1	0	0
Max. stipulated work-cycle time (min.)	240	20	180	40	480	240	2	<2
Number of work-station systems in sequence	1	27	1	4	1	1	>300	~200
Number of work-station systems in parallel	1	1	4	1	42	2	0	0
Buffers between work-station systems (capacity/type)	0	4	0	2	0	0	2	2

There are some aspects that are important to however a production system can accommodate more qualified work situations. One is the how the product, the description of the product, the assembly of the product and the material is structured. This should be done in a way that promote understanding of the product as a whole and its functions and all the structuring should correspond with each other. If such a structure exist it is possible to describe this in normal language and a professional language can be developed between the workers. The structuring and assembly description from the line assembly could not be used for long cycle assembly in Uddevalla. To realise this and make an alternative structure and description was one of the break-through in the Uddevalla project. This made it possible for the assembly worker to understand the product in such a way that they could influence the assembly work, make adjustments, go back and corrects mistakes and re-plan the order of assembly. This avoided the kind of accumulated faults that are present in serial line assembly. This also made it possible to help the other group members with their work when so needed as the workers understood and was able to do each other's work. The professional language is also a necessity for planning and development of work methods.

The available cycle time must be reasonably long to be able to control time and above all to get an understanding of the product. One quarter of the total assembly time seems to be a minimum.

A very important premises for qualitative work is how much overlap of competence there is in the group. This might even be more important than the length of the cycle time, provided it is reasonably long. The overlap of competence in the group is important for the flexibility of the system.

DESIGN ASSUMPTIONS AND THE ACTUAL OUTCOME

We have seen from the above presentation that the assumptions or expectations from the company have been quite different from the outcome of the projects. Arendal is the first example of this. The intention was just to design a temporary production facility that for a short time could meet the extra need of capacity. This had to be done with a reasonable investment in equipment. The outcome was a production system with dramatically improved quality and productivity and the first signs occurred that building trucks could become professional work not just unskilled or semi-skilled assembly line work.

In Kalmar and in most of the plants designed during the Gyllenhammar era, a Human Relation dominated philosophy dictated the projects. A lot of work was done to improve ergonomics, lighting, and noise reduction and also the environment with colours, plants, and more attractive building design. More rewarding work situations with more workers participation and responsibility were part of the pattern. The conception was that these improvements should result in production systems where quality and productivity could be combined into a work that would attract the younger generation.

Kalmar was designed to be the ultimate humanistic car plant. In international TV-commercials the plant was presented with pictures that showed the customers a plant there young happy people built cars in a handicraft manner, implying the superior quality that must be the result of such responsible and personal treatment of every car.

We know that the reality was somewhat different. The real improvement did not occur in the assumed direction until the technical system in late eighties had been improved to stand up to the high ambitions. The end result at Kalmar never really stood up to the humanistic ambitions but was developed into a quite good production system that within its possibilities had some qualities in terms of workers satisfaction.

The design assumptions for Uddevalla were also strongly influenced by Human Relations philosophy. The first layout sketches of the production system were variations on Kalmar and Torslanda. The vision was basically a traditional production system with strong emphasise on work environment and some new components in work organisation and technology. The outcome was a totally new innovation in production technology that proved to be extremely competitive in all respects.

Humanistic values

It is confusing to an outside viewer that Volvo on one hand strongly believes in traditional assembly line production and still go on doing these new radical experiments in alternative systems. It might be interesting to discuss this contradiction.

In the seventies up to end of the eighties Volvo was a company with much stronger corporate leadership. This made it possible for corporate policies to have much stronger influence than in the today's more atomised company. The managing director of Volvo was during this period Per G. Gyllenhammar, a strong believer on one hand in the company as a responsible part of society but also in the human being as a major resource not only in society but also to the company. In the seventies this was a quite radical standpoint for a leading executive in industry as the main stream in rationalisation contained a dream of the automated plant without man, regarded the weakest part of the production system.

The top management of Volvo embraced this more visionary view. This philosophy is well described in a book dedicated to Per G. Gyllenhammar and edited by one of his directors in 1985. The title of the book is in translation ”Work and Dignity”.

There was also a small group of people among production engineers that was well educated in the ongoing development of production systems alternative to paced, short cycle work. Some of these had ongoing contacts with the researchers at Chalmers who had designed some production facilities in other companies.

Investments funds were available

Another aspect that had some importance on the willingness to experiment was that large Swedish companies had, because of the big profits during the seventies, been legally forced to set aside money in investment funds. This money could not be used other than under certain conditions. The Kalmar plant was created partly with this kind of money and so were The Uddevalla plant and The SAAB plant in Malmö. Uddevalla, Kalmar and Malmö were all regions in need of industry, which made it possible to release these funds. The extra money made it possible to design experimental plants that would contribute to a more humanised production and make Swedish car industry more competitive.

Recruiting problems

The unemployment rate was at that time extremely low in Sweden and the difficulties to attract worker, especially young people to industry and especially automotive industry was obvious to everyone at the time. This fact influenced both quality and productivity in Swedish automotive industry. Humanisation of production seemed to be a way to deal with this problem.

