The Impact of Just-In-Time Manufacturing on the Transportation Sector

by

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A thesis submitted in partial fulfilment of the
requirements for the award of the degree of
Master of Philosophy of the
Loughborough University of Technology

December 1992

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Declaration

This thesis is the outcome of research carried out by the author in the Department of Transport Technology, Loughborough University of Technology. It represents the independent work of the author. Work of other researchers has been referenced where appropriate.

The author also certificates that neither the thesis nor the original work contained herein has been submitted to any other institution for the award of a degree.

Acknowledgement

I would like to extend my gratitude to all the individuals and businesses who have helped me with their advice and assistance and supplied me with the information required to complete this thesis.

Special thanks go to my supervisors, Dr. David Pitfield and Phil Wilson, for their help and advice during the course of this research.

Thanks go to Prof. Norman Ashford, Director of Research, for his guidance in the early stage of the research.

I also wish to thank Jamie McAnally for reading the manuscript.

Abstract

The Just-in-time philosophy has become more and more the focus of interest when companies define their strategies to be successful in future competition.

JIT was introduced by Toyota in the early seventies and rapidly adopted by many other Japanese firms. In the eighties, American and European companies were compelled to consider this new manufacturing approach in their own strategies if they wanted to hold their position as world class manufacturers and keep pace with the international competition. Since then, an increasing number of companies have been planning or implementing JIT principles in their production process.

Apart from the practical impact on companies' operations, a lot of theoretical work has been done on JIT. Numerous studies and research projects cover the elements of the Just-in-time philosophy and all aspects of its successful implementation into a manufacturing company.

One important aim and cost saving factor in JIT is the elimination of all unnecessary inventory. That requires the provision of parts just-in-time when they are needed, which causes more frequent deliveries of smaller shipments. In connection with that, much more attention must now be paid to the materials flow from the suppliers to the customer, i.e. JIT delivery must be ensured at any time. This leads to a new, higher rating of transportation as a crucial part of the entire system. The problem of JIT delivery and the role of transportation has been dealt with in relatively few surveys, which concentrate on selected aspects only. This was done almost exclusively from the point of view of the manufacturers or suppliers.

The aim of this MPhil project is to view the transportation element in a JIT scheme from a different angle. This includes the investigation of the implications which arise from a JIT delivery system for the carriers involved. The purpose of the research was to find out which changes in management and operation of a carrier company become necessary when he starts up a business in a JIT environment. In comparison to non-JIT clients, it is considered whether it is possible to quantify these changes or special efforts in terms of time, manpower and/or costs which could be assigned as JIT related, or whether a JIT service could mainly be provided with a new combination of the regular services. Further, whether JIT delivery schemes necessarily require a higher number of smaller vehicles and lower vehicle utilisation. This would, if true, increase the operational costs and resources.

Starting with an introductory literature review, the role of and demands on transportation in a JIT programme are outlined. This is followed by a brief introduction of state of affairs regarding JIT implementation in British industry.

The main part of the research work is based on information obtained from carrier companies in the UK. A number of selected JIT projects with different kinds of complex delivery approaches were identified. Through ongoing close contact with carrier and manufacturing companies, basic data of the systems could be obtained. The different operational models are explained in the form of case studies. On the basis of that, the implications for the carriers, arising from the different schemes, are analysed. This includes a comparison of resources and costs for different approaches, as well as comparison to non-JIT businesses.

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1. The role of transportation within a JIT system

1.1. JIT definitions

As the term 'Just-in-time' is often used in different connections and with seemingly various meanings, it is necessary to place some definitions at the beginning of this thesis.

(1) [JIT] 'completely tailors a manufacturing strategy to the needs of a market and produces mixed products in exactly the order required' [1].

(2) [JIT is] 'an approach to achieving excellence in manufacturing companies based on the continuing elimination of waste (waste being considered as those things which do not add value to the product)' [2].

(3) 'JIT may be viewed as a production methodology which aims to improve overall productivity through the elimination of waste and which leads to improved quality.' [3]

According to the Toyota philosophy [4] waste can arise from:

- overproducing
- time on hand (waiting)
- transporting
- processing itself
- unnecessary stock on hand
- unnecessary motion
- producing defective goods.

These definitions underline the fact that JIT is a whole strategy comprising all aspects of manufacturing, from procurement of material, to production and sale. The overall goal is to produce a high quality product at lowest costs and only according to demand.

The growing importance of JIT is arising from a change in customer demands. Voss defines the factors influencing future competition as [5]:

- shorter design to delivery on new products
- increased product quality and reliability
- responsiveness on a wide range of dimensions
- ability to deliver high quality at short notice
- shorter, more reliable leadtimes.

JIT is regarded as a successful approach to meet these requirements. The significance of the factor 'time', as well as of the need to eliminate waste, becomes clear if one considers the fact that for only 2.5% of the time that materials are in the factory value is being added [6].

1.2. Elements of JIT

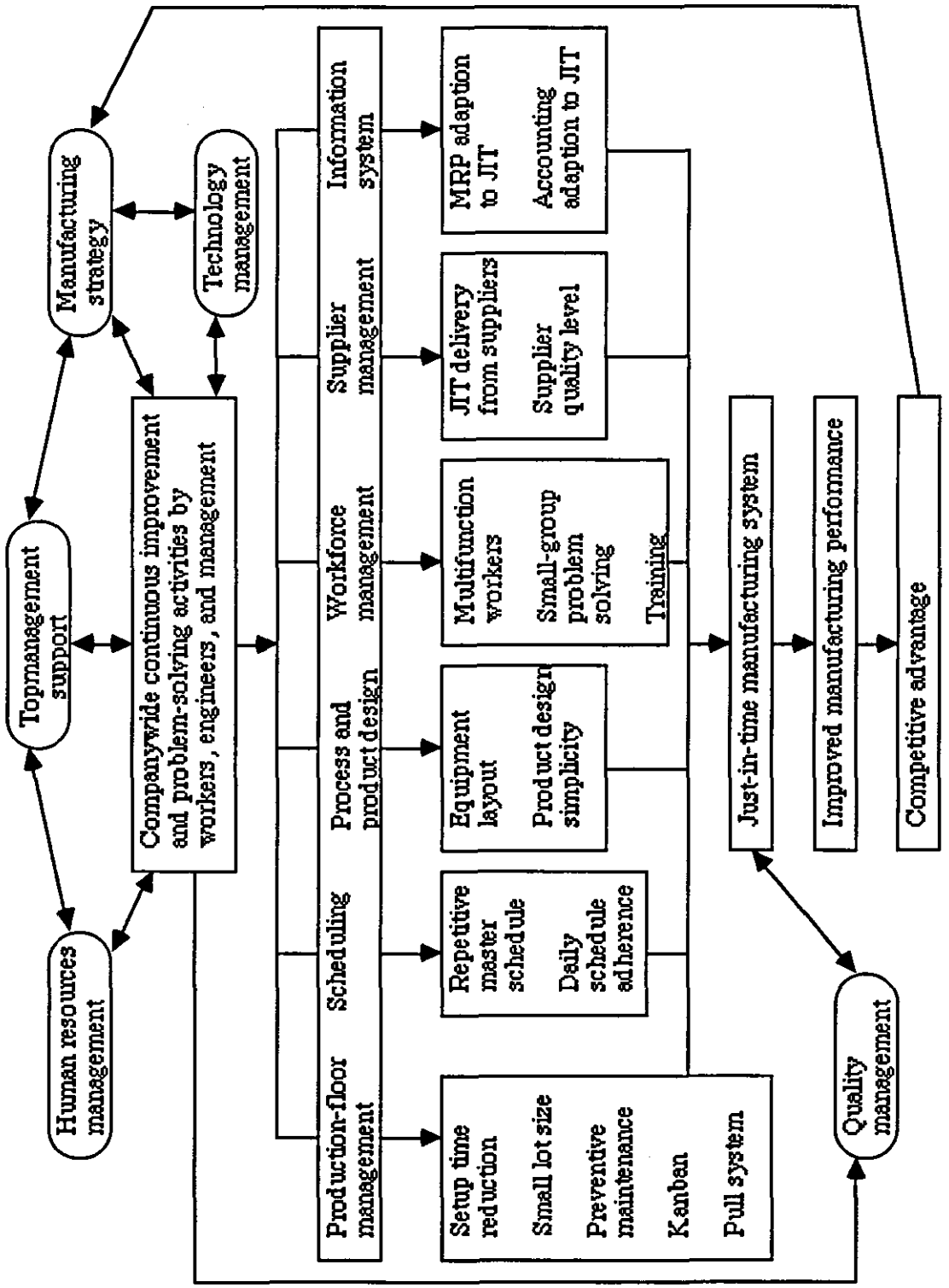
The elements of JIT within the manufacturing framework of a company are illustrated by Figure 1 [7]. This chart shows that JIT is not a set of production techniques only, but affects all sectors, like general management, product design, purchasing, human resources, accounting and information technology.

The best conditions for applying the JIT approach are repetitive and continuous production with a simple set sequence of work, like assembly lines or dedicated flow lines. The production process should be dedicated to only one or a few similar products. Production rates should be uniform and predictable with a regularity in material usage [8].

The main benefits from implementing JIT principles can be summarised as follows [9]:

- maximum labour efficiency
- maximum equipment utilisation
- better space utilisation
- high quality
- minimum inventory
- lower manufacturing leadtimes
- higher flexibility (more effective response to market demand)
- lower cost of failure (scrap, rework)
- better customer service.

Figure 1 Elements of JIT in the manufacturing framework



1.3. JIT purchasing

The implementation of JIT principles concerns mainly internal sectors of a company, as demonstrated in Figure 1. However, external relations to the suppliers must not be neglected in this process. It is necessary to expand on that point, if the role of transportation within a JIT system is to be defined. JIT purchasing means ensuring that parts are delivered just-in-time when needed, in small quantities but at high frequency and at the right quality. One hundred percent quality of the components is required at any time as JIT eliminates the quality check of incoming material which now goes mainly straight to the production line.

JIT requires new relationships between customers and vendors. The processes which happen within the manufacturing plant, should be transposed to operate between different companies. That means that parts are pulled through the system, starting at the suppliers, only when there is an end customer. In the ideal case of integrated processes, an actual Kanban purchasing could be operated [10]. Kanban means that signals are sent directly from the production line when parts have been used and need to be replenished. In order to make this work, the whole process needs to be simplified. Single sourcing for most parts is the goal and, thus, a reduction of the supplier base to a small number of reliable partners. Major criteria for vendor selection are quality and JIT delivery performance. Reliability and flexibility, i.e. being able to respond to changing material requirements of the customer quickly, are important and the reason that the price alone is not the crucial criterion anymore.

To make the process of materials pull from the vendors to the shop floor as smooth as possible, a stronger involvement of the suppliers into the JIT strategy, as well as closer interaction and sharing of information between customer and supplier are necessary. The traditional orders for purchasing of material in bulk are replaced by long term order forecasts, short-term scheduled orders and firm in-sequence shipping orders with exact times of delivery. These are based on real time requirements from the production line.

1.4. Total supply chain logistics

Based on the conditions described in the previous paragraphs, logistics and transportation are gaining high importance in a JIT environment. The perfect arrangement of integrated delivery services from vendors to the manufacturer is a prerequisite for a smooth JIT line feed to keep up the production process on one hand, as well as ensuring a minimal inventory level throughout the supply chain, on the other.

These are the reasons why JIT manufacturers get much more aware of materials movement and logistics and take greater responsibility for supply chain management. It becomes a vital part of the whole system, and closer relationships between all members of the supply chain, including the carriers, become necessary. For these reasons, many large firms have dedicated experts in purchase or even Logistics Departments which deal with these matters.

JIT inbound materials supply and delivery is the subject of this thesis and should be distinguished from the so called JIT distribution of finished products. The latter is usually made from warehouses to retailers, and although often strict time criteria for delivery exist, it is not actually part of what is defined as the JIT manufacturing strategy (see chapter 1.1.). Generally, the term JIT should not be used for transportation processes on their own, as it usually refers only to production aspects. Transportation is a link within a JIT production system to fulfill inbound and outbound requirements by moving materials more quickly. In a system without safety stock, timing, quantity and quality of deliveries is extremely important.

2. What demands does a JIT regime place on transportation systems ?

2.1. Features of the suppliers network

As it was mentioned in chapter 1.3., single sourcing is one of the most important changes in the supplier - customer relations in a JIT environment. The relationship is then, however, based on long term contracts, which results altogether in a smaller, but more reliable and stable supplier base. This has the advantage that, once a transportation system is set up, it can be operated for a long period of time without major changes, which is important for a highly sensitive concept like JIT.

Concerning the number of suppliers, there are remarkable differences between e.g. Toyota, who introduced these principles from the very beginning, and traditional car manufacturers like General Motors. In the USA, Toyota have 250 vendors, while GM initially had about 3,500 [11]. In the recent years, many of the large manufacturers, who implemented JIT, reduced their supplier base considerably, for instance [12]

- Twin City Disc (Control Data): from 900 down to 250
- Xerox Reprographics Division: from 5,000 to 300
- GM, Canada: 99% of material sole-sourced
- IBM Typewriter Division: from 650 targeting 32.

With regard to the location of the vendors, JIT concepts must cope with remote and off-shore suppliers as well as with local vendors. Local sourcing is the easiest way to ensure highly reliable and even sequenced JIT delivery of parts. That is the reason, why in many cases suppliers relocate or open new branch plants close to the customer. This must be justified, of course, by a very high delivery volume for this particular customer. A typical case for that are seat manufacturers, who supply the automotive industry. Another example are a number of German suppliers for British car manufacturers, who opened plants in the UK over the last few years, after JIT delivery became a growing factor of competition. These companies are e.g. Bosch who opened a plant outside Cardiff to make alternators, VDO Instruments in the West Midlands and Devalit in Scunthorpe.

Yet, the conditions of close proximity to the plant can be provided by only a limited number of vendors. Especially in High Tech industries, like computer manufacturing, a large share of components are sourced in the Far East. If there is a stable schedule, a kind of JIT delivery could be established over long distances, as well. However, there is a number of disadvantages arising from that. The in-transit inventory is increased as well

as leadtimes, the risk of damage during the long journey and costs for return of components if orders are cancelled in the meantime. Especially for transportation by sea, the in-transit time is often not exactly predictable. The dispatch of small and frequent shipments is more difficult in these pipelines.

Thus, in the long run, JIT manufacturers aim for local sourcing, which does not necessarily mean only a few miles radius around the plant, but could be the whole of Western Europe for a European company. Still, the closer the vendors, the better the control over the incoming material flow and its timing. If sourcing from distant suppliers is inevitable, close proximity of these vendors to each other could at least make transportation more effective.

2.2. Quantity and frequency of deliveries

The higher the frequency, the lower the quantity of parts delivered. The frequency of delivery depends on several factors:

- usage rate of the components at the production line
- size/volume of the parts
- value of the parts
- supplier location.

A high usage rate requires a frequent replenishment of the parts. High volume components could ensure full truck loads and would be delivered more frequently, as they would demand too much space for storage. Very small parts would not justify frequent transportation but could be held in a small buffer stock for a certain period of time. High value components, however, would only allow minimal stock, which would increase the delivery frequency.

The location of the supplier should not have a real influence on frequency and quantity but on the timing of arrival. The predictability of delivery times is much higher and more reliable, the shorter the distance to the vendor is. However, it is mostly the way that only domestic suppliers deliver several times per day at predetermined times, while collection from distant vendors is usually made only once per day with less stringent time criteria. But this is arranged with regard to transportation efficiency, and should be an optimum solution for the overall costs.

These arrangements are also dependent on how sophisticated the whole JIT concept of the manufacturer is. Depending on all factors considered, the delivery frequency in JIT schemes could range from several times per hour to once per week or less.

JIT supply scheduling is basically done in three major stages:

(1) long term materials requirements forecast (e.g. 6 months)

(2) short term firm schedule for production (e.g. one month)

(3) specific delivery instructions (e.g. one week in advance).

The exact timing depends on the leadtimes, which increase with the length of the supply pipeline. This can be several weeks for material coming from the Far East, or only hours for sequenced parts delivery from nearby vendors.

2.3. Standard containers

It is very typical that with the introduction of JIT into manufacturing processes the use of standard containers at the production line as well as for delivery of parts is required. These standard containers are mostly plastic containers of different size, which make the transportation and handling of even awkwardly shaped components much easier. The containers are used by the suppliers to pack their products, and are delivered right to the point of use at the assembly line, so that the costs for packaging can be reduced or eliminated. The handling of parts is facilitated throughout the supply chain, what reduces the risk of damage and allows standardisation and automatisation of all handling processes and equipment. Further, these containers are returnable and could, thus, replace purchase orders by being a Kanban signal that goes back to the suppliers [13].

Apart from that, curtainsided vehicles are preferably used in JIT systems as they allow a much faster loading and unloading. In connection with the standardised containers, times for unloading a truck could be reduced from hours to minutes only, which results in a faster turnaround of the vehicles.

2.4. Information technology

The internal and external relationships of a JIT manufacturing strategy require a much higher degree of computerisation than traditional schemes. This comprises of three main areas:

(1) computer links with the suppliers to facilitate order forecasts and order processing
(2) inventory control
(3) computer links with the carriers to ensure real time information about the in-transit shipment status of all parts.

A survey of companies that have implemented JIT gave the following results [14]: eighty-five percent indicated an expansion of communications with their suppliers and carriers. The quality of communications with the suppliers was improved in seventy-one percent of cases, with the carriers in eighty-four percent. Sixty-nine percent indicated that changes or investments in information technology with vendors and carriers were necessitated by JIT-related changes in transportation patterns.

Reasons for the new information technology requirements were stated as:

- the desire to manage on-time deliveries
- to decrease paperwork and the time loss caused
- to cut labour costs involved with paperwork flows
- on-line tracing capability

In JIT systems, real-time information about status and location of any in-transit shipment within the supply chain is of high significance and needs to be accessible to multiple users. The low inventory level requires greater attention to be given to verify that schedules are met exactly. Of particular relevance is the instant notification of any anticipated shipping problems. Real-time information replace the traditional batch system, when shipping data was entered into the system only at certain times, e.g. at the end of a day. [15] [16]

These requirements can only be met by advanced logistics information systems. The integration of transportation into such a computerised network is new and a challenge to all carriers who want to be successful business partners to JIT manufacturers.

2.5. Carrier selection factors

In the previous chapters it was explained that transportation is playing a new role in the inbound material flows in a JIT environment, and that it is a crucial point to make the whole strategy work. Therefore, companies pay much more attention to the selection of the carriers who could operate such a scheme. The aim is to reduce the number of carriers involved and to contract dedicated services on a long-term basis.

Several studies have been conducted on what factors influence carrier selection. The results of a survey of American firms is shown in Table 1 [14].

Table 1 Importance in carrier selection since JIT implementation [%]

Criteria	Less	No change	More
On-time performance		10	90
Responsiveness to short-term needs	3	7	90
Tracing capabilities	3	21	76
Extent of route network	3	41	56
Price	8	45	47
Terminal proximity	3	53	44
Availability of specialized equipment	5	60	35

Adherence to JIT delivery schedules and flexibility proved to be of the highest importance.

Another survey on the implications of JIT policies on carrier selection gives a similar rating of these factors [17].

(1) Customer service in terms of total door-to-door transit time and transit time reliability have highest priority. The low inventory in JIT puts more weight on the reliance on transportation to provide material just-in-time when needed.

(2) Door-to-door transportation rates/costs and the willingness of the carrier to negotiate rates is the second most important criteria. The rates for small shipments are normally rather expensive. As JIT requires to a large part the shipment of small consignments, it is necessary to gain cheaper rates in order to make the operation cost effective.
(3) Claims handling and follow-up services, which include claims processing, freight loss and damage, shipment tracing, delivery service and shipment expediting, are in third place on the scale. These are of particular importance to avoid stock out situations.
(4) Finally, equipment availability and service flexibility are rated.

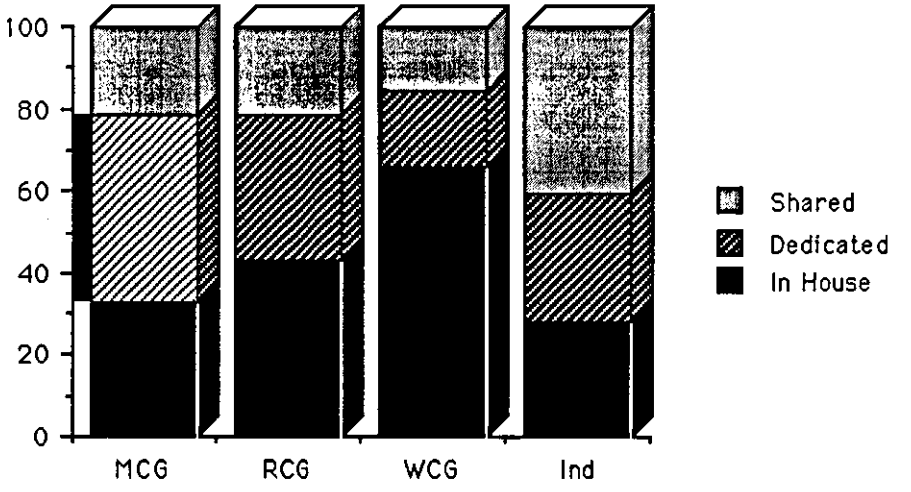
All these criteria, however, have highest value only if the JIT manufacturer is in charge of all transportation arrangements for materials supply from the vendors and a complex collection scheme is to be established. If every single vendor makes separate arrangements for his own components delivery to the customers plant, the demands on the carrier who is contracted by the single supplier have a much lower standard and complexity.

3. Changes in carrier-customer relations

3.1. Third party carriage

The general tendency in British industry is that more and more companies are willing to contract out transportation. The "Survey of Distribution Costs 1990/1991" [18] says that sixty-seven percent of the transportation costs of the companies questioned are third party costs. Figure 2 shows a further cost split for dedicated, shared and in house transportation in selected industrial sectors.

Figure 2 Breakdown of transportation costs by industrial sector



MCG - Consumer Goods Manufacturing
RCG - Consumer Goods Retail
WCG - Consumer Goods Wholesale
Ind - Industrial Goods Manufacturing

The share of third party carriage is largest in the manufacturing sectors, with a high usage of dedicated transport.

In house transportation is often used by large manufacturers with different plant locations for company internal component movements. In JIT schemes where the suppliers have to make their own arrangements for delivery of their parts to the customer's plant, a

supplier-owned vehicle fleet is often operated. To meet the requirement of small quantity, frequent, in-time deliveries, vendors use their own vans or small lorries.

However, things are different in a customer controlled JIT collection scheme. Chapter 2 illustrated the demands of a JIT system on transportation. Starting from that, it becomes obvious that only a professional carrier can provide all necessary resources and expertise to operate a JIT logistics scheme. In many cases the operation would be too complex for a company which is not specialised in logistics services. Apart from the invaluable expertise in JIT, third party carriage has the advantage of much greater flexibility in terms of manpower, vehicles and back up depot locations and networks. The customer only needs to pay for those resources which were used for the actual demand. Overexpenditure for holding unused capacities does not occur this way. Carrier companies also have the advantage of being able to offer different modes of transport if necessary.

If implementing JIT purchasing and delivery, not only the number of suppliers but also the number of carriers involved is usually reduced. This usually happens if the customer takes over the transportation arrangements from the suppliers. A survey of American firms confirms this: seventy-eight percent of them employed fewer carriers since the introduction of JIT [14]. In order to keep a complicated JIT delivery system under control and as visible and effective as possible, a very low number of carriers are contracted in this business. For example, Burrough Corporation, the third largest computer manufacturer in the USA, reduced the number of carriers involved in the materials supply from 120 to 8 [16].

Altogether, dedicated third party carriage is of special significance in JIT projects and the best way for manufacturers to find a cost effective and professional solution of all their logistics matters.

3.2. Modes of transport

There is hardly any doubt that road transport can meet the demands of JIT delivery best. It provides highest flexibility in terms of door-to-door service, decreasing shipment size as well as routing and scheduling of the vehicles for components collection. Further, it is able to respond quickly to short term modifications of any of these factors. The offer of the railways is almost exactly the opposite: firm timetables, interaction with passenger

traffic, delays, low flexibility, cost effective only for freight in bulk, access to plants only if tracks are existing and thus mostly an extra handling step for delivery to/collection from the station. This enhanced trend towards road transport in a JIT environment is approved by the results of a study, which are shown in Table 2 [14].

Table 2 Impact of JIT commitment on modes used (inbound)

Mode	Loss [%]	Same [%]	Gain [%]
Rail	49	49	2
Truck			
Common Carrier	24	50	26
Contract Carrier	--	49	51
In-house	14	61	25
Air	5	66	29

These figures prove not only the statement made in the previous paragraph, but also the trend of employing contract carriers (see chapter 3.1.) for JIT projects instead of in-house or shared transport.

Further, air freight is gaining more importance in JIT supply chains, especially for inter-continental routes. The trend from ocean to air service is, however, a very costly matter being suitable for parts of small size but high value. In order to avoid high transportation costs while shortening the in-transit times for deliveries, especially from the Far East to Europe, a combination of sea and air transport is often used as an alternative to optimise time and cost factors over a long distance.

In connection with the strong tendency towards road transport and more sensitive time criteria for delivery, it is necessary to mention the problem of traffic congestion. The question, whether JIT delivery practice is necessarily increasing traffic congestion or whether there is an alternative, will be considered later on in this thesis. On the other hand, several studies have been conducted on traffic congestion and its implications for JIT deliveries [19] [20]. The uncertainty of travelling time is increased and a significant cost increase for carriers as well as manufacturers could be caused if trucks are stuck in a traffic jam for several hours. The most effective measures to avoid these situations could be summarised as follows:

- planning of safety time for delivery;
- computer routing support to select uncongested routes;
- off-peak delivery;
- safety stock at the manufacturing site (this should be the last option as it is in contradiction to the JIT principles);
- if suppliers are located in congested areas, their components should be shipped to a warehouse or consolidation point in a different area, from where JIT delivery can be guaranteed (this also causes an increase of inventory in the supply chain and an extra handling step);
- change of facility location of supplier or manufacturer (long term measure);
- reduction of loading, unloading and receiving times.

3.3. Quality control

Quality is becoming an issue of the highest importance for any company in any business sector. It is essential for growth and success in the long term and does not concern products or services alone anymore, but the business as a whole. More and more companies incorporate principles of Total Quality Control to gain a maximum of customer satisfaction in a most cost effective way.

The JIT strategy is one approach of implementing high quality standards in all sectors of a manufacturing company. Apart from the internal measures, high quality is also required from all other involved parties, suppliers and carriers. Especially in those cases, where the carrier is to operate a complex collection system, the quality of performance demanded is on a higher level than usual (see chapter 2.5.). Certificates of BS5750 are often required and used for assessing a carrier's quality management system and thus the ability to provide satisfactory services. Quality schemes throughout a company can lower the risk of potential disruptions and improve the certainty of operation through eliminating conflicting activities and bringing the process under full control. This, in connection with pre-defined measures and responsibilities for the case of irregularities, is essential for the smooth run of JIT delivery schemes, which must be ensured by the carrier at any time.

Quality is not only a criterion for carrier selection but is audited closely throughout the operation. Lieb and Miller [14] came to the result that half of the specific contracts on JIT projects between customers and carriers contain performance incentives, and sixty-four percent include penalties for sub-standard carrier performance. In ninety-three percent of cases the carrier performance is closely measured and on higher standards than before JIT was introduced.

3.4. New carriers' strategies

All the previous chapters have explained that the market place environment for carriers have changed with the progressive introduction of JIT manufacturing in many customer companies. According to the new demands, outlined so far in this paper, carriers were, and still are, compelled to rethink and redefine their own strategies in order to face the challenge and to have a basis for business success in the future. [21]

They must be able to study a customer's materials flow and to tailor, accordingly, a disciplined and streamlined JIT transportation system, including a variety of services, with high flexibility, responsiveness and reliability. A closer relationship to the client and joint problem solving are more important than ever and mostly based on dedicated and long-term contracts. In addition to that, JIT also requires an emphasis on immediate action in the case of an emergency, which must be clearly defined in advance.

In connection with higher frequency of delivery, smaller shipment size, but high contract volume, carriers should be prepared to negotiate lower transportation rates and work out new approaches of cost reduction. This could include different delivery approaches as well as eliminating waiting times in connection with materials handling. The latter is also a matter of modern equipment.

A very important role in the new strategies is played by information technology which is necessary to facilitate the connections with the customers, tracking and tracing of shipments, routing and scheduling of the vehicle fleet as well as process monitoring.

Altogether, this chapter could only give a brief summary of the development in the transportation sector in connection with JIT customers. The following chapters will analyse in more detail the implications of the JIT business on carrier companies in Great Britain.

4. JIT in the UK

4.1. General survey

After their introduction by Japanese firms in the seventies, lead by Toyota, and having been adopted by many US companies as a weapon against the new competitor, more and more importance has been attached to JIT principles in Europe and the UK since the mid-eighties.

However, regarding the activities of the British industry, there is still far less commitment to an actual implementation of JIT practices than could be expected from the relatively high awareness of JIT as established by several surveys. According to a survey by the Business School of the University of Warwick [22], fifty-nine percent of 123 companies questioned felt that they had a good understanding of the approach and fifty-seven percent have planned or implemented certain elements of JIT, whereas less than fifteen percent have done this on a wider set of techniques as a complex strategy (Table 3).

Table 3 JIT activities in Britain

Technique	Implemented by % of total sample	Planned, implementing or implemented
1. Flexible workforce	30.1	80.0
2. WIP (Work in progress) reduction	18.7	67.1
3. Product simplification	16.2	60.0
4. Preventive maintenance	11.4	60.0
5. Statistical process control	13.8	58.6
6. Set-up time reduction	16.2	54.3
7. Continuous improvement	11.4	54.3
8. JIT purchasing	15.4	51.4
9. Work team quality control	11.4	50.0
10. Standard containers	15.4	44.3
11. Modules or cells	11.4	44.3
12. Zero defects	3.2	34.3
13. Mixed modelling	8.9	31.4
14. Smoothed line build rate	9.7	25.7
15. Parallel lines	10.6	22.9
16. U-shape line	9.7	22.9
17. Kanban	4.1	11.4
	n=123	n=70 (56.9%)

Only sixteen percent had a formal programme for investigations and implementation. This proves the assertion that many UK managers do not regard JIT as a corporate philosophy but as a set of techniques.

One reason for a lack of top management commitment to the new manufacturing strategy is often the assumption that only large companies with the ideal conditions of high volume, continuous and/or repetitive production are predestined to apply JIT successfully. In fact, larger companies, above all in the automotive, electronics and white goods sector, which are engaged in repetitive manufacturing, show the most interest and activities in this matter [23]. A questionnaire on JIT activities of manufacturers in Britain, conducted at the University of Bradford last year, had a response rate of twenty-seven percent. The profile of the responding firms by industry sector and size is given in Table 4 [24].

Table 4 Profile of responding firms

Industrial Sectors	% Respondents with a number of employees between			%Total
	1 and 249	250 and 999	Over 1000	
Chemical and allied	3	8	8	19
Mechanical Engineering	5	6	4	15
Instrument Engineering	3	6	6	15
Electrical Engineering	3	13	6	22
Vehicles and Aerospace	2	7	20	29

This shows clearly that the medium and large manufacturers of the vehicle, aerospace and electronic industries have the highest share among JIT users. But large companies are generally first to adopt new approaches and techniques. The necessity for smaller suppliers to use JIT methods of manufacturing will arise from the fact that a growing number of them will have to supply customers which operate on a JIT basis. An alternative to supply from finished stock and the most effective way to meet the new delivery requirements is to adopt JIT principles themselves. Certain JIT techniques are also applicable to non-repetitive processes.

The main impediments to the actual implementation are a lack of initial JIT expertise, i.e. difficulties in knowing what to adopt and where to start, as well as a lack of functional planning teams, poor communications within the company and supply chain problems [25]. Most companies concentrate, in the first instance, upon changes of the internal manufacturing process, with JIT purchasing practices often being neglected or left for last in the implementation strategy. But the failure to involve the suppliers in early stages can result in problems concerning their ability to cope with JIT deliveries at all. Quality and dependability are the most important criteria. Customers, however, are often not willing to bring the relations with their suppliers up to a higher level of mutual involvement and sharing of information, based on long term contracts [10].

On the other hand, customers who are serious about their JIT purchasing plans from the very beginning, for instance Japanese firms, find local sourcing a particular barrier to implement JIT in the UK. Their Far East suppliers still prove to be more accurate in terms of quantity and quality of deliveries. As a comparison, daily deliveries are arranged with suppliers in Britain, whereas in Japan material is delivered on an hourly basis. The implications on necessary buffer stocks are obvious [26].

Yet, there are several examples of comprehensive and successful implementations of JIT strategies in the UK. Details of improvements perceived by companies from JIT manufacturing techniques could be taken from the literature to which this chapter refers. In this paper, further investigations are designated to JIT delivery schemes.

4.2. Delivery approaches

JIT delivery schemes are arranged in rather different ways and with different implications for the carriers involved. The most simple approach, mainly applied by small and medium companies, are separate in-time deliveries from single suppliers, who are fully responsible for transportation themselves. Mostly not even all suppliers are involved in JIT but especially those who provide high volume or high value, since they have considerable impact on inventory.

Caterpillar (UK), for example, who could gain major benefits from their JIT manufacturing programme, receive eighty percent of their material on a JIT basis, which represent only fifteen percent of the number of suppliers [27]. Each supplier makes his own arrangements for transportation mostly using small vehicles of their own [28].

Cummins Engine, another example of successful implementation of JIT techniques in the UK, have included purchasing to a certain degree in their JIT strategy [29]. Some of their manufacturing plants, e.g. Daventry, work on a Kanban basis with replenishment mainly coming from a central warehouse in the Midlands. Another part of the components is delivered direct to the plant. Dependent on volume and location, suppliers deliver daily, weekly or monthly. Apart from direct deliveries, shipments are usually collected by one major carrier contracted by Cummins Engine. Altogether there are still seventeen days of stock on site, which is a considerable improvement as it used to be twenty-five to twenty-seven days beforehand. But that means that the whole delivery system is not very sensitive in terms of strict time criteria and dependency of the actual manufacturing process, which is well timed internally, on the punctuality of deliveries.

A replenishment system with higher time sensibility is operated by Lansing Bagnall at Basingstoke for a number of their standard components [23]. For example, there are about thirty battery removal attachments used per week. Three containers are filled with these parts, holding eighteen items each. Two of the containers are held on the assembly line, one is kept by the supplier. The latter is brought to the Lansing plant on twenty-four hours notice when one of the containers there is empty. The empty one is collected and refilled within a week. This is a simple system with a very low amount of stock held by both parties. Other parts are delivered direct to the Basingstoke plant in daily lots or on weekly schedules from local suppliers. Specific delivery instructions about the types of parts required are given on twenty-four hours notice.

In all of the examples given so far, the customers left mostly full responsibility for transportation to their suppliers. That means that there is no demand for a complex solution of connecting and covering a suppliers network, and thus no need for appropriate expertise and capacity, provided by a third party, to develop and operate such a system. The demands on carriers involved are not very different to their general business.

Much higher standards on delivery schemes are set by the large manufacturers in the automotive and computer industry. They often take over responsibility for transportation arrangements and contract a major carrier to arrange a complex collection scheme from numerous suppliers. As outlined in the previous chapters there is a complexity of new requirements concerning range and level of carrier services. The different approaches of setting up and operating inbound JIT delivery systems and the implications arising for the carriers doing business in a JIT environment were the subject of the research.

4.3. Introduction to the case studies (Research method)

As the topic of research is very much related to systems which are operated in practice, information could be obtained for the most part only from establishing closer contact with relevant companies. Those companies were identified initially from literature, newspaper reports and questioning experts in related subjects at Loughborough University, University of Warwick, Cranfield Centre for Transport and Logistics as well as contacting JIT Consultants and companies.

The idea of sending questionnaires to the companies turned out to be unsuitable for different reasons. Firstly, a questionnaire requires a reasonable sample size so that an acceptable number of usable returns could be expected. This research work is targeted on implications for carriers who operate extensive JIT collection schemes, covering a wide network of suppliers. The number of companies who actually set up systems in this advanced, complex approach and are thus relevant for further investigation is too low to get sufficient results from using questionnaires. In addition to that, as experience shows, the response rate of questionnaires is generally rather low, and more so if the questions are very detailed.

Secondly, the existing schemes are basically so different that a questionnaire could not have covered the variety sufficiently unless it had been of great length. In that case it would have contained certain sections that were irrelevant for one or the other carrier. This would have also had influence on the willingness to fill in and send back the questionnaire.

Thirdly, a questionnaire would not have allowed the in-depth analysis which is necessary for the purpose of this project. It could be foreseen that from the complexity and difference of the schemes further in-depth questions would arise in the course of research after obtaining a first lot of information. It would be necessary to expand on different points in more detail.

These were the reasons, as well as the awareness of touching on confidential information about the companies' businesses, that the option of personal in-depth interviews with a selected number of companies in the automotive and computer manufacturing sector was considered to be the most appropriate methodology for this research project.

Therefore, most of the information was obtained from direct contact with both manufacturers and carriers. Repeated personal and telephone interviews as well as tours through manufacturing plants, warehouses and other operational points were conducted to get a comprehensive impression of the JIT logistics chains. Prior to the actual interview process people were given a list of topics and questions [see Appendix]. Table 5 gives a summary of all case studies which will be described and analysed in the following chapters.

Table 5 Companies covered in the case studies

Manufacturer	Carrier
Hewlett Packard	- Air Express International
Rank Xerox	- Frans Maas
Rover	- British Road Services
	- TNT
Ford	- British Road Services
IBM	- United Carriers
Nissan	- Ryder
Honda	- [Swift - tender]
Toyota	- Automotive Logistics
	[Swift - tender]

Emphasis was laid on in-depth questioning of the carriers. The aim was to find out whether differences between JIT and non-JIT customers exist. This regarded all aspects of the carriers' contract management and operation. The factors on which the kind and extent of the necessary differences depend were identified. On the basis of that, it was investigated whether the special efforts of the carrier in a JIT business could be quantified and have a real impact on resources and costs. In connection with that, considerations were made as to whether JIT delivery concepts necessarily demand a higher number of journeys with smaller vehicles and lower vehicle utilisation and what this depends on.

With the exception of Ford and Honda, all of the manufacturers were also contacted in order to learn about their views and demands on the delivery systems and carriers' performance. This was covered mainly by the points 1, 2 and 4 of the questionnaire. This

research could, however, not investigate into the level of JIT implementation in the manufacturing processes of the companies in question. Work was fully concentrated on material replenishment and supply.

In the following chapter, the case studies give a brief introduction into the different delivery approaches and features of operation. Starting from that, the resource and cost comparison, as well as the implications for the different carriers operating these systems are discussed in further detail in chapters 6 and 7.

5. Basic JIT delivery schemes

5.1. Long supply chains

5.1.1. Introduction

The ideal conditions for JIT delivery schemes are the immediate proximity of the suppliers to the manufacturing plant and the collection of material in small shipments on a high frequency. But in spite of a reduction of the supplier base, there can be only a small number of them, being situated very closely to the customer. A large share of the components is usually imported from abroad. It is necessary to remark that for companies in Britain, all suppliers in Europe are mostly regarded as local. But High Tech manufacturers, and more so, the Japanese car manufacturers, with plants in the UK, do still procure a very large share of their components from the Far East or America.

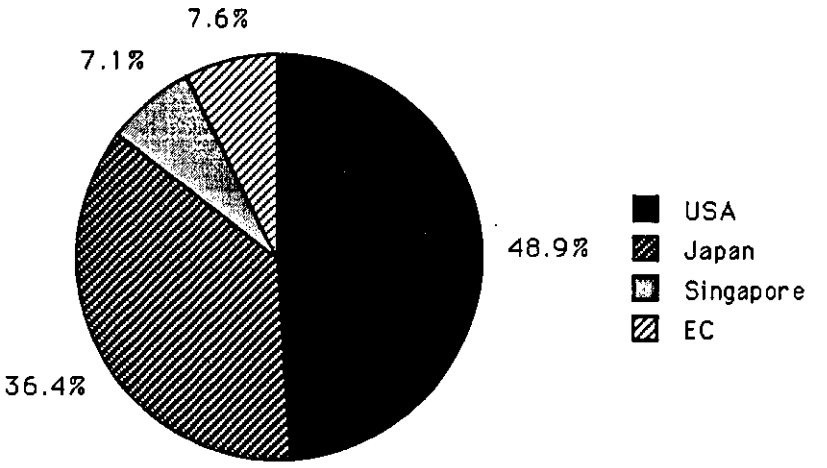
These long supply chains between different continents, including transport by ship and/or air freight, are also part of the companies' JIT strategies. The JIT factor is to have a well timed supply chain with reduced in-transit times of the material and predicted times of arrival. How such a time sensitive concept is realised over long distances should be illustrated by the following case study.

5.1.2. Case study: Hewlett Packard - Air Express International [30][31]

Hewlett Packard - one of the leading computer manufacturers in the world - started production in its UK Company Peripher Bristol in 1987. From the very beginning JIT principles of delivery were applied to the inbound flow of material, transportation and warehousing being contracted to third parties. The inventory held on site has an average dwell time of about 2 weeks, with some components held for 2 days and others for 1 month, based on an ABC-inventory control. On the basis of a 3 month forecast for material requirements, the exact delivery dates can be modified at short notice. Depending on the amount of stock, which is held for a certain part, some deliveries are more and some are less sensitive in terms of just-in-time arrival. Altogether there are 1,600 different inventory parts from two hundred suppliers. The latter number is still to be reduced.

More than ninety percent of the components come from outside Europe. That means that the whole JIT strategy concentrates mainly on long supply chain management. The exact split of sourcing is given in Figure 3.

Figure 3 Import share of Hewlett Packard



Suppliers in the UK deliver daily or even two or three times per day. They are in charge of their own deliveries. Several major carriers share deliveries from all other EEC countries, forming a European truck network with fixed schedules and transit times from different origins. Daily groupages arrive from Germany and France, consignments from other places come less frequently. The scheduled times of arrival are based on the date rather than hours. The bulk of material, however, requires perfect timing of long supply chains from Asia and America to England.

Some very voluminous freight from Japan, which makes air transport too expensive, is shipped by sea. This takes one month's time, but is about 10 times cheaper than by plane. In order to reduce the transit time as well as the extra inventory, that must be held for these bulky shipments, a new delivery approach is considered for the future; the components were brought by ship to the US West coast, shipped by truck to the East coast, and brought by plane from there to Europe. This had the effect of a 2 weeks transit time reduction and a total of only thirty percent of the air freight costs direct from Japan.

Yet, as the majority of components are of high value but little volume, most of them are carried by air freight. In the very beginning of the production in Bristol, Hewlett Packard contracted 2 or 3 air freight carriers, depending on demand for the incoming material. After about one year of operation, they checked the competitiveness of these forwarders to other carriers offering their services on the market. The main criteria were modern equipment, quality of delivery performance, reliability, cost, and experience in a similar business. As a result of that and in connection with geographical reasons - Bristol should be covered by an integrating system - the contracts were changed and Air Express International (AEI) was selected as the new and only carrier taking over the whole business.

The operation comprises carriage to Bristol from Tokyo and 4 major gateway origins in the USA with the following frequencies:

Tokyo	4 x per week
Seattle	3 x per week
San Francisco	3 x per week
Boston	3 x per week
Denver	2 x per week.

The separate shipments are collected from the suppliers and brought to the gateway airports by different local contract carriers. AEI are consolidating these consignments in the terminals and shipping them by air freight direct to London Heathrow airport. After customs clearance and simplified declaration the consignments leave the airport by truck for Bristol at 6:00 hours the next morning. The time slot for delivery to the Hewlett Packard plant is from 7:00 to 7:30 hours. The trucking service from the airport to the manufacturing plant is also provided by AEI as part of their door-to-door service.