Deeply founded Tayloristic culture

There were however some aspects that contradicted these favourable conditions. The majority of management on all levels were trained in and dedicated to traditional Tayloristic production methods.

The fact that a majority of Volvo management saw humanisation of production only as a mean to deal with the current recruiting problems and not as goal is one explanation to some shortcomings. Another problem was that the humanisation was focused on physical work environment and human relation's issues rather than production technology. Participation, group work, learning issues and other soft matters were investigated in some detail but often the technical systems could not deliver the work content, efficiency and flexibility that was needed. Those who should have investigated and developed such systems were not very dedicated to this as they did not believe in it. This is also why Volvo never has tried to reflect on or analyse or even collect the technical data from one experiment to another. Not even when the Volvo Uddevalla was closed down, one of the most famous and most elaborate experiments in the world, Volvo intended to keep the documentation of the production system. All material was saved by Chalmers researchers from being thrown away and is now kept for future research. In the design of the Auto Nova plant on in the same buildings in Uddevalla this data have been crucial. Therefore evidence of success related to alternative production has been a surprise. No theoretical explanation has been available, as no such explanation is at hand in the traditional Tayloristic praxis.

Strategic work is not favoured

To introduce new production concepts is a very long procedure. It took twenty years from the temporary plant in Arendal until a production system with the same qualities was introduced in the truck plant in Tuve. The way you make a career in Volvo is not designed for such long-term development. The average ”cycle time” for career at Volvo is about three

years. You will be judged on that you achieve during these three years on a job not what might be the result of your efforts ten years later. Nobody will even remember you did it and even so it would not be recognised as someone else would like to profit on it. Therefore strategic work has low status and does not pay off. It pays much better off to be tactical and focus on short term results even if they might be contradictory to long term goals.

Humanisation as "band-aid" or precondition to competitive production

A large group of managers and engineers saw humanisation as a way to get workers to accept the shortcomings of basically traditional production systems. Others focused so hard on the human aspects of alternative production systems that they forgot the technical aspects of the production systems design. The first group did not really believe in the competitiveness of alternative systems in terms of productivity and quality but saw no other way around the recruiting and absenteeism problem. The latter group understood alternative production systems mainly as social or democratic experiments.

Many projects have therefore suffered either from insufficient technological competence or from lack of commitment to the development of alternative systems. When the Swedish unemployment rates increased in the nineties Volvo saw no reason to pursue looking for alternative to the assembly line. The book "The Machine that changed the world" came as evidence that their attitude was the right one.

It is therefore important to state that the strongest part and an absolute vital condition for alternative production system to succeed is that they are based on technological solutions and theory that make them superior to traditional systems in terms of productivity and quality. This has been possible due to technical and organisational solutions that are more flexible and utilises the human intellectual capacity in a better way than traditional systems do. This attitude has been the standpoint of the core group of researchers and Volvo engineers that has been involved in most of the above-described experiments.

Engström et al have in several papers argued that efficiency of a production system cannot be measured by comparing man hour in assembly but has to be measured over the whole production process and put into a socio-economical context. They have further shown, in several studies that, even with these restricted measurements, the closed down Uddevalla plant was as efficient or more efficient than traditional assembly in Volvo was.

The role of the unions

As indicated above there was quite an interest in late seventies and early eightieth for alternative productions systems within the Swedish employer's organisation (SAF). The employers organisation (LO) and the metal workers union (Metall) kept however a low profile in the discussion on new production concepts. The reason to this is not quite clear to me but the expected transformation of work that could be a result of many new production concepts was surely an important ingredient. The suspicion against the Uddevalla project was solid in Torslanda. The alliances against the new concepts cut through management, middle management and blue-collar workers union. The middle management feared, of good reasons, that their positions as managers should be quite different and maybe threatened, in Uddevalla. The blue-collar union in Torslanda was very critical to the Uddevalla concept. It came to situations there the blue-collar union representatives in Uddevalla felt opposed by their organisation in Torslanda. This was especially tough as the union members in Uddevalla felt they really were taking part in an important project to upgrade industrial blue-collar work. The difficulties to define the difference between a blue and white-collar worker in the new long cycle group oriented production systems were certainly one of the reasons. There was a fear that these new professional workers should leave the union. Another reason to the opposition from Torslanda was the fear that the experience and knowledge gained through years of industrial practice should be obsolete when new theories and methods proved competitive. Uddevalla would get into focus instead of Torslanda and individual knowledge and seniority from car industry should be overdone by the skills of young, maybe former fishermen and shipbuilders in Uddevalla. Interesting enough the attitude from the central metal workers union turned out to be quite different from their largest member, the local branch at Volvo. They supported openly the Uddevalla project in the end and took an active role in the critical discussion following the close down of the plant.

CONCLUSION

The conclusion from Swedish experience is that there are two lines of development of production systems, Reflective production and Lean production systems. Under certain conditions with large volumes and high degree of design and effective exploiting of supplier's competence the Lean production systems could be well performing.

Reflective production systems in Sweden have proved to be more efficient than Swedish Lean systems and have potential to be so even in other contexts. It is clear that Reflective systems are superior in all human aspects. There is consequently a choice between two efficient systems depending on the structure of the company, socio-economic conditions and values regarding future quality of work in automotive industry.

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