5.2. Warehousing

5.2.1. Introduction

One of the main objectives of JIT strategies is the reduction of inventory in the flow of material from suppliers to manufacturers. The general problem in JIT, concerning the storage of material, is that the customer, who is implementing JIT not only in his manufacturing process but also in purchasing, tries to minimise the amount of stock held by himself. That means that everything else is pushed back to the vendor. Richard Schonberger says in his book "World Class Manufacturing" [32] that it is a principle of JIT to store material at the point of manufacture, i.e. the supplier, for 3 main reasons:

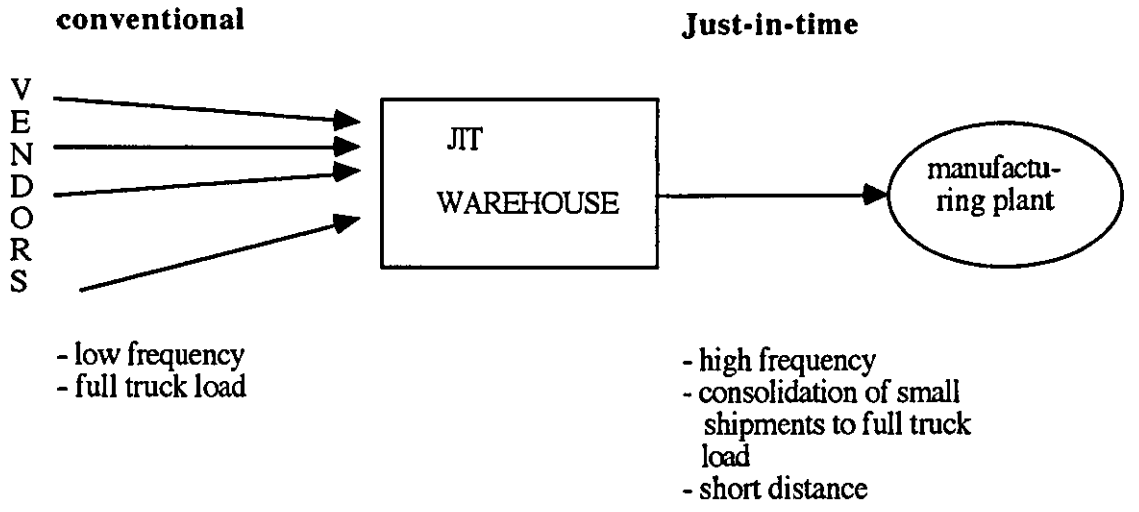
1. Avoidance of initial transport costs and cost of returns in case of cancelled orders.
2. Avoidance of one handling step if material goes from the vendor's stock direct to the customer's production line, and thus lower risk of damage or loss.
3. If the supplier is fully responsible for the costs of storage, it is the best incentive for him to avoid making the components before the customer needs them.

At the same time there is a trend towards so called "JIT warehousing". The establishment of a warehouse as part of JIT supply chains is actually negating the idea of JIT in terms of stock and lead times reduction, leaving the vendors free from any pressure to commit themselves to JIT delivery. Schonberger says "that the addition of another middleman is sure to increase stocks, lead times, and all related costs." Apart from that an additional communication link will also be necessary. But what is the purpose of having a JIT warehouse ?

Such a warehouse, usually being dedicated and located very close to the customer's plant, could be regarded as a kind of replacement for JIT delivery from suppliers to the manufacturer. It is a cut in the supply chain where

a) conventional delivery of full truck load from the vendor to a warehouse terminates
b) JIT delivery of consolidated shipments over a short distance to the plant starts. (Figure 4)

Figure 4 JIT Warehouse system



This warehouse could be operated on the initiative of the suppliers, in order to cope with the requirements of JIT delivery, if high frequency transport of small shipments is too costly for the single vendor. But this would demand joint action of a high number of small suppliers and a high degree of coordination and investment. So it is not very likely that this would actually happen.

A JIT warehouse is generally operated by the manufacturer. After having implemented JIT principles in the internal manufacturing process, this is usually an attempt to provide JIT line feed without including the suppliers in the JIT strategy. At the same time the risk of delay or any major problem within the JIT supply chain is kept to a minimum by having the warehouse close-by. All of the following three case studies proved that the warehouse is, however, supposed to be a temporary solution only to bridge the gap, until a satisfying JIT supply network is prepared and implemented.

5.2.2. Case study: Rank Xerox - Frans Maas [33][34]

Rank Xerox, being rather successful with their JIT supply and distribution strategies especially in the Netherlands, have undertaken the first changes towards JIT line feed in its UK plant in Mitcheldean in the beginning of 1990. Before that, all material coming from Japan (fifty percent), Europe (thirty-five percent) and the UK (fifteen percent) was stored on the manufacturing site. The new strategy was to reduce the amount of inventory held in Mitcheldean to a minimum of buffer stock, and to provide JIT deliveries on a Kanban basis from a close-by warehouse.

Rank Xerox contracted one major carrier for the whole operation - the Dutch freight forwarder Frans Maas, who run the main part of the Rank Xerox distribution business in the Netherlands.

The material supply to the manufacturing plant is arranged as follows. All suppliers get a purchase order forecast for one year which is converted into firm orders and delivery schedules for eight to thirteen weeks every month. The longest lead times are, of course, allowed to the shipments coming from Japan, twice a week. There is an extra stock of these components to allowe for production changes.

The biggest suppliers in Europe are Germany and the Netherlands. One full truck load arrives every day from each of these countries. Shipments from other countries come once a week as groupage, usually mixed with consignments of other customers. This is carried out as part of the European Frans Maas collection and delivery network. Frans Maas receive a delivery schedule from Rank Xerox every week, but the actual orders to pick up the shipments are given by the vendors by phone on twenty-four hours short notice. Basically the same system is operated for collection of material from vendors in the UK. Small shipments are given to the collection and delivery services of local road hauliers.

Only very voluminous freight like pallets and packaging material is delivered in full truck load by the suppliers themselves. These shipments come every day and go direct to the production line, as handling through stock is too expensive for these items.

Apart from the latter and some components in the buffer stock on the manufacturing site, all other consignments go through the warehouse in Gloucester, about twelve miles

away from Mitcheldean. This warehouse is completely controlled by Rank Xerox but operated by Frans Maas. The average amount of stock held is 7 days. If one considers the relatively higher amount for the Far East, there is an inventory of 2 to 3 days for material from European and British suppliers.

The replenishment system for the warehouse and manufacturing line works as follows: Every month the Marketing Department of Rank Xerox gives a forecast on demand for products for the next month. On that basis a production plan as well as the material requirements plan are set up weekly for every single day of the following week.

In addition to that, each station on the shop floor is connected with the central computer system in order to feed in the real time material requirements of the production line. This is the basis for replenishment from the warehouse the next day. The computer compiles the up to date orders for all components to be delivered to the shop floor early in the morning. Frans Maas receive these orders as the computer network is connected with the warehousing system, and consolidate the required shipments for the day. Full truck loads are shipped from the warehouse to the plant, with material for only one or two shifts of production, which must arrive at the beginning of the shift.

Altogether the process as a whole can be divided into two separate operations: firstly, materials collection from the vendors and transportation to the Gloucester warehouse, and secondly, daily JIT production line feed from the warehouse.

This warehouse, however, is regarded as only a temporary solution which should be replaced in the future, in favour of a further reduction of inventory. Rank Xerox's plans include, firstly, a further reduction of the number of vendors. Secondly, the suppliers should be stronger involved in the JIT strategy. Through the introduction of external materials pull, lead times are to be reduced to 15 days and the inventory to one or two days. This would come closer to strict JIT delivery and the warehouse could be turned into a consolidation point. This would also put more pressure on the carrier in terms of more stringent time criteria for arrival of the parts, as well as more frequent collection of smaller shipments.

5.2.3. Case study: Austin Rover - British Road Services [35][36]

With the introduction of the Rover 800 in 1984/85, a new strategy for storage and movement of the final assembly materials in the Rover manufacturing plant in Cowley became necessary. Conventional approaches would have required more stores to be built and more expensive inventory to be held. Apart from high costs for storage, there was not enough space on site to cope with a higher amount of stock and/or more trucks delivering the components on a higher frequency. Even beforehand the place was often congested with lorries unloading their shipments at several points and causing up to 5 hours waiting for the drivers as there was no system of timed deliveries.

The new strategy was to set up a consolidated warehouse near to the plant, from which a JIT line feed, with less than two shifts stock on the manufacturing site, could be guaranteed for most components.

The materials in the warehouse are still in the possession of the suppliers until they are delivered to the plant, i.e. the vendors have to bear the costs for storage of their components themselves. Apart from long term requirement plans, every day all suppliers get information about their stock level in the warehouse and consumption of components on the next day by Telefax. This allows them better planning of production and replenishment. All vendors are in charge of their own delivery to the warehouse. Most of them do usually deliver in full truck loads once a week, some in small vans, depending on the volume. Delivery to the warehouse instead of the plant saves them much time and thus leads to faster turn rounds of the vendors' vehicles. Only large volume items with a high usage rate are delivered direct to the track on a daily basis. The amount of stock in the warehouse is now between 2 and 7 days.

The considerable reduction of storage space on Rover's site allowed this space to be used for an extension of production or to be made redundant, respectively, in order to make the plant's operation more efficient altogether. Between 1986 and 1989 the inventory at the Cowley plant has decreased from £50m to £35m.

The carrier who is operating the material supply from the warehouse to the plant are British Road Services (BRS). The 47,000 sq ft warehouse is only one mile away from the Rover plant and caters for two hundred and fifty suppliers with about three hundred lorries arriving each week. BRS run only four 40ft trailers which deliver consolidated shipments for the next production shift from the warehouse to the production line on a four hour turn around.

These four hours include selection of the required items, labelling, loading, documenting, printing, delivery to the plant, collection of empty pallets and return. About ninety percent of the components go direct to the track. There is a small percentage of parts held in small buffer stock on the manufacturing site. These are parts, where the usage rate is varying as they are used on less than twenty-five percent of the production.

The material requirements and orders for the next consolidated shipments are generated direct at the production line on the basis of a Kanban system. By the means of computer links between the track and the warehouse, the items are called off as required, and a new stillage is ordered automatically. These orders are to be fulfilled within the next 4 hours and BRS have to ensure that all consignments required will be consolidated in the right order.

5.2.4. Case study: Rover - TNT [37]

The Rover manufacturing plant in Longbridge is the largest part of the Rover works in the UK. Under the initial transportation scheme, all material used to be delivered by the suppliers in full truck load direct to the stores on the manufacturing site. The average amount of stock held on site was about 3 weeks.

In the early eighties, Rover carried out fundamental changes to the production process towards JIT principles in some of their manufacturing plants. In Longbridge a manufacturing capacity of one car per minute caused a higher and faster use of components in the production process, requiring a good replenishment system. But the extension of production caused a deterioration in the situation of having too many trucks on site at the same time, causing congestion and long waiting times for unloading at different receiving points. This situation turned out rather similar to the one in Cowley as described in the previous case study.

A decision was made to change the whole system of delivery and make it part of the JIT strategy. The main target was to decrease the inventory to be held by Rover on their own site. The solution was to set up a distribution centre a short distance from the plant and to operate a JIT line feed from there. All this was very similar to Rover's first project in Cowley, and this supply strategy was introduced into other manufacturing plants at the same time.

In this case, TNT got the contract for the business and were in charge of providing the expertise and resources necessary to carry out Rover's plans. The dedicated TNT distribution centre is located in Wythall, about 6 miles away from the Rover plant. About two hundred and thirty suppliers deliver their materials in full loads to the warehouse where 2 to 5 days of stock are held. The suppliers bear the facility costs for the distribution centre as they pay for the storage of their parts in the warehouse. Forty vendors deliver direct to the plant.

The operation from the distribution centre includes material replenishment for the production line on a Kanban basis as well as sequenced delivery of bumpers to the plant. There are one hundred and twenty different types of bumpers. Only after the painted body shells have passed a trimmer on the track, the orders for the appropriate bumpers are made in the sequence they ought to be delivered. The Kanban system at Longbridge is basically the same as the one in Cowley, described in the previous case study. TNT have to consolidate the shipments and deliver all material required within 4 hours after receipt of the orders, including about fifteen minutes travelling time. The maximum amount of stock, held on the shop floor, is 8 hours. This approach of delivering consolidated shipments to the plant allows the use of big trailers.

As was said at the beginning of this chapter, the solution of a close-by distribution centre for JIT materials supply is meant to be only temporarily. Although it took a lot of time, expenses, and efforts to implement these concepts, Rover and TNT are already working on JIT collection schemes for the near future. This programme will be described in the following chapter.

5.3. Consolidation points

5.3.1. Introduction

"Consolidation of inbound freight involves grouping two or more small shipments from one or more suppliers to form a single large shipment at a convenient point, designated as a consolidation centre." [11] If it is profitable to set up a consolidation point, and where the best location is to do so, depends on several factors [38]:

- concentration of vendors in the region,
- volume of freight generated in this region,
- frequency of deliveries,
- linehaul distance between consolidation centre and destination.

Consolidation services in the JIT business, unlike general collection and delivery services, are usually dedicated to one customer. The latter has full control and flexibility to change shipment instructions quickly and at short notice, e.g. shipment size, routing, or delivery schedules. These are factors of high importance in JIT schemes and underline the significance of closer relationship between customer and carrier. The considerable cost advantage of consolidation over separate shipment of components will be discussed in chapter 6.

5.3.2. Case study : Rover - TNT [39]

As mentioned in chapter 5.2., Rover's JIT delivery strategy is still being developed with the target of further decreasing the inventory level in the supply chain. Rover's goals for the new approach are:

- to minimise stock throughout the whole supply chain,
- control and visibility of the pipeline,
- frequent delivery of small shipments with recognition of transport cost economy,
- finally one hundred turns of inventory per year (presently fourty).

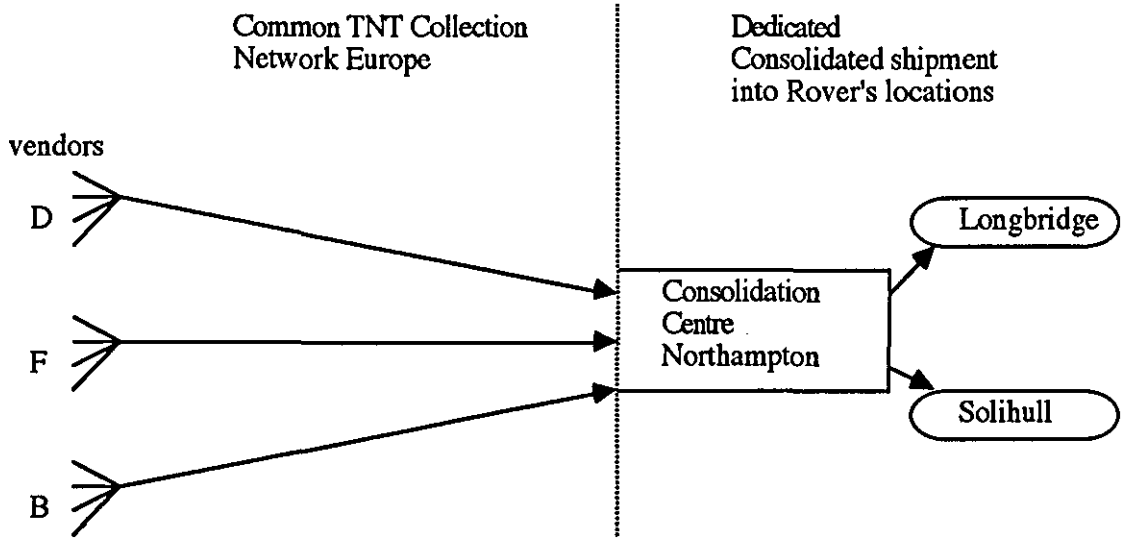
With the introduction of a new system, the warehouse operation should be finally replaced by a collection and consolidation service. The latter has already been introduced for the delivery of materials coming from the European continent. A UK collection service is being prepared at the present. These projects have been initiated and implemented in cooperation with TNT as the logistics expert.

1) The European collection scheme

The implementation started with a change of the terms of delivery from 'delivered' to 'ex works' for shipments from those vendors who were included in the pilot schemes. There are three hundred suppliers in Europe altogether, with main origins in Germany, France, and Italy. The pilot scheme started in September 1991 with twelve German suppliers. After that, all fifty-five German suppliers were included in the system by June 1992, all French by October 1992, and the Italian vendors should be involved by December 1992.

The components' collection from the suppliers could be taken over by the common European TNT network. As there are fixed transit times for shipment from certain origins in Europe to Britain, the collection of the parts is fitted in to the schedules according to Rover's requirements concerning the date of delivery. The consolidated shipments are brought in full truck load to the consolidation centre in Northampton. By summer 1992, two trailers arrived per day, but it is expected to have six trailers arriving per day by the time the operation is fully implemented. Figure 5 illustrates the basic features of the operation.

Figure 5 TNT collection for Rover (European suppliers)



At the same time the Northampton consolidation centre is an inland clearance depot, with twenty-four hours customs' attendance on 6 days of the week which speeds up the handling of t imported goods. In the consolidation point, the shipments are not stored for longer but re-consolidated according to Rover's requirements, and shipped to the different plants in full truck load (FTL) on the next day, at the latest. The date of delivery is given by Rover but the exact time of arrival during the day is announced to Rover by TNT. Then there is allowed a time slot of only thirty minutes for FTL or fifteen minutes for LTL (less than truck load) for the truck to be on Rover's site for unloading.

2) The UK collection service

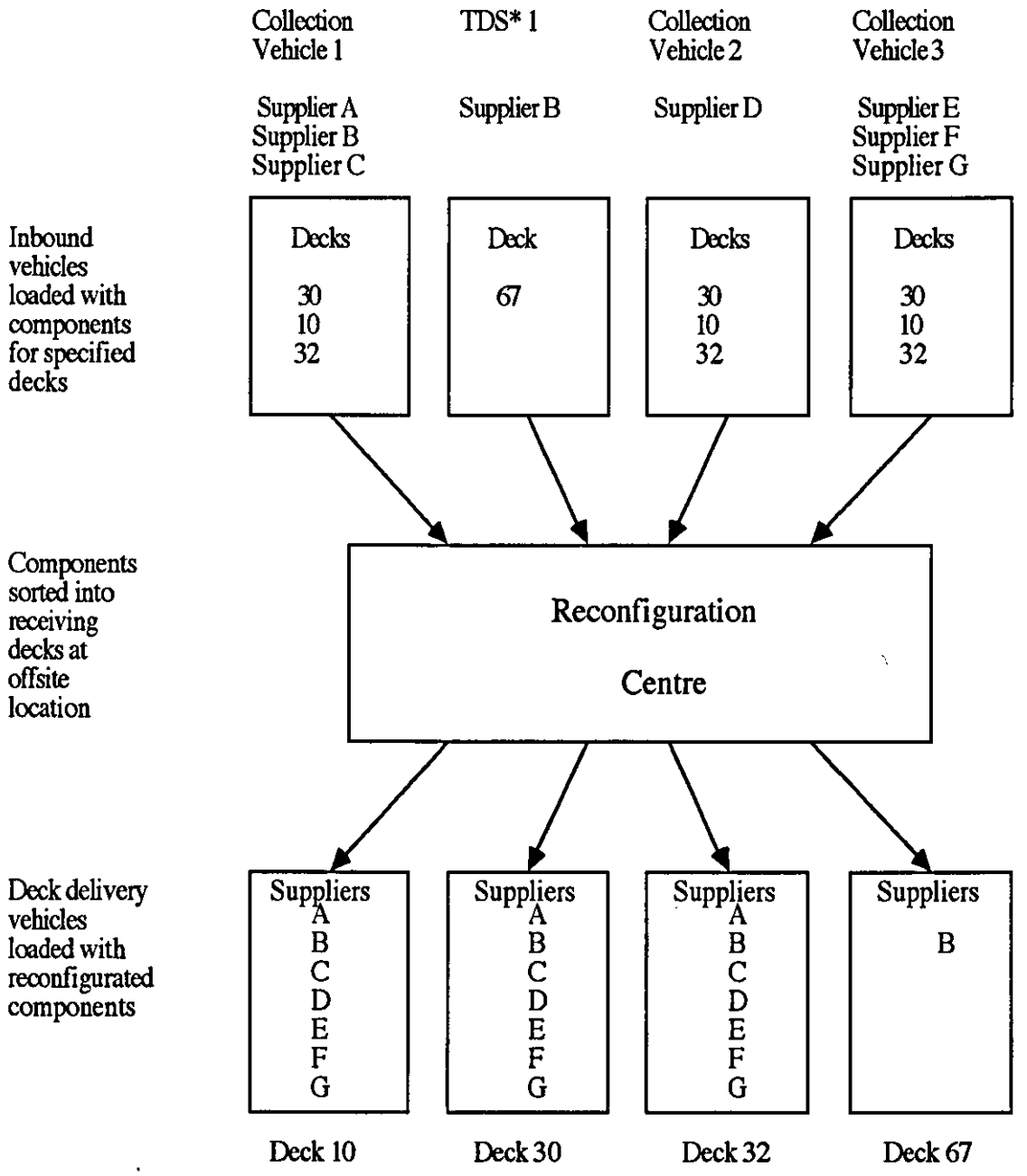
Rover's preparations for the introduction of a collection service in the Midlands area, where the bulk of suppliers for the motorcar industry are concentrated, began at the end of 1991. Again, TNT was appointed as the logistics partner in this project.

Out of the seven hundred vendors supplying Rover from the Midlands, a number of forty-nine were included in a pilot scheme, being covered by 6 collection routes. TNT reckon that they could possibly include the majority of the suppliers by December 1993.

On the basis of an 'ex works' collection scheme the components will be collected from the vendors on so called milk rounds. Before being finally delivered to the Rover works the shipments will be brought to a reconfiguration centre close to the plants where the single parts are sorted and loaded on delivery trucks for specific receiving decks. This process is illustrated by Figure 6. This approach guarantees full truck loads for the collection rounds as well as a short distance between reconfiguration centre and plants.

The essential difference, however, of this reconfiguration centre to all that was said beforehand, concerning the purpose and location of a consolidation point, is that it was initially not established to save transportation costs over a long distance. This could have been realised by milk round collections delivered straight into the plant. The problem here was not only to rationalise delivery from several vendors to one customer but at the same time to cope with shipment from one vendor to different customer's locations.

Figure 6 TNT Reconfiguration Centre for Rover



* Transit Depot Scotland (consolidation of shipments from numerous suppliers in Scotland)

As the terms of delivery were changed from 'delivered' to 'ex works', TNT was also put in charge of negotiating the new piece prices with the suppliers. These prices used to include a part of the transportation costs born by the suppliers. As TNT is the 'expert' for all questions concerning transportation, Rover left it to TNT to estimate the savings which could be achieved in the purchase of the components. Using the economies of scale which arise for Rover from giving high volumes of freight to TNT, and thus gaining best conditions of rating, the savings in the purchase prices and savings in transport costs should result in a lower overall total cost for Rover.

8.3. Case study: Ford - British Road Services [40]

Ford have several manufacturing and assembly plants in England and Wales receiving material from a few hundred vendors in the UK, Europe and overseas. Until 1982 all vendors had responsibility for delivery of components to the Ford plants. With the introduction of JIT principles and the goal to cut costs by reducing the high inventory, a new delivery strategy needed to be developed and an 'ex works' scheme was initiated.

Different carriers were contracted by Ford for deliveries from different regions. The UK was progressively divided into 4 regions, each covered by a different road haulier, in order to expand the 'ex works' practice nationwide. In the meantime the European suppliers could also be included by having a European collection network run by Frans Maas.

Before this system was established as a whole and all Ford suppliers could be included, an initial scheme was piloted by British Road Services in the Midlands area where most vendors for the car industry are situated. BRS cover a fifty miles radius around Birmingham serving three hundred and fifty-two vendors of Ford which provide about fifty percent of the incoming material. The parts are collected, go through a consolidation centre and are delivered to the different Ford manufacturing plants, all on a JIT scheduled basis. Thus, the amount of stock held at Ford's locations was cut down to between one and a half and five days. At the same time a reduction in the overall transportation costs could be achieved and Ford was given greater control and flexibility of the materials flow. In addition to that, Ford intend to reduce the number of their suppliers in the long term.

The BRS consolidation centre in Birmingham is dedicated to Ford and the only one of its kind run by BRS. Its location was chosen as a balance between logistical aspects and cheap available premises. But there is no question about the profitability of a consolidation point in an area with more than three hundred vendors within a fifty miles radius.

The operation is carried out as follows: Ford give a schedule for material requirements with thirty days lead time to their vendors. BRS get a monthly supply release document in order to be able to plan the vehicle capacities. One day before the collection is due, before 4.30 p.m., the vendors give the order for pick up to BRS by phone. The schedule and routing for collection is then made manually. Some sixty to seventy percent are regular frequent collections. Depending on volume and destination there are different forms of delivery services to the manufacturing plants (see Figure 7):

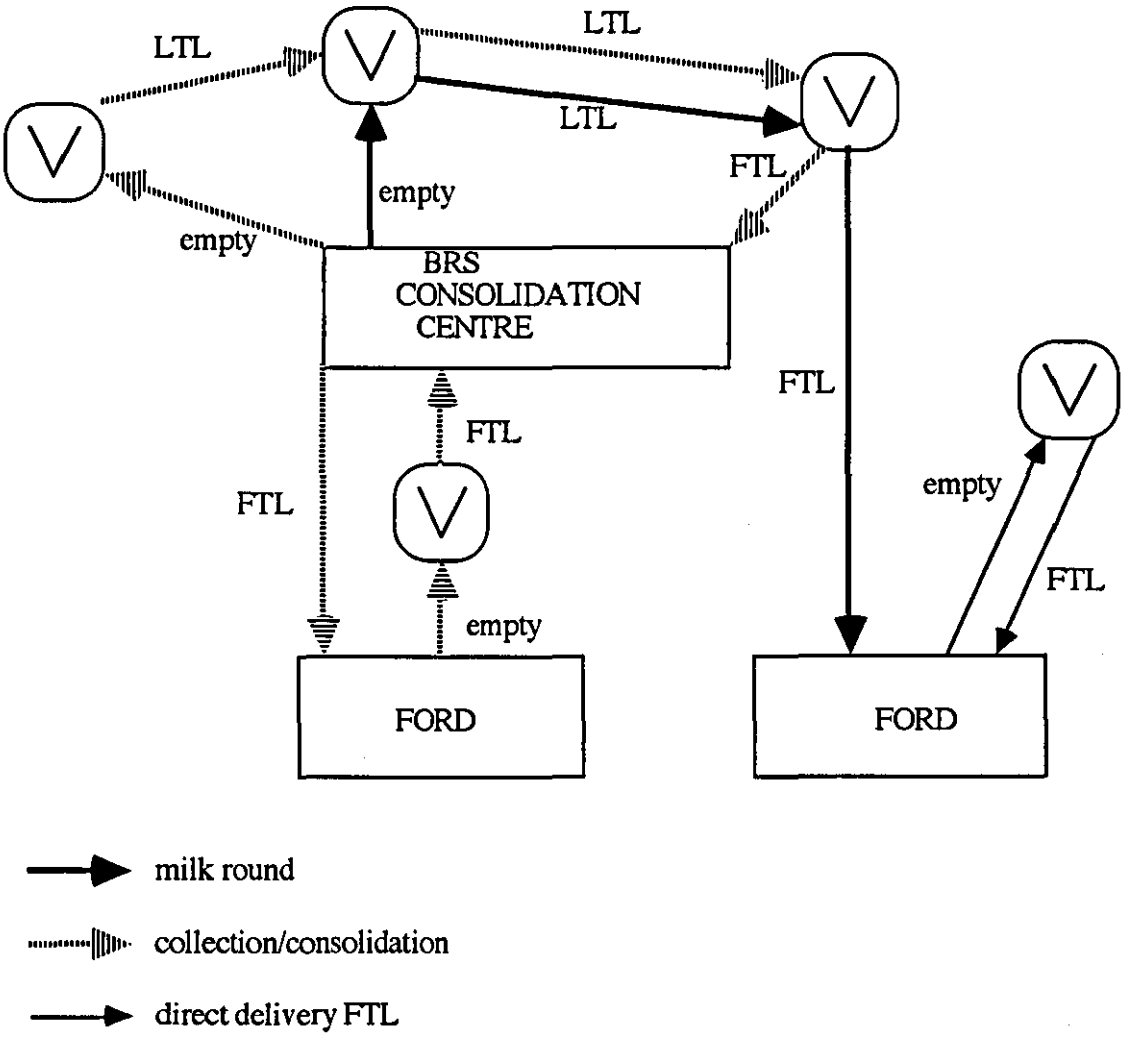
(1) direct delivery of full truck load from one supplier to one plant,
(2) milk round collection of LTL from different vendors filling up a truck to FTL and direct delivery of this load into one plant,
(3) collection of components from one or several vendors and carriage to the consolidation centre where the consignments are re-consolidated into separate FTL shipments for different Ford locations.

There are plans to send the trucks on a second collection run on their way back from the plants.

If the material goes through the consolidation point, it does not stay there for longer than minutes or a few hours to get loaded off and on the trucks. It takes a maximum of fourteen hours to complete the delivery from the supplier to Ford.

The decision between milk round to the plant and collection into the consolidation centre is usually made by Ford. There used to be regular standard milk round collections on a fixed schedule, although in most cases FTL could not be reached. Milk rounds were preferably made for high value goods in order to save one handling step. Because of the declining manufacturing volumes of Ford, however, milk rounds are not carried out anymore on a regular basis.

Figure 7 Delivery services to the Ford plants

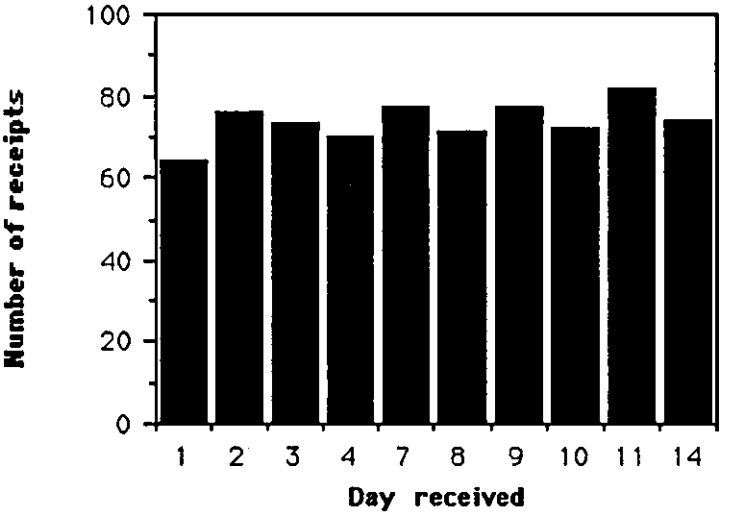


When the advise of dispatch is given to Ford on the day of collection, they send a list of high priority part to BRS which must be delivered as quick as possible on the same night. Usually the components are delivered by the start of a shift and the time of delivery is advised to Ford by BRS. Time slots for arrival exist only for those locations where the docks for unloading are small, and the incoming deliveries must be scheduled in order to avoid congestion and time lost waiting. But on the other hand, BRS can charge Ford for trucks exceeding a certain time limit on site for off-loading.

At Ford's major plants, shunters undertake the off-loading of the trailers and loading of empty pallets for return. The delivery drivers may simply drop off the full trailer with the incoming material and pick up a trailer full with pallets. This approach facilitates a fast turnaround of the vehicles.

The operation is carried as a twenty-four hours service on 5 days per week and twelve hours on Saturdays. About 1,175 loads are handled through the consolidation centre within a period of twenty days (see Figure 8).

Figure 8 Receipt of BRS collection vehicles into consolidation point (01/10/91 to 14/10/91)



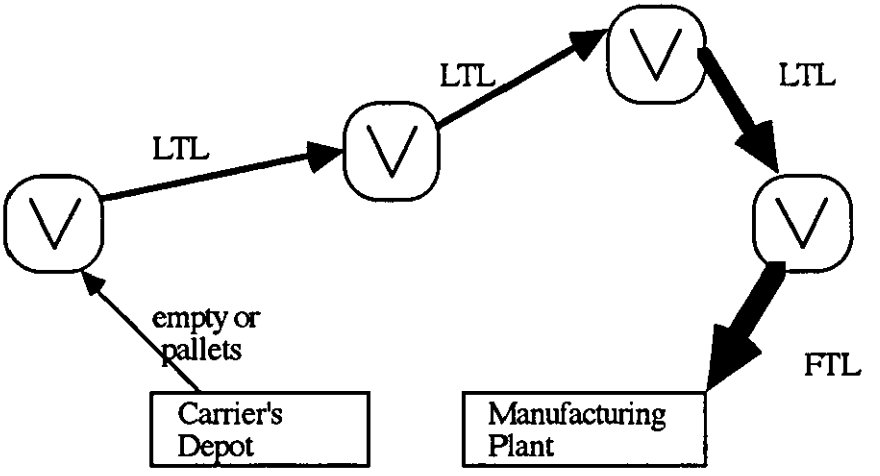
The consolidation of material from all suppliers in the Midlands and delivery to all UK Ford locations, as described in this case study, is a transportation system of the highest complexity. BRS are the largest consolidator for Ford, collecting, handling and delivering about forty thousand tons per month to all Ford locations in the UK.

5.4. Milk round collection

5.4.1. Introduction

The principle of milk round collection has already been mentioned in previous chapters. It is simply the collection of LTL shipments from different vendors for one customer on one truck, and finally FTL shipment direct to the manufacturing plant. The supply chain is not broken by an extra handling step via warehouses or consolidation centres and, thus, the risk of damage, loss or mix up is decreased. (see Figure 9)

Figure 9 Milk round collection service



This kind of delivery service comes closest to the idea of JIT as an approach to reducing lead times and inventory throughout the whole supply chain. It is usually carried out on an 'ex works' basis. Depending on volume and distance, milk round collections allow pick up from the vendors several times per day. The basic demand on JIT of small shipments and high delivery frequency can be met in the most efficient way by applying this concept.

5.4.2. Case study: IBM - United Carriers [41][42]

Planning the prospective product lines for their Havant manufacturing plant, and considering that the storage of material tied up large amounts of space and capital in connection with significant transportation costs, IBM decided to change their UK delivery strategy towards JIT in the mid-eighties. Before the new scheme was started in February 1988, IBM contracted sixteen different carriers for different regions in the UK. An optimisation of delivery from vendors, situated in proximity to each other but covered by different carriers, was not possible. Material from Scotland was even shipped by rail. There were no schedules for delivery; all parts were brought to a warehouse with an average stock of 6 weeks.

For the new scheme the suppliers' base was reduced from a few hundred to sixty-five in Britain. The amount of stock held in the warehouse could be reduced to about 2 weeks and a small number of items only. That means that those parts that are still kept in the warehouse are originated overseas and could not be included in the JIT concept. As there is less space in the warehouse used for storage of components now, it is partly used for manufacturing and other purposes.

The majority of the materials is collected in milk rounds and delivered JIT direct to the manufacturing lines. Only one major carrier was contracted to take over the whole system. United Carriers became the new logistics partner of IBM.

There are ten fixed collection routes every day, including the shipment of FTL from suppliers of high volume parts and collection of consignments coming from overseas and arriving at London's airports. Altogether about eighty-five percent of all shipments are delivered direct to the plant on a JIT basis. These routes may be different each day, as from about twenty vendors material is collected on a daily basis whereas others deliver between three times and once per week. The collection programme is fixed week by week, but changes are often made by phone at short notice. In the case of a particular region which is not covered the very day when a certain consignment needs to be expedited, United Carriers have the opportunity to pick up and deliver the components by their nationwide parcel service. Otherwise there is always a van ready to go and pick up single consignments.

Collected parts from the local area are delivered to the plant on the same day. In remote areas like parts of Northern England and Scotland, the material is picked up from the vendors during the day and shipped down to Havant during the night arriving by 7.30 in the morning. Two trucks are used for one route, one for collection and one for the trunk haulage. The demountable modules of the two vehicles are simply swapped in a truck depot of United Carriers situated at a central point. The trunk vehicles do local collections during the day as well which allows a very high vehicle utilisation. This may be increased by returning empty packaging to the vendors by the outgoing vehicles or connecting the network with the distribution of finished products.

The modules are brought to a central point of the Havant plant complex, from where they are delivered by a shunting vehicle to the different manufacturing locations within the plant, according to a timetable.

5.4.3. Case study: Nissan - Ryder [43][44]

Nissan started production in their UK manufacturing plant in Sunderland in 1986. They pursue a policy of single sourcing, and although a considerable amount of material is still coming from Japan (fifteen percent), there is a supplier base of one hundred and seventy firms in Europe, of which one hundred are located in the UK.

Until 1991 each vendor made individual haulage arrangements for scheduled delivery of their parts. This included weekly deliveries as well as deliveries several times per day. The average amount of stock from all European suppliers was 2.5 days. An expansion of production from 124,000 cars in 1991 to over 220,000 in 1993 would have required a higher amount of inventory which would have meant the building of another warehouse.

A new target was set to reduce the inventory to about one day, on average, by increasing the delivery frequency. The highest frequency is reached by single vendors located near to the Nissan plant and supplying parts in a sequence that is required by the production line on a Kanban basis at very short notice. There are up to more than one hundred variations for certain components, depending on colour, engine size, extras and whether the model is left- or right-hand drive. Only as the painted body shells pass a trimmer on their way from the paint shop to the assembly line, the sequence of the parts that will be needed for assembly is indicated.

This system of sequenced delivery is operated by six vendors who have set up plants within a few miles radius. Every day four hundred and sixty deliveries arrive from these suppliers, taking twenty thousand parts to the plant. Seats, for instance, arrive in FTL from a distance of a quarter mile every twenty minutes. Two stillages of door panels and one stillage of consoles are delivered from another supplier in the same frequency. The delivery frequency of assembled exhaust systems is every thirty-eight minutes at maximum car production. Carpets are delivered one hundred and twenty times per day. All these deliveries are made by the suppliers own fleets.

This system, however, could not be applied for other vendors supplying lower volume and from a further distance. But through targeting a lower amount of safety stock, the risk of running out of material in the case of delayed delivery increased. In order to lower inventory and risk at the same time, Nissan decided to take the operation in their own hands to have full control over the incoming material flow.

The new strategy should be introduced in form of a pilot scheme which included thirty-two suppliers in the Midlands. For those, the terms of delivery were changed to 'ex works' collection and the transport operation contracted to Ryder Distribution Services. The pilot scheme started on the 2 December 1991 involving nine Midlands based vendors. A further twenty-three joined the project in January 1992.

Predetermined routes and timetables ensure that the components are collected from the vendors at specific times, mostly once or twice per day. Ryder receive a forecast of the delivery volume for the next sixteen weeks. A firm schedule is given one week in advance. Changes can be made on short notice but are hardly ever necessary. Trucks collect from up to six vendors to ensure FTL for every journey and deliver direct to the plant. Nissan work in two shifts. The collected parts arrive once each shift within specific time slots.

5.4.4. Case study: Toyota [45]

In the case of Toyota it was not possible to question a representative of the carriers who are working for Toyota and presently preparing the new logistics scheme. Although several attempts were made to approach different members of the team, an interview was not granted. However, the Logistics Department of Toyota provided sufficient information to give a detailed introduction into the JIT delivery system, as it is planned and being implemented at present.

Toyota have built two manufacturing plants in the UK as their European base, one engine assembly plant in Shotton (North Wales) and a car assembly plant near Derby. Production will start in Derby in December 1992. The JIT philosophy is initially regarded as the Toyota philosophy, and a classical example of perfectly arranged JIT practice is being set up in Britain. For that Toyota have the best conditions through building a brand new plant on a 'green field' site and laying out the whole process of materials procurement, manufacturing and product distribution in a sophisticated JIT manner from the very beginning.

At the beginning of the operation, Toyota have a supplier base of fifty in Europe of which fifty percent are located in the UK and twenty-five percent in Germany. The bulk of material will still come from Toyota in Japan with eighteen containers arriving every day. The receiving container yard, where 5 days of stock will be held, is about forty minutes away and material will be delivered from there to the Derby plant on a JIT basis. However, the number of European suppliers is going to be increased over the next few years to one hundred and twenty and eventually to one hundred and seventy. This needs to be done not only because of transportation matters but there are EEC regulations which demand a minimum share of eighty percent of the components being sourced from European companies.

The frequency of collection from local vendors, i.e. UK and other European, and delivery to the Toyota plants depends on the usage rate of the parts which is specified by Table 6.

Table 6 Collection frequency related to the volume [m^3]

Collection Frequency	Daily Volume
4 times per day (or more)	> 5.48
2 times per day (or more)	> 2.74
once per day	> 1.37
once per week	< 1.37

The highest frequency is for parts of high volume, like door trimmers and brake pipes. Similar to Nissan, Toyota tried to use vendors which have to provide sequenced delivery of high volume parts that are in close proximity to their plant. The supplier of seats, for instance, has set up a new plant in Burton-on-Trent. The seats will arrive every hour having a lead time of 3 hours, which include manufacturing and transport (some twenty minutes), after the body shells have left the paint shop and the exact sequence of assembly is known. The seats will be delivered in FTL of thirty-six seats with the vendor's own fleet.

Yet, the delivery scheme is generally based on 'ex works' collection and handed over to logistics professionals. Automotive Logistics (AL) is a joint working party of experts from BRS, Frans Maas and two Japanese trading companies, which cover all European vendors and the South of England. UCI Logistics, which is owned by Japanese shipping lines, cover the remaining part of the UK.

The material supply is arranged as follows. All suppliers and carriers get a requirement forecast for a period of 3 months, of which the first one is firm. Two weeks prior to the week of pickup the fixed times of delivery are released. This is the basis for the carriers to fix the exact routes and timetables for the milk round collections from the UK vendors. All parts coming from Europe will be imported by the common Frans Maas collection network with two consolidation depots in the UK. Dedicated vehicles deliver the consolidated shipments from there to the Toyota plant once per day. Two trailers per day will arrive from both France and Germany.

The majority of vendors would be served by regular collection run vehicles with largely predetermined collection times, unless the supplier is required to deviate from the normal supply volume. Table 7 gives an impression, how often materials are delivered to the plant.

Table 7 Delivery frequency to Toyota

Delivery Frequency	Percentage of materials
4 times per day	15%
2 times per day	20%
once per day	} 65 %
once per week	

Altogether eighty vehicles will arrive during one shift at predetermined times, forty-five 17t rigid chassis vehicles and thirty-five 40ft trailers. Therefore it is necessary to predetermine time slots for arrivals at the docks; time slots of thirty minutes will be allowed for delivery. The average amount of stock on site would be one and a half days.

6. Resource and cost comparison of different JIT delivery strategies

6.1. Introduction

The case studies in the previous chapter show that all the complex systems of JIT delivery services are run on an 'ex works' basis although with different time criteria and demands on the transportation system. The reason for the change of the terms of delivery from 'delivered' to 'ex works' collection is not only greater control over, and flexibility of, the inbound materials flow that is given to the manufacturer from being in charge of transportation. It is also connected with significant differences in the overall cost structure and has fundamental impact on the carrier's operation regarding the necessary resources and costs arising. Furthermore, differences in that respect occur also between different systems of 'ex works' JIT collection. These issues are focussed on in this chapter.

6.2. Terms of delivery 'ex works' - 'delivered'

As it was outlined in chapter 4., in many JIT projects the suppliers are still in charge of transportation of their components to the customer's plant and make separate arrangements. This approach has several disadvantages:

(1) JIT demands delivery on a higher frequency but in smaller size of shipments. The transportation costs for direct delivery of each consignment from the suppliers to the customer would be increased markably, regardless of whether the components are shipped as LTL with a common carrier or delivered by the fleet of the supplier. In this case the vehicles are often not even fully utilised. The single supplier would transfer the arising extra costs to the customer via the price per piece of his material.
(2) The manufacturer has no direct control over his materials supply chain and has to rely on each of the numerous vendors. The security of this approach reduces with the inventory of the parts.
(3) As each of the suppliers delivers separately, a high number of vehicles of different size arrive at the manufacturing site and could cause congestion and increased waiting times for unloading.

These factors were identified as the main reasons for the manufacturers to change their delivery strategy and the terms of delivery from 'delivered' to 'ex works'. The implications for the carriers arising from establishing a coordinated, complex collection scheme, covering the suppliers network partly or entirely, will be discussed in this chapter. By means of two examples a direct comparison of resources and cost structures of the two different strategies can be given.

Example 1: Nissan

Nissan are still supplied with the majority of their components on a 'delivered' basis. About six hundred delivery vehicles arrive every day. For the reasons stated in chapter 5.4.3. a pilot scheme for 'ex works' collection was initiated.

Supplies from the thirty-two vendors which are included in the pilot scheme involved initially one hundred and twenty-four vehicle movements per week. The potential requirement for 1993, under the conditions of higher production and lower inventory, would have been two hundred and forty-five vehicle movements per week. Through the new Ryder collection scheme this number could be reduced to only forty-five per week. This is a reduction of eighty-two percent.

A cost comparison according to these figures can be made as follows:

The basis for the calculation are average vehicle costs as given in Table 8 [46].

Table 8 Average vehicle costs per day

Vehicle type (tons)	Vehicle costs (£ per day)
3.5	140
17.0	180
28.0	193
32.0	230

The figures in Table 8 include all direct cost factors like driver, fuel, maintenance, depreciation, insurance, as well as elements for recovery of corporate overhead.

Assumptions:

- Suppliers would use all types of vehicles. For that reason an average of the different costs per vehicle will be applied, which equals £185.75 per day.
- Nissan operate only 40ft trailers, which equals £230 per day.
- There is one delivery (vehicle movement) made per vehicle per day.

'delivered'	'ex works'
245 x £185.75	45 x £230
= £45,508.75 p.week	= £10,350 p.week

Under the conditions assumed, the 'ex works' scheme would result in cost savings of 77.26%.

Example 2 : Honda [47]

Production at the new Honda car assembly plant in South Marston, Swindon, was due to commence in October 1992. The logistics concept was planned as follows:

Similar to the Rover plant at Longbridge, all components should be supplied to the manufacturing line in standardised wheeled containers from a local distribution centre (SDC), operated by Honda Express. In the SDC, 2 days of stock would be held. UK suppliers will deliver directly to the SDC on a daily or weekly basis, using Ro-/Ro-containers. Other European vendors will deliver once a week to a separate European supply warehouse located in the Swindon area, where the parts will be decanted into Ro-/Ro-containers for a daily or weekly delivery to the SDC. Some vendors will deliver direct to the production line in exact car building sequence. The suppliers profile is shown in Table 9.

Table 9 Profile of Honda suppliers in Europe

	UK	Ireland	Continental Europe	Total
Total number of suppliers	93	3	21	117
of which have				
- daily collection	57	--	--	57
- weekly collection	22	3	21	46
- daily and weekly collection	14	--	--	14
Cages per week	5,291	87	966	6,344

One year before production started a number of carriers submitted their proposals to provide a logistics solution for an 'ex works' collection scheme. One of them wasSwift Transport Service Limited who have experience in the motorcar industry from contracts with Ford and the Rover Group, as well as Lucas Electric. As Swift were tendering for Honda but did finally not get the contract, full access was granted to the documents of the proposal. On the basis of this material, which is still relevant for the purpose of this research, the following cost and resource comparison for different delivery approaches can be made.

Three basic options of collection service were suggested:

(1) - no consolidation of delivery activities
- each vehicle trip dedicated to one supplier
- all parts delivered to the SDC in Ro-/Ro-containers

(2) - collection of parts from different suppliers in milk rounds
- consolidation of shipments in a consolidation point
- all parts collected and delivered to the SDC in Ro-/Ro-containers

(3) - collection from suppliers in standard containers (non-Ro-/Ro-) which allow double and triple stacking within the vehicle
- regional consolidation of maximum volume loads for trunking to Swindon
- double shifting of collection vehicles to trunk the consolidated loads to Swindon
- utilisation of non-dedicated resources (common Swift network)
- transshipment of standard container loads into Ro/-Ro-loads at the Swift local distribution centre at Swindon for final delivery to the SDC.

The three options result in the following resource requirements and costs (Tables 10 and 11). The basis of the cost calculation is explained in more detail in chapter 7.7.

Table 10 Summary of resource requirements per option

	OPTION 1			OPTION 2			OPTION 3		
	UK	Eur/Irl	Total	UK	Eur/Irl	Total	UK	Eur/Irl	Total
Vehicles:									
Tractor Units (Trailer)	37	3	40	34	2	36	20	2	22
17 t rigid	4	-	4	-	-	-	4	-	4
7.5 t rigid	20	-	20	1	-	1	-	-	-
Total Vehicles	64 vehicles			37 vehicles			26 vehicles		
Staff:									
Drivers	71	6	77	57	4	61	42	4	46
Distrib. Centre	4	-	4	-	-	-	15	-	15
Contract Controller	1	-	1	1	-	1	1	-	1
Contract Supervisor	2	-	2	2	-	2	2	-	2
Traffic Administration	2	-	2	2	-	2	2	-	2
Total Staff	80	6	86	62	4	66	62	4	66

Table 11 Weekly costs per option (£)

	OPTION 1	OPTION 2	OPTION 3
UK Eur/Irl	83,310 49,553	73,814 40,347	52,918 34,592
Total	132,862	114,161	87,510

Option 1, which is separate collection from each vendor, is practically comparable with what was earlier explained under the terms 'delivered'. In this proposal for an 'ex works' scheme it serves only as a basis for comparison to the other options. The costs of option 3 include 2,787 m^2 space in the distribution centre and the operation of four fork lift trucks.

Options 1 and 2, which have the same conditions of collecting materials in Ro-/Ro-containers, show a significant difference in the number of vehicles used. While the separate collection from each vendor involves a high number of small vehicles, the milk round collection allows the use of 40ft trailers for all deliveries. The suppliers network would be connected with collection routes ensuring mostly full truck loads. Only one smaller vehicle of 7.5 tons would be held in case irregularities from the schedule occur. The cut down of staff members could mainly be reached through an accordingly lower number of drivers. The cost savings of option 2 over option 1 come to 14.1%.

The reason for the need for even less vehicles in option 3 is the high loadability factor of the lorries if other than Ro-/Ro-equipment is used. The wheeled trolleys can be loaded only in one level, so that a vehicle utilisation of only forty percent could be reached for the first two options. The total amount of costs in option 3 is 23.3% lower compared to option 2 and 34.1% less than option 1.

The disadvantage of handling the shipments through the Swift local distribution centre is, however, an increase of the transit times and the overall stock level within the logistics chain. If this extra step of re-loading the parts into Ro-/Ro-containers could be eliminated and all parts could be delivered to Honda's SDC in normal standard containers and FTL, a further £17,266 per week could be saved in option 3. This would then come to £70,604

per week, which is a 19.7% saving over the initial costs of option 3 and equals only 53.14% of the total costs of option 1.

These figures prove that it is of great importance for the manufacturer to decide from which point of the logistics chain the use of the special Ro-/Ro-containers can be justified. The advantages of the wheeled trolleys gained at the manufacturing line must offset the increase of transportation costs that they cause.

Regarding the effects for the manufacturer, the two examples in this chapter show that the change of the terms of delivery to 'ex works' collection gives the customer the opportunity to take advantage of economies of scale. Through the high volume of freight now given to one major carrier by one customer, high volume shipment rates can be reached, especially because the number of vehicles involved can be reduced considerably and larger vehicles can be used. Although the direct transportation costs for the manufacturer increase from taking over responsibility for all arrangements with the carriers, this results in a markable decrease of the total transportation costs in comparison to single shipment from each supplier. The overall saving for the manufacturer in terms of lower costs of inventory holding, as well as eliminating the transport element from the piece prices of the suppliers, offset the higher direct transportation costs. Apart from the cost advantage, the customer gets full control over the inbound materials flow which is of highest significance in a JIT system. This qualitative aspect must be rated as high as the quantitative cost advantage as delivery is only one part of the JIT strategy, integrated into the entire manufacturing process.

The findings from the two examples are also of essential significance if the impact of JIT on the transportation sector itself is considered. It could be proved that the demand for frequent, small shipment delivery at predetermined times of arrival does not necessarily mean that the carriers involved have to complete their fleet with a higher number of smaller lorries and vans. In addition, they do not have to face lower vehicles utilisation and altogether higher operational costs. If one carrier company takes over the entire 'ex works' collection scheme of a customer the routing and scheduling can be optimised in a way that the use of large vehicles with full utilisation can be ensured most of the time. These aspects will be considered in further detail for all case studies in chapter 7.4. The main fact is, regarding the implications of JIT for the carriers, that the necessary resources and costs of operation can be kept rather low, in relation to the much more stringent conditions, if a complex logistics solution is applied to the system. But even between advanced collection schemes like milk round collection and consolidation, differences in the resource and cost structures exist.

6.2. Milk round - Consolidation

An analysis of resources and costs of different solutions for the same JIT delivery project can be made on the basis of the proposal that Swift Transport Service made for Toyota. [48] Apart from the predetermined tender, they suggested a more effective solution regarding transportation costs. Swift were one of the few carriers who were in the last round of tendering for Toyota and had to submit a very detailed proposal. As Swift were not appointed as the final contract partner, the documents of the tender were released for this research project. The material did not loose relevance for the purpose of this analysis. Further details of the Toyota criteria and the process of carrier selection are given in chapter 7.2.

Swift's proposal consisted of two main parts: first, a Bidding Packet responding to Toyota's demands on the basic features of the concept, and second, an Alternative Proposal of a more cost effective version in terms of transportation costs. The main criteria of these two parts are summarised in Table 12 .

Table 12 Features of the different strategies for Toyota

Bidding Packet	Alternative Proposal
Collection frequency = delivery frequency	Major of vendor volume collected once per day
Vendors open 24 hours	Vendors open 8:00-17:00
No overlap of parts throughout the supply chain	Consolidation of volume
	Operation through local transit facility
	Direct loads to plant for large suppliers

The Bidding Packet required 'ex works' collection of levelled volumes in strict accordance with the delivery frequency, i.e. up to four or more times per day. The Alternative Proposal would still ensure delivery according to the frequency requirements but material would be collected from the vast majority of the suppliers only once per day. Swift would establish a distribution centre about fifteen minutes away from the Derby plant, where the parts would be consolidated for JIT delivery to the plant at the specific time of arrival. The handling of the components through a consolidation point would increase the level of in-transit inventory to an average of 1.5 shifts while otherwise collection and delivery would be made less than one shift ahead. However, the effect on the necessary vehicle resources is remarkable as illustrated by Table 13.

Table 13 Vehicle resources

Vehicle	Bidding Packet		Alternative Proposal	
	UK	Europe	UK	Europe
3.5 t	10	35	-	3
7.5 t	2	49	-	-
17.0 t	7	-	2	-
32.0 t	18	26	21	15
	37	110	23	18
	total: 147		total: 41	

The high number of small vans is significant, especially for deliveries from the European continent. Toyota required, for instance, six vehicles per day collecting and delivering from Portugal with a relatively low volume of material to be collected on each occasion. This would be an extremely costly operation, and apart from that, additional cost would arise as Swift had to buy new a large part of the necessary fleet. The comparatively very low number of dedicated vehicles in the Alternative Proposal results from the combination with Swift's common user resources, i.e. the existing depot infrastructure in the UK and Europe could be used for the collection ex vendors and delivery to the distribution centre.

Tables 14 and 15 provide the exact data of operational costs and vehicle utilisation which would occur in each of the two concepts.

Table 14 Summary of total weekly costs (£/week) and loading efficiency
Bidding Packet

	Components from inside UK	Components from Continental Europe	Total
FTL total (Aministr. fee) (Profit margin)	75,408.60 (11,311.29) (8,671.99)	185,260.64 (27,789.10) (21,304.97)	260,669.24
LTL total	410.37	2,884.27	3,294.64
Total	75,818.97	188,144.91	263,963.88
Loading efficiency	91.09 %	72.59 %	84.57 %

Table 15 Summary of total weekly costs (£/week) and loading efficiency
Alternative Proposal

	Components from inside UK	Components from Continental Europe	Total
FTL total (Aministr. fee) (Profit margin)	53,225.55	86,647.77	139,873.32
LTL total	5,336.71	13,803.28	19,139.99
Total	58,562.26	100,451.05	159,013.13
Loading efficiency	91.0 %	91.0 %	91.0 %

The savings of the Alternative Proposal over the Bidding Packet are the following:

- components from inside UK	22.8%
- components from continental Europe	46.6%
- total	39.8%

These figures show that the collection from European suppliers outside the UK has the biggest impact on the cost structure. The Bidding Packet required an extraordinarily high number of small vehicles. The reasons for that were different delivery frequencies and schedules for the single suppliers, as well as too long distances between them to arrange milk round collection routes to fill vehicles of larger size under the time limits given. Although many small vehicles would have been used for this option, the loading efficiency would have still been rather low with 72.59%.

The main reason for the high savings in the Alternative Proposal is that the resources of Swift's common European collection network and part of the UK network could have been used for this operation. The number of dedicated vehicles would be reduced and costs from low utilisation could be avoided. This becomes clear when comparing the figures for FTL and LTL. The share of LTL costs in the total expenses increases from 1.2% to twelve percent in the Alternative Proposal. That means that a high number of shipments could be collected as LTL by the common collection network instead of being delivered as FTL in a dedicated small vehicle.

The comparison of the Bidding Packet and the Alternative Proposal of Swift for Toyota shows that advanced JIT delivery systems can be operated in different ways with profound impacts on the necessary resource and cost structures. The crucial factor is the collection frequency. If delivery two or four times per day is required from thirty-five percent of the vendors, it is inevitable for the carrier to operatet a high number of vehicles with relatively low utilisation, unless the frequency of collection is lower than the frequency of delivery. Collection on a daily basis, consolidation and usage of the common collection network could make a demanding system like this more economical in terms of transportation costs. The Alternative Proposal would still have guaranteed JIT delivery to the plant according to the required frequency without a considerable increase of inventory in the supply chain.

7. Implications for the carriers

7.1. Introduction

On the basis of the case studies this chapter will analysed whether the JIT schemes cause any special efforts for the carriers, and if so, what these are, to what extend they become necessary and what they depend on.

7.2. Project Preparation

Air Express International - Hewlett Packard

The process from obtaining first information from the customer about their objectives, until the system was brought into operation, took about twelve months. This was not only a time of close co-operation between AEI and Hewlett Packard, but involved also the airlines and other third parties which would be used by the forwarder. Responsible for system development as well as for the actual operation later on was a so called Account Management Team. "Account" is a term for one single customer, including all business matters in relation to them. Such Account Management Teams or Account Managers, respectively, work for all bigger customers and are not dedicated to only one client. In this respect the JIT scheme of Hewlett Packard was dealt with like any other customer.

In order to get familiar with the JIT philosophy, all employees involved got some internal training. However, this was part of the regular training process that the staff undergo in adherence to BS 5750.

Altogether the preparation of this JIT scheme did not cause any more or less efforts or costs than any other business with a customer, the size of Hewlett Packard, would do.

Frans Maas - Rank Xerox

The Dutch international forwarding company Frans Maas is the major contract carrier and distributor of Rank Xerox in the Netherlands, covering transportation throughout Europe and running similar warehouse operations such as the one at Mitcheldean. But when

Rank Xerox (UK) were looking for a business partner to take over the new operation, Frans Maas was only one among fifteen competitors who submitted their tender for the project in the first place.

This included not only the warehousing function, but collection from UK and European suppliers as well. What Rank Xerox requested, however, was a simple solution to be worked out by the carriers; they already had a relatively detailed plan of how the whole system should work. All they still needed from the different forwarders were the provision of appropriate resources and evaluations of specific cost elements. There was rather little flexibility left for the carriers concerning the design of the system, and little chance to add value by including extra services. One main Account Manager was placed in charge of working out the proposals and calculations for this project. He did not need to be dedicated to this special contract because the tender was not so complex that dedication would have been necessary.

The whole selection process prior to the decision that Frans Maas would get the contract, took about 9 months altogether. The actual preparation and implementation of the operation took another 4 to 5 months. These were mainly spent with equipping a dedicated 10,000 m^2 warehouse and providing the necessary resources. The actual JIT element of the process which is the line feed to the plant from the warehouse, did not require special consideration in the phase of preparation. It is part of modern warehousing that orders for materials replenishment are transmitted electronically. Frans Maas had to provide well trained staff for the warehouse to cope with this Kanban system.

The collection of material from the vendors which is not very time sensitive, did not need to be prepared in further detail, as it could be taken over by the existing Frans Maas European network.

BRS - Rover

BRS were involved in the set up of the distribution centre for Rover in Cowley from the very beginning in 1986. They were chosen for this contract because they were involved to a considerable extent in the previous delivery scheme and familiar with the components and routes as well as Rover and the vendors as business partners. It took about one year to develop the initial concept of JIT line feed from a close-by warehouse. A joint working

party of BRS and Rover was establishing the system in cooperation with the suppliers, before it was officially opened in its final stage in 1989. Over these three years the warehouse was already being operated but the introduction and smooth operation of the Kanban system was completed only in 1989.

The dedicated warehouse was rented by BRS only one mile away from the Rover plant. All instructions to make the BRS employees familiar with the JIT operation were given in a similar way to the establishment of any major contract. The preparation of this project was comparable with the take over of an advanced warehouse system. The JIT aspect in this scheme is equivalent to the one in the Frans Maas project.

TNT - Rover (warehouse operation)

A similar case is the JIT delivery system of TNT for Rover in Longbridge. Before the new approach could be started it took about eighteen months to prepare and implement the concept as a whole. As Rover is in close cooperation with Honda in the UK and especially in Longbridge where Honda cars are built at Rover's manufacturing lines, Honda's experience in JIT was initially used to work out a new delivery method. TNT was consulted as a third party distributor to deal with all practical questions of the establishment of the system and to optimise all aspects of the logistics supply chain.

TNT set up a multi-disciplined project team of 8 people for the Rover project, e.g. experts in process engineering, packaging, and accounting. This was to get them familiar with all the customer's needs and details of the scheme. It was carried out in close interaction with Rover as well as the vendors. This project was more demanding than the previously described schemes as it involved not only delivery of consolidated shipments from the warehouse to the plant but also sequenced delivery of different types of bumpers, as explained in chapter 5.2.3. Part of the preparation was also the development of appropriate computer software in addition to Rover's Kanban system (see chapter 7.4.).

However, the process altogether was similar to implementing a new warehouse operation, and so accordingly were the steps taken during the phase of preparation. TNT were in charge of leasing and equipping a warehouse and bringing it to full operation. Special instructions or training for the employees were not necessary, apart from a short simulation of the Roll-on/Roll-off loading process of the wheeled containers. This technology will be covered in more detail in chapter 7.3.

TNT - Rover

1) The European collection scheme

The idea of introducing a scheduled collection service from the European vendors was initiated by TNT who are one of Rover's major logistics partners. The idea was to consolidate shipments for the two Rover manufacturing plants in Longbridge and Solihull near Birmingham in order to make the scheme more efficient. As the Rover plants work as profit centres, it was not easy for TNT to convince Rover to accept the new concept as an alternative to the existing close-by distribution centres. A brief summary of the demands on the new scheme was worked out by Rover before the remaining design of the system was left to TNT as the logistics expert.

Before the first pilot scheme could be started it took about 12 months to get familiar with

- all needs of the customer,
- the material requirements,
- locations, volumes, and frequencies of deliveries from the different vendors,
- to work out the routing and scheduling of collection and delivery and
- to develop the relevant software

Only 2 members of TNT's Contract Distribution division were involved in this stage of project development, however, not on a dedicated basis.

The implementation started with a change of the terms of delivery from 'delivered' to 'ex works' for shipments from those vendors who were included in the pilot schemes. Rover have three hundred suppliers in Europe altogether, with the main origins in Germany, France, and Italy. The pilot scheme started in September 1991 with twelve German suppliers. These first deliveries were controlled and monitored carefully in order to spot, analyse, and eliminate problems before a higher number of vendors would be included. Since the practical implementation phase started, three of TNT's employees have been working on Rover's site with one transport specialist of Rover completing the team.

The start up costs including the pilot scheme were estimated at £150,000 with the highest proportion being personnel costs. About £20,000 were spent for the development of new computer software.

2) The UK collection service

Rover's preparations for the introduction of a collection service in the Midlands area, where the bulk of suppliers for the motorcar industry is concentrated, began at the end of 1991. Eleven carriers presented their first proposals in December 1991. They were given information about material requirements from thirty suppliers which should be covered by the tender. After assessment of the first round, 6 companies were asked to work out a more detailed plan, and on the basis of that, 3 carriers were chosen to be examined in depth. This was carried out in the form of a 2 hour presentation of the final tenders which were measured in every detail, as well as an auditing of the operational points of the carriers. After a careful check of all criteria, the final logistics partner was appointed, once again TNT.

The next phase was to develop a final model of the operation in full detail, on the basis of all information being provided. The collection routes had to be worked out and the operation of the reconfiguration centre to be prepared. A further 3 months were allowed for that, and a pilot scheme should be implemented after another month. Preparation and implementation of this part of the Rover business were carried out by the same staff who deal with the European collection scheme. Both schemes are implemented and/or operated in parallel.

Summarising the JIT projects of TNT for Rover and comparing the approach to services offered to other contract customers, the following statement can be made: TNT's Contract Distribution division in the UK offers a wide range of specialised services to all potential customers, including e.g. warehouse design, transport system design, vehicle specification, as well as computer system design and implementation. The service for every contract customer starts with a project development stage when the client's needs are examined in depth by a team of functional specialists. An implementation team then deals with all aspects of a timely and effective set up of the system, after an appropriate proposal is accepted. Thus TNT offers tailored system solutions for logistics operations on a dedicated basis to all their customers. The main procedures of project preparation, implementation, and operation as well as auditing and providence of computer systems are basically the same for major customers in the non-JIT business.

Start up costs for the development of computer software tailored to the customer's needs, for dedicated people for the project preparation and implementation, as well as for pilot schemes, occur in connection with most customers the size of Rover. Apart from that, no extra efforts or costs arose from the specific JIT aspect of the schemes examined.

BRS - Ford

BRS already had the bulk of deliveries from the vendors to the Ford plants, before the 'ex works' scheme was initiated. Thus, they were able to take over the business under a contract with Ford without causing great disturbance to the whole system which was one factor in appointing BRS as the new contract carrier. Apart from that, principles of high quality assurance for performance throughout the company were an essential criterion of selection.

The preparation and implementation of the new concept, including the set up of the consolidation point, took about twelve months. In the frame of a customer care and liaison programme, it was necessary to obtain all relevant information from Ford and the suppliers, including visits to the manufacturing plants and vendors, to figure out costs and negotiate rates as well as to develop appropriate computer software. A great advantage was that BRS had a considerable part of the business under the previous scheme and was familiar with many of the vendors, components, routes and transport costs. This earlier involvement and experience facilitated the preparation and implementation of the new approach, saving time and costs.

Non-dedicated Account Managers were in charge of dealing with this project in parallel with other businesses. Although the Ford contract is outstanding among other contract customers concerning resources and costs of the operation, it is mainly the volume that distinguishes it from the latter. The actual JIT factor had no great influence on the preparation of the project. It was not necessary to work out routes and schedules in advance. The costs for establishment of the consolidation point were again dependent on the high volume. The consolidation itself is not different from the operation of general collection and delivery services for the shipment of small consignments from and to different places.

United Carriers - IBM

The initial process of selecting the new contract carrier of IBM took about one year. Ten different carriers were tendering in the first place, and after one day of presentation, 3 companies were selected to work out a more detailed proposal. After that it was decided to have United Carriers as the new contract partner.

The main criteria of the selection were quality of services and cost. This included, for instance, management skills, equipment, as well as providing recovery in emergencies within the shortest possible time by offering strategically located back-up facilities in a dedicated delivery system. Apart from that, IBM requested a very detailed cost split of the operation and even separate cost surveys for 2 and 5 year contracts. The tender also included routing and scheduling of the collection process.

The implementation and take over of the new operation by United Carriers was carried out by a joint working team on IBM's site, consisting of one manager and one supervisor of United Carriers with support of two IBM staff completing the team for the first 8 weeks.

Before the operation could be started, IBM demanded a simulation run for the collection from Scotland in order to make sure that the long distance supply could be assured on a JIT basis. This trial was made 4 times per week over two weeks with one empty truck plus driver. These simulation runs, including all cost elements of the vehicle and driver for all eight trips, as well as planning and monitoring, came to £8,000 altogether.

It was also necessary to introduce all staff members who are involved in the project, into the JIT philosophy. This was done for people in the management of United Carriers through the process of preparing and setting up the operation. The drivers got the usual session of instructions. The use of demountable equipment, which will be explained later on, required some efforts to familiarise especially the vendors with the new technology.

The start up costs included not more than the simulation run to Scotland, the cost for having one manager and one supervisor dedicated full time to this project for about two months, as well as 2 weeks of recruiting and instructing the drivers. Only the simulation run can be allocated as specific for the JIT aspect of the scheme as the other factors are part of any new business, especially if it is the size of IBM.

Ryder - Nissan

It took about eighteen months of preparation before the pilot scheme for Nissan could be started in December 1991. In the very first place more than thirty different carrier companies were consulted, of which ten were asked to present a detailed tender for the scheme. As a result of this, 4 companies were chosen to work out a more detailed plan on the basis of much more information being provided. Finally, Ryder Distribution Services were appointed as the logistics expert to take over the project. This was in March 1991.

Criteria for the selection of the contract carrier were corporate culture with factors like good management skills, professionalism, innovation, flexibility and good planning capabilities. Very important was a good understanding of all specific requirements and an open-minded approach of tailoring a transport system according to the needs of the customer. Ryder met all these demands having developed a professional understanding of the motorcar industry by running JIT delivery and distribution schemes for Toyota and General Motors in the United States.

During the 6 months of the planning stage of the Nissan project, Ryder's Logistics Planning Group, who are experts on the development of dedicated transportation systems for contract customers, was collecting all necessary base data. This included visiting vendors as well as the Nissan production plant in order to fully understand the system of manufacturing, packaging and materials replenishment. On the basis of that, the systems requirements were defined and a detailed operating plan was developed. After that it took a further 3 months to implement this plan. This included mainly:

1) training for all staff involved,
2) simulation run on the collection routes,
3) establishment of the computer system.

Ryder's personnel was trained by staff of Nissan in order to become familiar with the stringent quality and safety requirements of the manufacturer. Over a period of 6 weeks the contract management and the dedicated drivers were introduced not only into the JIT principles of delivery service but also purchase, goods' receipt, line feed, high bay operation and the Kanban system. They were even working partly in the goods incoming area to get a full understanding of the time sensitivity of the materials' flow. Other people in finance or information technology development, for instance, were familiarised only with selected issues over one or two weeks.

Later on the collection of shipments from the suppliers on fixed routes and JIT delivery to the plant were simulated three times with empty trucks.

The start up cost that arose from all the measures mentioned so far came up to some £100,000 which is extraordinarily high compared to about £30,000 for other, non-JIT contract customers. The adjustment of the computer system is not included in these figures. The extra costs arising for Ryder in the phase of preparation in this project can, in fact, be assigned to be 'JIT costs'. They were caused only in connection with the strict time criteria which must be adhered to at any time. It had to be guaranteed that the system would work perfectly from day one of the operation onwards.

Toyota

In 1989, more than three years before production started, Toyota released a first batch of information to all carriers which were interested in the project. This information included e.g. the post codes of suppliers, volumes and types of materials, specification of vehicle types and the necessary information technology. On the basis of this data, some forty companies were tendering. Eight of them were selected to design another, more in depth plan of the delivery scheme, after further details of the operation were provided. The carriers had then the opportunity to present a simulation of their concept.

Toyota's main criteria of carrier selection were:

- experience in the automotive industry
- presence in the UK and Europe
- existing contracts with Japanese customers
- automotive customers have a big share of their business
- commitment to quality.

The fulfilment of all these criteria should ensure a good understanding of this particular business and Toyota's requirements.

Finally, in April 1991 two companies were chosen as the contract logistics partners. One is Automotive Logistics (AL), a joint working party of experts from BRS, Frans Maas and two Japanese trading companies. The other one is UCI Logistics, which is owned by Japanese shipping lines. This practice underlines again that Toyota still give priority to Japanese business partners because of their experience and high reliability of services.

After the appointment of the contract carriers, over eighteen months were left to develop the delivery scheme in all the necessary details and to make sure that it would work perfectly by the start of production. This included long negotiations with all involved parties in order to get to know all requirements and the data base of the whole system. Working out the routes and timetables for collection and delivery, defining responsibilities, procedures, documents, and measures for the case of irregularities, recruiting and training staff, procuring vehicle resources and supporting the system with appropriate information technology were only the main tasks that had to be done.

The AL and UCI preparation teams consist of dedicated representatives of the carrier companies involved. For about eighteen months these teams dealt exclusively with the

preparation of the Toyota delivery system. They have an office on Toyota's site and are in close interaction with Toyota's Logistics Department. This department is part of the Production Control Division and consists of ten people who are in charge of managing the supply chain in cooperation with the logistics partners and vendors. The size of Toyota's Logistics Department explains the great significance that JIT delivery has to the manufacturer.

Prior to the actual beginning of the operation, all drivers will have to undergo two weeks training to get an introduction into the JIT concept and to run simulations of the tight scheduled collection and delivery scheme.

As the carrier team could not be interviewed, a cost evaluation of this entire preparation process in comparison to other clients cannot be given. However, it is obvious that the dedication of about 6 experts in a preparation team over a period of eighteen months is very peculiar to the special JIT requirements of this customer. The arising personal costs which come to about £30.000 p.a. per person are the largest part of the preparation costs which further include the training and simulation run. These costs definitely arise only in connection with the JIT aspect of this business and exceed the requirements of any other customer.

Swift (proposal for Toyota)

As Swift are operating JIT delivery schemes for Rover and Ford and have been tendering for Toyota and Vauxhall, a general comparison of these businesses can be made in some points of chapter 7, although Swift finally did not get the contract with Toyota. The operations that Swift run for Rover and Ford are basically the same as described in the case studies of TNT and BRS.

Swift offer the development of tailored delivery systems to any customers, which, however, in each case demand a different amount of work and time to be spent, depending on the specific requirements of the scheme. This is illustrated in two examples:

1) Vauxhall had very clear ideas about the design of their new delivery system, and basically required from the carrier only the necessary resources to put it into operation. It included materials collection in FTL from vendors in the UK as well as consolidated shipments from other European countries. JIT delivery was not required yet. The

appropriate operation plan was then worked out by two of Swift's people on a non-dedicated basis within a mere two weeks.

2) In the case of Toyota, the applicants for the business were given only the goals and quality demands of the required JIT system. The design of the whole scheme was completely left to the expertise of the carriers. Swift's proposal was developed by a team of about twelve experts involving the

- Sales and Marketing Director
- Operations Director
- European Business Development Manager
- UK Sales Manager
- Business Development Coordinator
- Business Development Executive
- General Manager Planning and Development
- Senior Planning Manager
- Quality Administration Manager
- Transport and Development Manager.

The final proposal included a detailed description of all stages of the operation. Information sheets were worked out for each collection-delivery route giving exact data about the distance, time, vehicle resources, standing times at the suppliers and Toyota, times for customs clearance of imported goods, nightouts of the vehicles, consolidation, vehicle utilisation and all costs occurring from these factors.

Apart from that, an Operational Manual was written, which was available to all employees who were associated with the contract. It provided comprehensive step-by-step instructions that insure all staff carry out their responsibilities in an efficient and coordinated manner.

A Drivers Handbook contained key operational instructions for them, as well as troubleshooting details. Both Operational Manual and Drivers Handbook gave clear and precise instructions for the event of irregularities.

All these measures are comparable only with the rather complex system of collection, consolidation and delivery for Ford. Route information sheets, Drivers Handbook, emergency actions etc. were necessary to be provided for this contract, as well. But the Toyota project required an enhancement of all that with much higher specifications.

Altogether the system was designed over a period of about eight weeks and incurred staggering costs of £10,000. As the competition for big contract customers is very high, proposals for new projects are not paid for by the customer.

If Swift would have been appointed to become one of Toyota's logistics partners, an implementation schedule over nineteen months would have come into force (see Figure 10). All the single steps in the implementation phase of the system are a standard procedure for the set up of logistics solutions for any customer. The complexity of a JIT concept and the special requirements of Toyota, however, let this project demand a much higher amount of work, time and money to be spent in this process.

One example would be the necessary instructions and training for about forty dedicated drivers, which would have taken 2 weeks with a cost of £1,000 a week per driver. As they would be hired newly for this project, they would have undergone two or three days of internal introduction into Swift as their employer and spent the rest of the time with Toyota and on the collection routes. The familiarisation of the staff in the operational management with the project would have been conducted on the basis of the Operational Manual and would have taken several months until everything was ready to start.

Preparations in that length and detail, especially simulation runs with empty vehicles (operational trials), have never been necessary for other customers and are due to the perfection that is required by this complex and true JIT system.

Figure 10 Toyota/Swift Logistics project schedule (April 1991 to February 1993)

Task Description - Key Dates	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F
1. Proposal presentation	X																						
2. Toyota final decision on logistics partner		X																					
3. Nominate project team Swift		<-->																					
4. Nominate joint project team Swift-Toyota		<-->																					
5. Design logistics plan		<--	---	---	-->																		
6. Undertake supplier visits			<--	---	---	-->																	
7. Agree packaging and modules			<--	-->																			
8. Revise final logistics plan						<--	-->																
9. Toyota approve final logistics plan										X													
10. Establish phased equipment plan					<--	---	---	---	-->														
11. Implement phased equipment plan													<--	---	---	---	---	---	---	-->			
12. Establish phased personnel plan					<--	---	---	---	-->														
13. Implement phased personnel plan										<--	---	---	---	---	---	---	---	---	---	-->			
14. Identify and appoint contract manager		<--	---	-->																			
15. Design staff training programmes							<--	---	-->														
16. Implement staff training programms									<--	---	---	---	---	---	---	---	---	---	---	-->			
17. Design EDP system /status control				<--	---	---	---	---	-->														
18. Test and implement EDP system													<--	---	---	---	---	---	---	-->			
19. Conduct operational trials												<--	-->					<--	-->				
20. Adjust final logistics plan													<--	-->					<--	-->			
21. Commence supply of engine plant															X								
22. Commence supply of vehicle plant																					X		
23. Joint project meetings		X		X		X		X		X		X	X	X	X	X	X	X	X	X	X		X

7.3. Computer systems

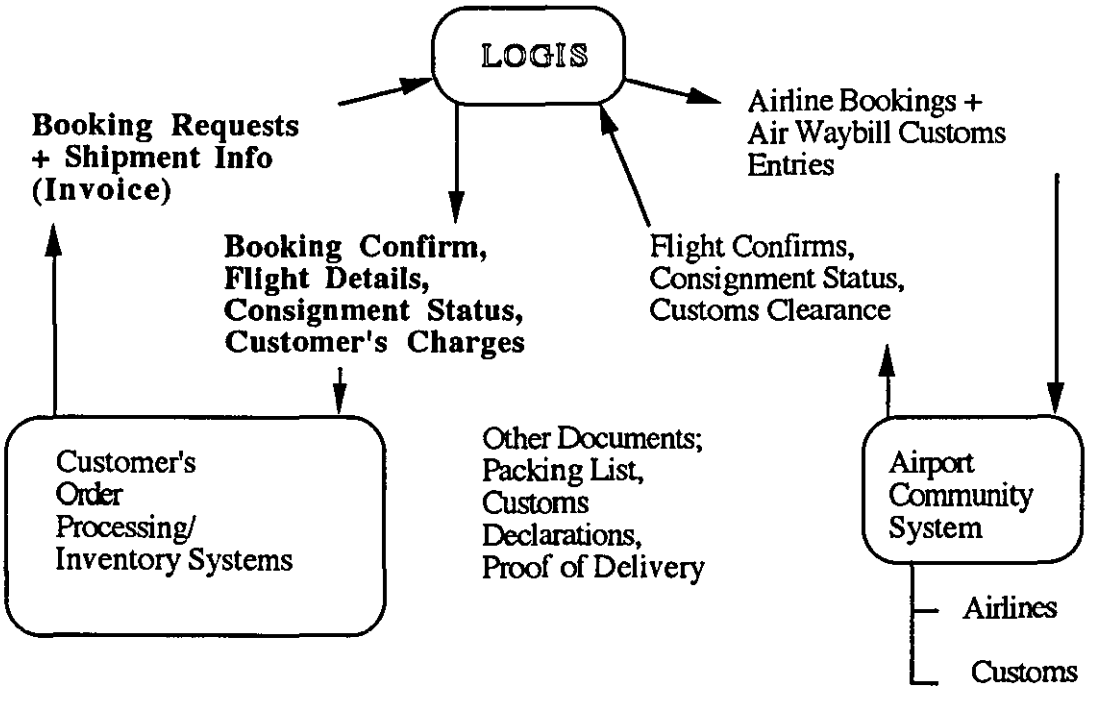
Air Express International - Hewlett Packard

The development of a new computer system in connection with the JIT requirements was not necessary for AEI, as the existing network is sufficient in every respect.

The importance of a high standard computer system in JIT was outlined in chapter 2. AEI operate a global Logistics Information System, called LOGIS, through which ninety percent of their worldwide activities are processed. With more than 1,500 terminals, on-line information can be given for over 400,000 consignments. Computer inter-action is guaranteed with customs, airlines, shippers and consignees, providing twenty-four hours freight tracing and tracking. The main features of LOGIS are illustrated by Figure 11.

Figure 11

LOGIS - Electronic Data Interchange



By the means of that system, AEI are able to establish computer links to all of their customers if necessary. It matches all requirements of the JIT scheme, especially in terms of real time information and comprehensive reports as well as reduced transit times and improved planning and scheduling. As the air freight sector is generally dealing with fast moving, time sensitive goods, the run of an on-line information system is essential in this kind of business.

The initial development costs of LOGIS were $25m, the annual operational costs come up to a total of about $13m, with a share of £1.3m for the UK. As the system was not established especially for JIT business, but as a part of the general quality scheme and important criterion for competitiveness in the long term, none of these costs can be assigned as extra costs for JIT

Frans Maas - Rank Xerox

It was not necessary for Frans Maas to develop new software for the Rank Xerox project but the existing computer network could be applied for all transportation processes. The tracking and tracing capabilities of the standard computer system are sufficient for the needs of this operation. The complete system for the warehouse operation was provided by Rank Xerox in connection with their own in-house system.

BRS - Rover

The computer Kanban and warehousing system was developed and provided by Rover as part of their in-house system for inventory control. It was necessary that all people associated with the process were given instructions and training, emphasising the proper use of the Kanban system. These measures were taken by Rover and included the employees in the distribution centre.

TNT - Rover (warehouse)

The Kanban system at Longbridge is basically the same as the one in Cowley. TNT could take over the computer system for material requirements and warehousing completely from Rover. Extra software was developed by TNT for the sequenced delivery of

bumpers which included order transmission from the trimmer at the manufacturing line to the warehouse. The development cost for this programme was about £80,000 to £100,000.

TNT - Rover (collection scheme)

For collections in the framework of the common European TNT network, the existing computer system of TNT is used with a special EDI link to Rover, including all consignments, their routing and schedules. This allows a pre-advise to the customs and clearance in advance.

A more specufued system is being developed by TNT to achieve an optimisation of the dedicated collection process for Rover in Europe and the UK. This system should process data about each vendor, as well as volume, frequency, and arrival times for individual part numbers. On the basis of this information, the computer should consolidate the single consignments to collection runs, including routing and scheduling. This system is not completed yet. The development costs are estimated with £20,000 as part of the start up costs. During the implementation phase, routing and scheduling are carried out manually.

Very essential to the smooth running of the operation in the reconfiguration centre is appropriate information technology, including bar codes. Direct EDI link with suppliers as well as with Rover is necessary in order to confirm dispatch and receipt of the components and to allocate them to the right receiving decks. This will be part of the computer system mentioned above which is still to be developed.

BRS - Ford

There are two separately working computer systems involved in this operation. One is Ford's own MITCOS system (Material In Transit Control On-line System). Through computer links of Ford's manufacturing and storage locations with vendors and carriers, the location and delivery status of production material can be ascertained at any time. All necessary hard and software for connection to MITCOS were provided by Ford.

BRS's Traffic Administration System facilitates day to day control and administration of the operation. This system was developed especially for the Ford project. The initial Cincinnati computer in 1982 was approximately £68,000 which is even less than the amount that was spent to develop the software. Subsequent charges to Ford for enquiries into the system were £20,000 per 4 weeks which allowed recovering of the cost during the first phase of the contract.

United Carriers - IBM

There was no computer software developed newly for this project. United Carriers operate their own common tracking system and have links with the IBM network. An extra system for routing and scheduling was not necessary. There is only a limited number of fixed basic collection routes, which would not have justified the high costs.

Ryder - Nissan

All information technology that was necessary for the Nissan project, could be taken over from Ryder's JIT business in the USA. This JIT Information System was designed to assist field personnel in the development, execution, and performance analysis of transportation services dedicated to JIT manufacturing operations, aiming at maximum transport system quality. Its main functions are:

- planning and establishing a cost effective route structure,
- monitoring actual performance vs. the schedule on a real time basis,
- providing objective measurements of service quality,
- relieving management of routine tasks so that they can focus on the critical aspects of the business.

The different types of information being processed by this programme are listed below:

- forecast shipping requirements
- shipping releases/Kanban data
- supplier locations, contacts, number of pickups, stop time, time windows, holidays
- point-to-point mileage and travel times
- container types and dimensions

- part descriptions, weight and packaging
- plant and domicile locations
- available drivers and equipment by domicile
- fixed route assignments
- dispatch, pickup, delivery, check call, break, wait, and layover times
- pickup and delivery dock assignment
- equipment and driver assignment
- actual check call times
- manifest, driver, equipment, route, supervisor, and general broadcast messages
- odometer readings and fuel consumption
- actual arrival and departure times at suppliers and delivery points
- exception reason codes.

The initial development of this computer programme cost £500,000. The adjustment of the software for application on Nissan caused another £70,000 plus £80,000 for the installation of all necessary hardware and communication links. Nissan was bearing the cost for the programme adjustment.

Toyota

In spite of the complexity of the Toyota collection scheme, it was not necessary to develop a new computer programme as the existing tracking and tracing systems of the involved carriers, as well as those for routing and scheduling, could be applied and adjusted to the individual requirements of this project. Thus a real time information and report system will be provided.

Swift (proposal for Toyota)

It would not have been necessary to design new computer software for the Toyota scheme as Swift have their own consignment tracking system on main frame which is connected with all UK depots by dedicated data transfer lines. It can be tailored to include any details specific to customer requirements and is especially suitable for JIT as it provides complete visibility of the transportation process in real time. The adjustment of the system to the Toyota project would have cost £10,000 as part of the start-up costs.

7.4. Operation; Vehicle utilisation

Air Express International - Hewlett Packard

AEI consolidate the consignments in the gateway airport terminals, ship them by air freight to Heathrow and deliver by truck to the Bristol plant. The average transit time of the deliveries is 2 or 3 days. The times of arrival are given to the forwarder with the shipping instructions. According to that, AEI book the necessary capacities with the airlines which is the same procedure as for other clients. Although only 5% of their customers use air freight as an integral part of JIT manufacturing strategies, most clients give predetermined times for delivery. The reason for that is the nature of the air freight business where mainly time sensitive, high value goods are moved.

For the delivery from the airport to the plant AEI use their own fleet. They operate altogether ninety vehicles in the UK as forty percent of their air freight volume is delivered by truck to the customers, which means there is no special arrangements with regard to the JIT factor. The shipments for Hewlett Packard normally guarantee full truck loads.

Frans Maas - Rank Xerox

The collection of material from the vendors to the warehouse is operated by the common European Frans Maas collection and delivery network. There are no dedicated vehicles for Rank Xerox. A complex planning process is not necessary either. The vendors give the orders for pickup at twenty-four hours short notice which is the same for collection within the UK. Small shipments from remote suppliers are given to local road hauliers.

The JIT line feed from the warehouse to the plant guarantees full truck loads of consolidated parts every day. These shipments include material for one or two shifts only. This operation does not require any flexibility nor extra expenses or resources in connection with the JIT factor. The warehouse operation itself belongs to the service programme of Frans Maas offered to all their customers and is a usual part of non-JIT business.

BRS - Rover

In this JIT line feed system from a close-by warehouse BRS have to ensure that all consignments required will be consolidated in the right order and delivered to the track within 4 hours of order placement. This does not demand any extra resources but well instructed people to carry out and supervise the process. Full truck load is mostly guaranteed.

The warehousing operation belongs to the normal business of the distributor and thus there are no particular expenses arising for BRS which could be defined as JIT related costs. It is the higher pressure to be accurate the first time which distinguishes it from non-JIT.

TNT - Rover

The materials replenishment system for Rover at Longbridge is basically the same as in the two previous case studies. However, although only 40ft trailers are used for all regular deliveries from the distribution centre to the plant, a one hundred percent vehicle utilisation cannot be reached because of the special containers in which all material is delivered to the manufacturing line. These containers are wheeled trolleys, designed by the engineers of the joint project team of Rover and TNT especially for this operation. On the one hand, they simplify the whole process of materials handling as well as the movement of empty stillages on the shop floor. On the other hand, a special design of the trailers is necessary for their transportation.

The trailers need to have tracks as a guiding system for the rolling trolleys. Two lines of seven trolleys can be carried on one trailer. Pins are locked into holes along the sides to make the trolleys stand in a stable position. The seven in one line are connected with each other, so that they can be pulled off the lorry in one go which shortens the unloading process remarkably.

These wheeled trolleys, however, allow a vehicle utilisation of forty percent only as they can not be stacked on top of each other, but loaded only at one level. Apart from that, the special design causes extra costs of £2,000 to £3,000 per trailer which is up to twenty percent of the price of a normal trailer. These are the only costs which could be related to the JIT aspect of this project. All stillages are loaded on the trolleys only in the warehouse, apart from those consignments which go direct from the vendors to the plant.

Although the whole operation is dedicated to Rover, all tractor units and staff could be used for other business if necessary. The tracks on the trailers can be removed easily. If Rover close for 5 weeks of holidays every year, TNT have holidays at the same time so that there is no disadvantage arising from the dedication of all resources.

TNT - Rover

1) The European collection

The components' collection from the suppliers abroad could be taken over by the common European TNT network. There are fixed transit times for shipment from certain origins in Europe to the consolidation centre in Northampton. The collection of the parts is fitted in to the schedules according to Rover's requirements concerning the date of delivery. From Northampton dedicated vehicles ship consolidated loads to the different Rover plants. This approach ensures full truck loads all the way from the vendors.

Special arrangements concerning the time factor in the process of delivery are not necessary. The date of delivery is predetermined by Rover but the exact time of arrival during the day is announced to Rover by TNT.

2) The UK collection

The milk round collection of parts from different vendors to the reconfiguration centre, as well as the delivery from there to the specific receiving decks in the manufacturing plants guarantees full truck loads in most cases. Only 40ft trailers are planned for this operation. The time restrictions for delivery are the same as for the collection from Europe.

The reconfiguration centre could be regarded as a special arrangement for this JIT scheme. Yet, additional costs do not arise for the system as a whole. Only through the reconfiguration centre it is possible to ensure FTL throughout the whole supply chain for both Rover plants. Apart from that, TNT being experts for express and parcel services have all experience and expertise necessary for an operation like this - the quick sorting and reloading of small shipments. In this project it is only a new combination of standard services for a total logistics solution.

BRS - Ford

BRS run only 40ft trailers for the Ford project although FTL cannot always be reached. The average weight per load is 14.5 tons. For small, unprofitable shipments BRS give the order to one of their sub-contractors. The vehicle utilisation is generally increased by returning empty pallets to the vendors.

The dedicated fleet consists of thirty-three MAN tractor units, selected because of their high reliability and fuel economy, and one hundred and twenty trailers. The tractor units work in two shifts, i.e. seventy-six drivers are employed. It is proposed to introduce triple shifting in order to achieve further cost cuts.

In January 1991, when the latest 4 year contract with Ford started, a new core fleet of one hundred and twenty postless trailers was introduced. Contrary to the previous mixed fleet of curtainsided trailers with roof support, the new trailers allow an easier and quicker loading and maximum utilisation. The utilised space capacity per trailer could be increased by approximately fourteen percent. With a purchase price of £12,715 one postless trailer is £500 more expensive than trailers with posts. Altogether this comes to £60,000 extra costs for the whole fleet. This can be related to the JIT factor of the Ford project in so far that the time required for materials handling could be reduced, and so could the in-transit inventory.

As the fleet is dedicated and cannot be used for other customers, the capacity is set against a base level and changes in the volume are undertaken by a group of sub-contractors. Thus, flexibility can be maintained without losses caused by unused reserve capacities. During the period of Ford's holidays the fleet undergoes intensive maintenance.

The consolidation of material from all suppliers in the Midlands and delivery to all UK Ford locations is a transportation system of the highest complexity. The dedicated consolidation point facilitates the optimisation of the handling of shipments from many different vendors for different manufacturing locations. Compared to other contract customers of BRS, however, the difference lies in the extraordinarily high volume of the Ford contract and the coordination of the high number of shipments. The most demanding point is to have skilled employees who are able to cope with the process of reconsolidating a high number of shipments swiftly and accurately.

The time criteria for delivery are not very strict; dates are fixed rather than hours. BRS get the orders for pickup from the suppliers only the day before collection. There is no complex planning of exact routes and timetables in advance.

Apart from the staff in the dedicated consolidation point, there is nobody in the management dealing full time only with the administration of the Ford contract but Account Managers who are dedicated to different contract customers at the same time.

United Carriers - IBM

United Carriers run ten basic collection routes for IBM which are fixed week by week. The collection of material from different vendors allows mostly full utilisation of the vehicles. Through trunking material from distant areas overnight some vehicles can even be used in two shifts per day. The utilisation is additionally increased trough the return of packaging to the vendors or connecting the outgoing vehicles for collection with the distribution of finished products. Figures 12 and 13 show an example of routing and scheduling the vehicles for an optimum utilisation.

The local collections are usually carried out by 40ft trailer vehicles. Small vehicles are generally used only for emergency pick ups out of the normal schedule or for movements within the IBM plant. Outside of the local area, which is a radius of about 50 miles, demountable modules with a platform length of 51ft are used.

As the demountable bodies provide an extra length of 11ft, compared to normal trailers, they are especially suitable for low density/high volume goods. The biggest advantage of these modules is that an empty one can be left with a supplier, to be filled up until the next collection, and exchanged against a full one. This saves time for loading and off-loading the parts. The boxes can be used by the vendors as well as by IBM for the storage of components. Yet, it does not mean that a supplier always has to fill up a whole box but might do it partly and it will be filled up in the course of the collection round. Even the internal height of these modules can be increased allowing double decking/double stacking of stillages. The use of drawbar vehicles and demountable boxes was no special requirement of the JIT programme although it facilitates the process. It was proposed by United Carriers as they use these vehicles to a great extent for their parcel deliveries already.

Figure 12 United Carriers milk round collection (Scotland)

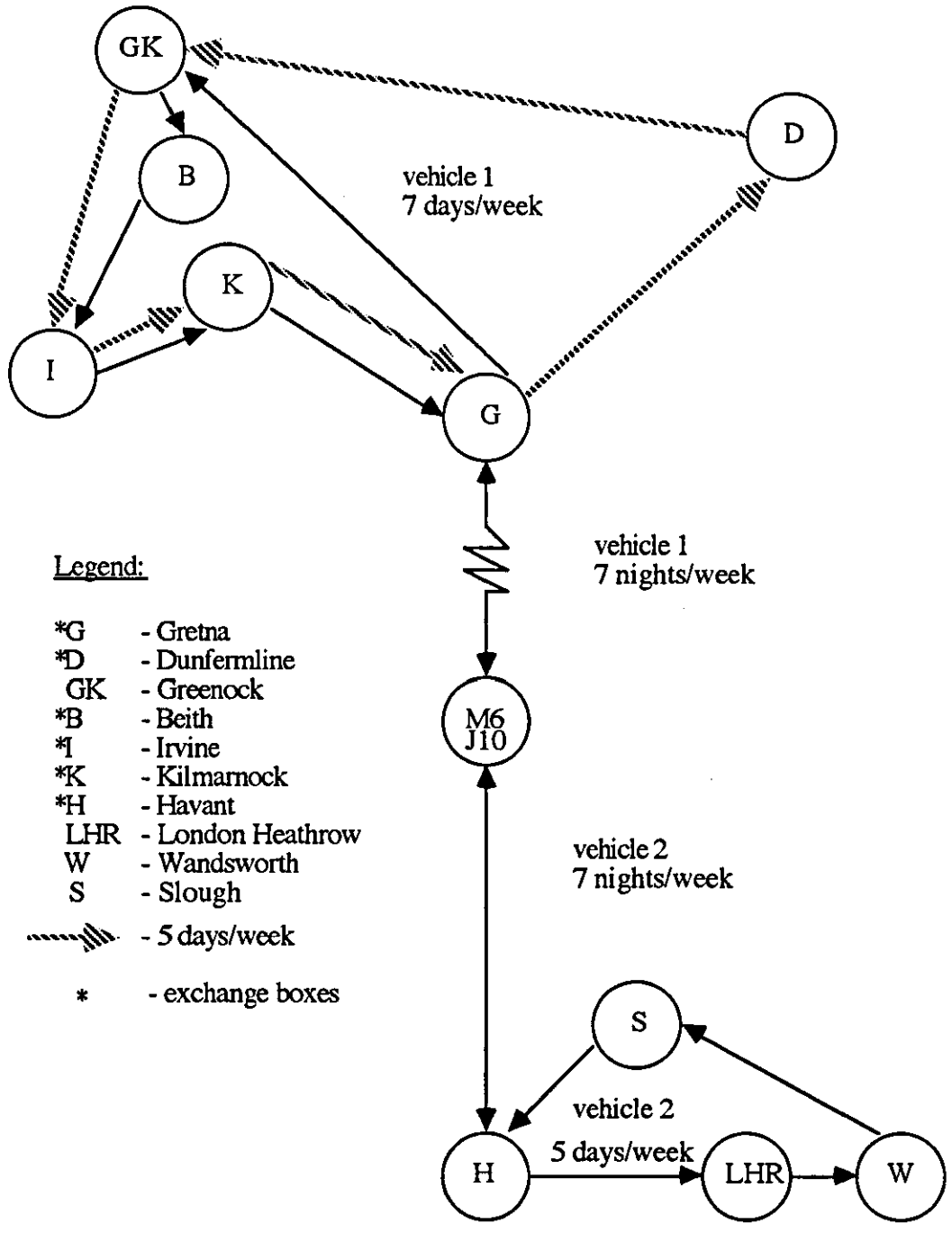


Figure 13 United Carriers milk round collection (Scotland) - Scope of work

Vehicle 1

Night work	Miles	Times
Gretna		1930-2000
M6, J10	200	0000-0045
Gretna	200	0445-0500
Shunting	—	
TOTAL	400	9.5 hrs
Driving time		8.0 hrs
(7 times per week)		

Day work	Miles	Times
Gretna		0600-0630
Dunfirmline*	125	0930-0950
Greenock	75	1150-1210
Irvine	25	1240-1300
Kilmarnock	10	1330-1350
Gretna	85	1620-1635
Shunting	10	
TOTAL	320	10.5 hrs
Driving time		8.5 hrs
(3 times per week)		
(*= 5 times per week)		

Gretna		0600-0630
Greenock*	115	0900-0920
Beith	20	0950-1010
Irvine	15	1040-1100
Kilmarnock	10	1130-1150
Gretna	85	1420-1435
Shunting	10	
TOTAL	255	8.5 hrs
Driving time		6.5 hrs
(3 times per week)		
(*= 4 times per week)		

Vehicle 2

Night work	Miles	Times
Havant		1715-1745
Petersfield	18	1815-1830
Wandsworth (for GK)	52	2030-2045
J10, M6	134	0000-0045
Havant	170	0445-0500
Shunting	15	
TOTAL	399	11.75 hrs
Driving time		9.0 hrs
(6 times per week)		

Sunday

Havant		1930-2000
J10, M6	180	0000-0045
Havant	180	0445-0500
Shunting	15	
TOTAL	375	9.5 hrs
Driving time		8.0 hrs

Day work	Miles	Times
Havant		0700-0730
LHR	75	0945-1045
Wandsworth (for Havant)	16	1115-1145
Slough	26	1245-1315
Havant	75	1530-1545
Shunting	15	
TOTAL	207	8.75 hrs
Driving time		6.0 hrs
(5 times per week)		

Because of the high volume of the IBM contract United Carriers have one supervisor, a workshop with four fitters and thirty dedicated drivers located at the IBM plant in Havant, as well as seven more drivers located in different depots of United Carriers.

Although IBM demand adherence to predetermined times of arrival, the operation is running smoothly and does not require extra capacities of small vehicles or staff. Through delivery for retailers as well as the parcel service United Carriers have experience in routing, scheduling and handling of small shipments. The involvement of dedicated vehicles and staff is necessitated by the volume and complexity of the operation like in any other case of a customer that size.

Ryder - Nissan

As the time criteria for delivery of parts are rather strict in this project, an exact planning of routes and timetables for collection and delivery in advance is necessary. Ryder get a firm schedule of material requirements one week in advance which is the basis for the vehicle allocation and scheduling. The approach of milk round collection allows an optimisation of the loadability factor of the vehicles up to ninety-five percent in most cases. This is supported by Nissan's system of returnable packaging.

Ryder's dedicated fleet consists of curtain sided 38t vehicles. Certain vendors, who supply high volume parts, require vehicles with the increased loading height of 2.90 metres (usually 2.60 metres).

Concerning the staff involved, a dedicated operational team was set up including management, supervising, operational planning and the drivers. Costs for running the dedicated team come to £100,000 per year. Apart from that, a managing director as well as people in computing, planning and finance deal with the contract.

Comparing resources and costs for the operation of this JIT contract, the only difference to a non-JIT business that size is the exact route and time planning every week in advance. Yet, this does not require extra manpower as it is mainly done by the computer system. Apart from that, there is a certain part of regular collections which makes the process less complicated.

Swift (proposal for Toyota)

The Toyota contract would have been managed by a Communications Centre (CC) based close to the manufacturing plant and having EDI link with Toyota. This would have been manned twenty-four hours on 7 days of the week to constantly control all operations. Although no cars will be built at the weekend, there would still be the trucks on the road which deliver from Europe or remote suppliers in the UK. Apart from the contract manager and controllers in the CC, contract coordinators would be based at each of Swift's involved depot locations, reporting to the CC.

Toyota would transmit a monthly diagram of the inbound material requirements (suppliers, part numbers, quantities) to the CC where it would be translated into a logistics plan, i.e. collection routes, timetables, vehicles resources. This would be discussed with the manufacturer and the suppliers within two weeks before the relevant month. If Toyota agreed to this plan it would be transmitted to the operating depot locations. This approach of detailed and fixed planning of all operations for one month in advance is very peculiar to Toyota. Ford, for example, send a message with materials requirements two weeks in advance with a firm schedule for one week ahead. The actual orders for the pickups is then given by the suppliers on twenty-four hours notice only.

Apart from small weekly shipments which could be collected by Swift's common fleet, all collection vehicles for Toyota would be dedicated. The utilisation of the vehicles would be between fifty and one hundred percent. The return of packaging to the vendors on the collection routes lowers the number of journeys with empty vehicles. The deliveries to the Ford plants ensure a utilisation of even more than eighty percent although only 40ft trailers are used. This is due to the fact that Ford's JIT system is not that stringent and consignments can be collected over a period of time (hours) instead of immediate delivery like for Toyota.

A quick round run of the collection vehicles to the Derby plant is facilitated as follows. The incoming full trailers are dropped off in the trailer park on Toyota's site and an empty one, or one that is pre-loaded with empty returnable packaging, is picked up. A maximum of thirty minutes is allowed for the changeover of the trailers. Artic shunt vehicles are positioned on site to move the incoming trailers from the trailer park to the appropriate unloading docks, and afterwards to the empty pallet area for loading of returns, or back direct to the trailer park. This may not take longer than one hour per trailer.

The shunt vehicles would not cause any major cost. They are old lorries which are not suitable anymore for normal use on public roads. As they work on private property no tax or insurance need to be paid and they have no book value anymore. Only labour costs occur for the drivers.

Air Express International - Hewlett Packard

The necessary high quality of performance is basically proved by the BS 5750 Certificate gained by AEI. By means of a Quality Management Information System, working throughout the global network of the company, the high standards of performance are audited from origin to destination of all transportation processes.

In order to measure and analyse the JIT performance of AEI, there is a regular reviewing process carried out internally, as well as strict auditing by Hewlett Packard. This reviewing process comprises:

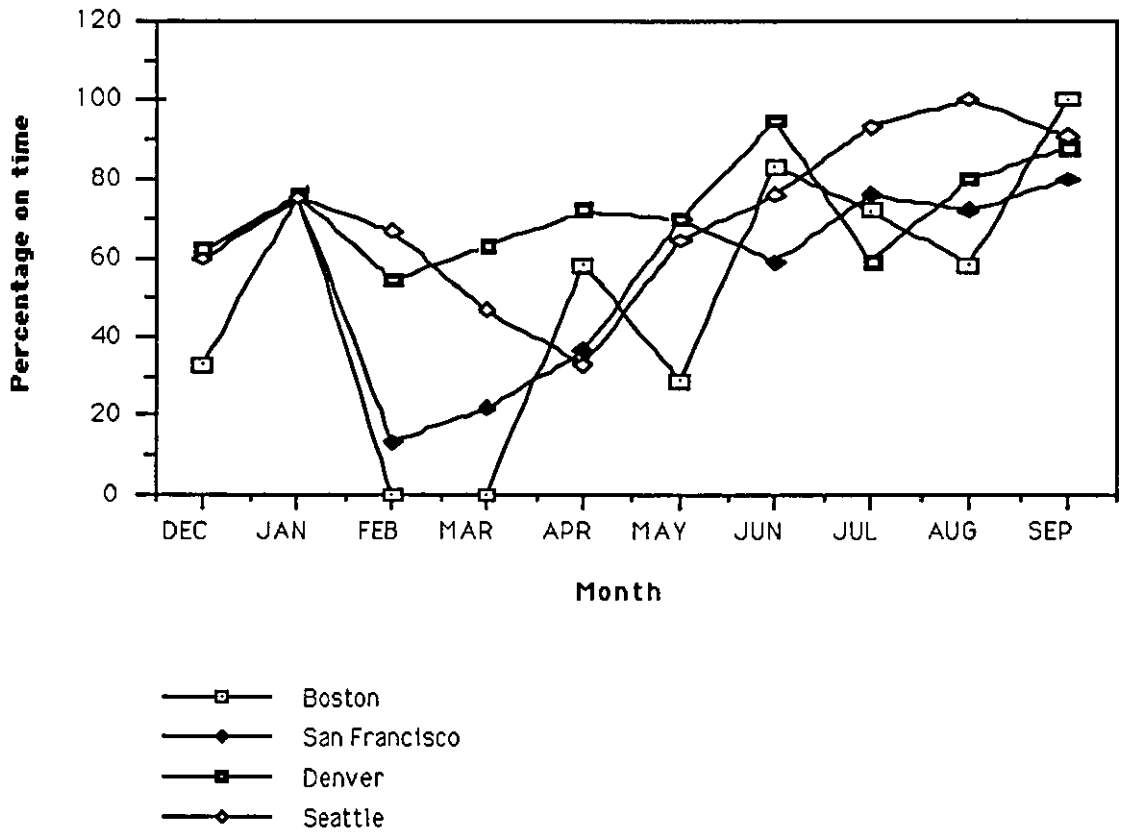
- daily operational reviews
- monthly review meetings with the customer
- quarterly management review
- senior management review twice per year.

This kind of performance auditing is, however, a standard programme, especially for large customers, and part of the Quality network of AEI.

The difference in the JIT business is that the whole procedure is much more formalised, and the standards of performance are measured much more closely, especially regarding the fulfilment of time criteria. Hewlett Packard set up a special Logistics Department in June 1990, to deal with all matters of the complex JIT delivery scheme, and to establish closer contact with the carriers. This department is analysing the in-time delivery performance, and discussing deviations with the parties involved.

Less than ninety percent of the AEI deliveries adhere to the JIT schedules. This is illustrated by Table 16 which shows the on-time performance from the American gateways over the period December 1990 to September 1991.

Table 16 On-Time Performance of AEI (December 1990 to September 1991)



There are different reasons for the deviations from schedule. Firstly, delays are caused in most cases by suppliers who do not have the material ready at the time of collection. A second major problem is insufficient space in the airplanes. AEI need to know the capacities required as early as possible. A forecast is given about 2 or 3 months in advance, but the exact delivery dates of certain amounts of material can be modified every month. Thus it is not always possible to book the exact capacity with the airlines long enough in advance. As AEI is a very big customer, however, they have priority in booking over other customers, to a certain degree. And as Hewlett Packard is a big customer for AEI, the HP consignments should have priority as well, especially because they are bound into internal JIT manufacturing schedules. A third reason, in connection with the latter, are changes and cuts in the schedules of the airlines.

The obvious downfall of the quality of performance especially in Winter and Spring 1991, as illustrated by Table 16, was caused by the special circumstances in connection

with the Gulf war, when an extraordinarily high number of flights were cancelled. During that period an extra day of transit time was allowed for all shipments.

Delays of delivery, however, do not necessarily cause a stop of the production line. There is a buffer stock of one or two days on the manufacturing site for most parts.

TNT - Rover

The demands of high quality service from the carrier are basically met by the BS 5750 Certificates 1 and 2 held by TNT. Part 1 was awarded for the design and implementation of logistics operations on behalf of contract customers, and part 2 for the operation of warehousing and distribution systems.

But this high quality level can only be maintained by every day auditing of all operations. Apart from a continuous improvement programme for the Rover project, in order to increase efficiency of the whole process, there is a TNT Quality Action Team, consisting of two people on Rover's site, to get a good understanding and update of all needs of the customer, to monitor operation and to deal with all problems arising. This approach is part of TNT's Quality Management Scheme and applied for all of their clients depending on the volume of the contract.

BRS - Ford

A high standard of service level is guaranteed by BRS through the application of principles of Total Quality Management throughout the company and the achievement of BS 5750 Part 2. On the basis of that, Ford have their own Carrier Quality Rating Scheme. This is to become a formalised standard for all Ford's carriers throughout Europe and will enable the carriers to be rated annually, based on agreed criteria. Depending on the results of the rating they will be categorised as excellent, satisfactory or unsatisfactory carrier with according consequences. The criteria of evaluation are:

	value
- lead times	50
- customer focus	15
- management/administration capabilities	15
- equipment and facilities condition monitoring	10
- technical assistance and innovations	10
	= 100

The performance of the carrier is evaluated for instance on the basis of questionnaires filled in by all Ford employees who are in touch with BRS, about their experience and cooperation throughout the year.

BRS could achieve the 'excellent' status which means that they have reached an overall score of eighty-five percent and a minimum of seventy percent of the points available for each criterion. Apart from being the basis for long term contracts, this will also result in less monitoring by Ford because the self monitoring facilities have proved effective. Actually, there is no other reviewing process of the operation in shorter terms, but every delay in delivery caused by BRS will result in lower marks in the overall performance measuring at the end of the year.

United Carriers - IBM

A review of mileage and cost of the contract in the last four weeks is given to IBM in the frame of a monthly review meeting, in which problems which occurred in the course of operation, are also discussed. However, this is a routine that United Carriers have with all of their contract customers. The on-time delivery performance is usually around one hundred percent, delays are mostly caused by the vendors. Altogether United Carriers could reach the status of providing the best transportation service for IBM in the UK.

Ryder - Nissan

The measurement of Ryder's service quality is executed by means of the computer system on a real time basis. Reports on the in-time performance can be given at any time and for any period of time required. Both Ryder and Nissan have access to that information. Data about deviations from schedule and their reasons are also included so that problems can be spotted and dealt with in the short and long term.

Swift (proposal for Toyota)

Toyota's quality demands on the daily operation can be summarised as follows:

- adherence to the JIT delivery schedules
- high level of vehicle fill
- minimum transit time
- maximum fleet utilisation
- correct vehicle type allocated to each route
- compliance with all national and international legal requirements
- cost effective solution
- avoidance of in transit damage.

These criteria would be measured by permanent monitoring of the whole process on a real time basis. The status control updates would have occurred as follows:

- liaison between Toyota, Swift Communication Centre and all depots during logistics and operational planning process
- as vehicles depart on collection/delivery runs
- as each collection/delivery is completed
- as soon as any problems occur or delay in excess of 15 minutes
- as vehicles pass from one country to another or trailers handed over to other driver
- on arrival at the consolidation depot
- on dispatch from consolidation depot.

All this data would have been put into the computer and could have been summarised in report format for any time period. Toyota could have observed the system and, thus, checked the location of any part anywhere in the logistics system. On the basis of this data, regular contract reporting and review meetings would have been held between Toyota and Swift on a weekly, monthly, quarterly and annual basis in order to discuss operational performance and non-conformities.

If an irregularity could have been identified as the logistics partner's fault, a full internal investigation would have been made and, depending on the severity of the fault, appropriate management action plans implemented to avoid re-occurance in future. Apart from that, Swift would have had an internal Quality Audit Manager who would have documented and discussed the operational performance with the depot managers.

This very tight control system is very special and far beyond any requirements of other customers so far, as it demands much more real time knowledge and immediate action in the case of irregularities. Within the Ford delivery scheme, confirmation is given to the manufacturer only if the parts have arrived in the consolidation centre, and the time of arrival at Ford will be dispatched. Only if problems occur, Ford are informed by phone and make an input into their computer system.

7.6. Liability

Air Express International - Hewlett Packard

In the previous chapter it was shown that deviations from the schedule happen rather often for a number of different reasons. In emergencies it is then necessary to either charter a private aircraft which is very expensive, or possibly to use another airline which may not offer the same price conditions as the regular business partner.

Delivery not being on time means mostly a delay of 1 or 2 days. For most parts there is still enough stock on site to keep production going. So far there has never been the case of a likely line stop, which would have caused real emergency action.

Altogether, as far as delays of delivery are concerned, there are no clauses of a higher than usual liability in the contract between Hewlett Packard and AEI. That means, AEI is not liable for losses that arise for Hewlett Packard in case of a line stop in the manufacturing plant because of delayed delivery. But there is still the risk for AEI to loose the whole business, if the performance level is not satisfying in the long term.

Frans Maas - Rank Xerox

As the time criteria for materials collection into the warehouse are not very strict it is a quite exceptional case that it becomes necessary to expedite single consignments because of delay or urgent need in production. In such case emergency measures would be taken, i.e. use of extra vehicles or Express Services. There is an extra van held in Gloucester for such cases within the UK. This one also serves for exceptional deliveries between warehouse and plant. The usual clauses of liability of the carrier are applied.

BRS - Rover

As the warehouse in Cowley is only one mile away from the Rover plant, the risk of running out of material at the production line because of the carrier's fault is extremely low so that no special clauses of liability and insurance between BRS and Rover are necessary. For exceptional cases of a mix up of components or urgent delivery, there is a van held in reserve.

TNT - Rover

In all TNT projects for Rover the usual regulations concerning the carrier's liability for freight damage or loss are applied. In connection with that they are in charge of speeding up urgent or delayed deliveries. At the distribution centre for Longbridge TNT have two vans in reserve in case it becomes necessary to expedite certain parts. Presently they do about forty journeys per week.

BRS - Ford

Regarding liability, BRS would not be charged for losses arising from a line stop at one of the manufacturing plants because of delayed delivery. Yet, they had to bear the extra costs occurring for expedited delivery of the needed parts if the delay was caused by themselves.

United Carriers - IBM

In the case of an incident like vehicle breakdown or a supplier not having his parts ready for collection at the time, the driver is obliged to ring up the depot so that appropriate measures can be taken in cooperation with IBM. All trucks are equipped with phones. It is important that in the remote United Carriers' depots where the collection and trunk vehicles meet, drawbar vehicles being able to carry the extra long demountable modules must be held to be a replacement for a broken down truck. These drawbar vehicles can usually not be hired from truck rentals.

The terms and conditions of insurance are much the same as in any other contract concerning the transportation of goods. Yet, there is a special clause regarding disaster recovery meaning a commitment of 4 hours recovery to provide back up in an emergency. The pressure to handle delays of deliveries is, of course, much higher in the frame of a JIT schedule because it must be done immediately. But close relationship and cooperation between carrier and manufacturer allow a certain flexibility, and many matters of that kind can be settled internally, without creating greater problems.

Ryder - Nissan

Regarding emergency delivery and disaster recovery, the contract with Nissan includes an additional insurance policy for the recovery of costs that arise to catch up missed manufacturing in the case of a delayed delivery. But actually not every component would cause a stop of the assembly line because of delayed arrival, like parts which could be fitted afterwards. In the case of an incident, the driver must report to the depot, so that appropriate decisions can be made. All trucks are equipped with a cab phone. Ryder have their own nationwide round-the-clock emergency service which provides prompt roadside assistance or replacement of the vehicle if necessary. This can easily be taken from one of the over one hundred and fifty Ryder rental dealers throughout the country.

Toyota

If any reasons occur that parts cannot be delivered at the predetermined time, the problem will always be solved in connection with Toyota. They judge how urgent the particular components are and according to that measures of expedited delivery will be taken. This could include taxi, railways or even helicopter in order to prevent a line stop. Although such exceptional measures seem to be costly, one must consider that they are likely to occur very rarely and would not offset the savings that are gained from the low safety stock in general.

The liability of the logistics partners covers the extra transportation costs for emergency delivery but not the losses arising from a line stop. This would be an amount of £4,000 per minute and could, in the worst case, make the carrier unable to continue the business. But this would not be in the interest of Toyota either, as it took too much effort to establish the necessary close connection between carrier and manufacturer to run this complex system smoothly.

Swift (proposal for Toyota)

For the case of any irregularity such as supplier problems, vehicle breakdown, traffic congestion, missed collection/delivery, or Toyota needing certain parts urgently in deviation from the monthly diagram, very detailed instructions and allocation of responsibilities would have been exactly defined in the Operational Manual. The local

contract coordinator had to be informed immediately, Toyota had to be advised and a non-conformity report had to be completed. In the best case, route instructions or timetables would have been changed and the logistics plan amended. As soon as the situation would have threatened the predetermined times of collection/delivery by a delay of more than fifteen minutes, additional or emergency transport had to be executed. All decisions would have been made in inter-action with Toyota.

As it would have been necessary to get information from the drivers at the different stages of the operation all vehicles would have been equipped with cab phones. A more advanced technology in this field is a new system transmitting information via satellite. Digital messages can be sent and received between lorry and depot. The driver can put data into the system and print it out in a standard form. A link with Toyota's system could have been established providing real time information at any time. Although the expenses for the initial installation of the system are very high, it works out cheaper over a period of time as it is cheaper per unit than phone. Swift already equipped their fleet partly with this new technology, emphasising vehicles that work in JIT systems because there it proves to be a real advantage for the customer.

7.7. Price

Although the demands on the service level of carriers' in JIT delivery schemes are generally rather high and performance measurement much stricter, there is no additional price margin compared to other contract customers. The price is mainly based on the actual costs arising from the operation. The reason for that is that JIT is usually implemented by large manufacturers first, which ensures a large business volume and long term contracts for the carriers involved. The competition to get these contracts is very strong and the price is one important criterion of the carrier selection. But although the profit is relatively the same like for other customers, once a carrier is operating a JIT scheme for a major customer succesfully, this increases his competitiveness for new businesses markably.

However, in some of the cases special arrangements were made between customer and carrier concerning the conditions of payment. This was the case when the fleet was dedicated to the customer completely.

BRS - Ford
Ford pay for transportation on the basis of vehicle runs and mileage. The actual weight of the shipments carried and vehicle utilisation have no influence.

United Carriers - IBM
The price of the operation is measured on the real costs occurring, based on a certain number of dedicated vehicles in operation. It consists of fixed basic costs per vehicle per year, split for every week, plus variable costs per mile. The weight of the shipments and vehicle utilisation are not the basis for pricing.

Ryder - Nissan
The operational costs for the whole project are £5m per year. Nissan pay Ryder an annual fee for the contract as a whole, based on fixed resources such as a certain number of dedicated vehicles and staff plus the usual elements to cover a part of the overhead costs and profit margin. The mileage or weight being actually carried in the course of the operation do not effect the price.

Toyota

The price that will be paid to the carriers consists of:

a fixed fee per month for basic costs of the dedicated fleet including drivers
plus a fixed fee per route (no consideration of the actual weight)
plus special fees in emergencies (if not caused by the carrier).

As was explained in the previous chapters, all routes for material collection are worked out in advance and in a way that optimal vehicle utilisation can be achieved under the conditions given.

Swift (proposal for Toyota)

Swift's proposal for payment was to have a weekly price for the dedicated fleet on route basis. The costs per vehicle would be based on

1) an hourly rate of
   - total standing costs
   - incl. elements for recovery of corporate overhead
   - incl. recovery of depreciation and interest charges
   - incl. likely call charges for in-cab telephone
   - incl. provision of fully trained and qualified drivers (55 hours per week)
     --> full recovery of employment costs and direct wages
   - incl. cost associated with Vehicle Excise Licence, Vehicle and Goods In Transit Insurance

2) distance
   - incl. fuel, maintenance and tyre costs.

On the basis of these factors the costs per route can be calculated. The calculation of the weekly operational costs would have been made as follows:

costs per route x route frequency per week = weekly costs per route

The total of the weekly costs per route for all routes would have been the total operational costs per week. An overhead percentage of about ten to fifteen percent would have been added to cover direct contract administration, management and status control technology. The profit margin comes to about ten percent.

Altogether, the calculation of the price on the basis of the mileage and the fixed costs of a certain number of dedicated vehicles appears to have different implications for the carriers. The case studies show that these calculations are almost exclusively based on large vehicles, mainly 40ft trailers. As the actual weight of the shipments carried has no influence on the price, there is little pressure on the carriers to use smaller vehicles even when the vehicle utilisation of certain collection routes is low. The full costs and profit margin for large vehicles will still be recovered by the fixed price structure in any case. If the carrier works out the routes and schedules for the vehicles in a most effective way ensuring a low number and high utilisation of the vehicles in use, the operational costs can be minimised. That would also mean low transportation costs per unit delivered. The benefit from that, however, would only go to the carrier as it would result in a consequently higher share of the profit margin in the fixed price.

If, on the other hand, the use of fixed capacities is not optimised and extra vehicles are needed, the operational costs would increase with the result of a lower profit margin. BRS and United Carriers stressed that small shipments from remote areas, where separate collection becomes uneffective, are normally given to sub-contractors, i.e. local road hauliers without dedicated resources.

The scope for the carrier to influence the profit margin becomes smaller in a more stringent scheme like the one at Toyota. Although the weight of shipments still does not play a part in the calculation, the price is not simply based on the mileage but on fixed costs per route. These routes are already predetermined in advance with the aim of the highest possible utilisation factors which means lowest transportation costs per unit delivered within the time limits given. This ensures a minimum number of vehicles for the entire collection scheme. The price is, thus, based on an operation of the highest efficiency. The carriers must adhere to the predetermine schedules; all deviations would result in the curtailment of the profit or even loss. This business practice makes clear once more why such a high emphasis is put on the preparation of the whole project.

The agreement between Nissan and Ryder to fix the price for transportation as an annual fee in the contract without even measuring the actual mileage or weight is an enhancement of the approach applied by Toyota. This annual fee is calculated on the basis of material requirement forecasts and the according demand for transportation services. The manufacturer is only interested in the minimisation of the transportation costs of his components. Therefore it is necessary to work out exactly the routes and frequency of collection in advance, as well as to predetermine the necessary vehicle resources for a

most efficient operation. Again, the profit of the carrier is only guaranteed if he can perfectly adhere to all schedules. There is no scope left to increase this margin as these schedules are based on the highest possible efficiency.

For both partners, an essential benefit from the fixed price of a contract is that this approach saves a significant amount of paperwork, i.e. the necessary workforce, time and money to deal with all the different transport documents and procedures of invoicing. While these processes are simplified significantly, excellent planning capacities and accuracy for the calculations in advance are required.

Finally, as a dedicated fleet can usually not be used for another business, the contract prices cover the costs for fifty-two weeks per year in order to avoid losses during the period of the manufacturer's holidays. This is the typical business practice with all contract customers using a dedicated fleet.

8. Discussion of the results and conclusions

This thesis identified the implications that arise for carriers from doing business in a JIT environment. On the basis of investigating various JIT projects in Great Britain the following points could be concluded.

The complexity of JIT delivery schemes is very different and so are the demands on the transportation systems required. However, it appears that all carriers surveyed apply basically the same procedures of design, implementation and operation of transportation systems for any of their contract customers. A wide range of high quality standard services includes the initial analysis of all requirements of the client, the design of an optimal logistics solution and its cost effective implementation. Dedicated non-JIT projects can be of similar complexity as JIT. The demand for third party carriage, often on a dedicated basis, and consultancy for the establishment of tailored logistics systems is generally growing and typical for more complicated and extensive schemes. This is usually the case for 'ex works' contracts of major manufacturers with a wide network of suppliers.

The time, work and money which are spent on the development of any new delivery scheme for a major customer, depend on different factors:

1) complexity of the programme (volume; number of suppliers; time sensibility)
2) purpose (e.g. first presentation to the customer amongst other competitors or a detailed plan of operation to run a system)
3) flexibility (e.g. the customer defined the basic concept already and the carrier is asked to put it into operation, or only the goals of the new strategy are given but it is mainly left to the carrier to design an appropriate delivery scheme).

On the basis of the case studies, extra costs arising from the JIT aspects of the delivery systems were identified only in the advanced milk round collection schemes with tight schedules of predetermined time slots. In these cases material is collected only one shift ahead and deliveries must be absolutely reliable. In order to ensure a smooth operation from 'day one' onwards emphasis must be laid on the preparation of the scheme. This requires a lot of extra planning capacities, dedicated only to the JIT aspect, for routing, scheduling and vehicle allocation in advance. Furthermore, all staff involved must be familiar with all requirements and procedures of the JIT scheme before the operation

starts. Extra training courses become necessary. The stringent time criteria are also the reason for simulation runs with empty vehicles. These measures can be assigned as extra JIT demands which are hardly ever necessary in any other regular business. The arising costs can, in fact, be defined as JIT related. They occurred only in the the cases of IBM, Nissan and Toyota.

Information technology, being absolutely necessary to ensure the smooth running of a JIT delivery system, could be identified as another important cost factor. However, basic computer programmes of routing, scheduling and consignment tracking and tracing are used by all of the larger carrier companies in the day-to-day business and can usually be adjusted to any customer's requirements. These sorts of information are demanded by an increasing number of customers, especially in dedicated contracts of high volume.

An exception from that is the Kanban programme developed by TNT for the sequenced delivery of bumpers from the warehouse to the Rover plant. This was a special 'JIT requirement' although a form of modern warehousing rather than transportation.

The development of dedicated computer software for Ford by BRS was necessary mainly because of the high volume. Apart from that, the system was introduced in the beginning of the eighties when the standards of general computerisation of the transport business were not as high as they are today. The same fact is true for the initial JIT information system of Ryder which today can be applied for most of the contract customers as real time information is more and more relevant in all sectors of business.

With exception of the Rover Kanban and Ford systems, costs in connection with information technology arose in all other cases only from the adjustment of existing software to the special requirements of the customers. The extent of that depends on the complexity of the collection system like volume, number of suppliers and collection frequency.

Regarding the actual operation, it turned out that the complexity of JIT systems can be very different and is not necessarily higher than that of non-JIT contracts. The point in every JIT concept is to optimise routing and scheduling of vehicles in a way that frequent collection and JIT delivery of small shipments to a production plant can be ensured. A cost effective solution and high vehicle utilisation should be guaranteed.

In the case of a close-by warehouse routing and scheduling are simplified to direct delivery from the distribution centre to the manufacturer with shipments being 'collected' and consolidated in the warehouse. All deliveries can be made in FTL. Emphasis in preparation and operation is laid on the warehouse operation, which is illustrated by Table 17. The cost split of Rover's warehouse systems is compared to the Ford and Toyota collection and consolidation schemes. The missing share to complete one hundred percent are overheads and growth margin.

Table 17 Split of operational costs [%]

Project	Warehousing	Transport
Rover - BRS	67.4	12.6
Rover - TNT	43.0	20.0
Rover - Swift	50.0+	20.0
Ford - Swift	--	60.0+
Toyota - Swift	--	60.0+

The only factor that can be counted as a special demand of a JIT-warehouse is that easy access to all parts must be guaranteed at any time as all components are fast moving. Yet, the set up and operation of dedicated warehouses is a normal part of the non-JIT business of all carriers involved. There was no demand for the development of complex transportation schemes, but the only novelty was to cope with the Kanban materials pull principle.

Both companies in the case studies concerning warehousing, Rover and Rank Xerox, stated that this solution is only temporary before the vendors themselves could be included in a more complex JIT collection scheme. However, the inventory level could still be reduced, as the stock held in these warehouses amounts to one week average, which is only one third of the average level in industry being twenty days [49].

Regarding the milk round collection and consolidation systems, new demands concerning the accuracy of routes planning and scheduling were set. However, scheduling one or two weeks in advance was only required for the IBM, Nissan and Toyota collection schemes. These extra planning capacities do not necessarily require additional manpower and time but are provided by the computer systems.

The assumption that the carriers would be compelled to operate a relatively higher number of smaller vehicles for JIT delivery schemes proved to be wrong. This is only the case if the suppliers deliver all shipments separately. The 'ex works' collection schemes give carriers the opportunity to optimise routing and scheduling of the vehicles in a way that full truck loads can be achieved in most cases. Even in the very complex milk round collection schemes mainly 40ft trailers are used. The average vehicle utilisation in general business where deliveries are usually made within 2 or 3 days after order placement, is about sixty percent [46]. JIT can ensure a higher utilisation because the process is much more controlled and the vehicle allocation can be planned in advance. This can be even improved by systems of packaging return. The number of vehicles in use is minimal and there is usually no need for extra resources in the form of smaller vehicles than 40ft trailers. The dedication of a certain number of vehicles to one contract customer is common business practice depending on the volume of the contract.

Another advantage is that JIT manufacturers do mostly use standardised detachable pallets and boxes which facilitate the combination of mixed parts loading and a maximum use of cube through a high level of stackability in the trailer. A negative example in this regard is, however, the use of wheeled trolleys by Rover which allow no stacking and result in a vehicle utilisation of forty percent. But this may be regarded as an exception for the short distance supply from warehouse to the close-by plant as it would by no means be an effective approach over long distances.

Because of the relatively work intensive and costly implementation of complex operations for major customers, they are usually based on long-term contracts. BRS, for instance, have contracts for their JIT projects over 5 years with Rover, 4 years with Ford and 3 years with Toyota. These contracts get extended in the normal course of business as it would cause too much effort to change the logistics partner under the circumstances given. Yet, this is normal business practice with any major contract customer and no speciality of JIT.

As was said earlier on, the time factor plays an increasingly important role in the industry and predictability of processes is required more and more often. That means that customers are generally more aware of timed deliveries even where these are not part of a JIT project. The difference is, however, that JIT customers are much stricter in auditing the process and insisting on in-time delivery, as there are other internal production schedules which must be adhered to. Delays could have much more significant implications for the whole manufacturing process than in the case of other customers, where material is delivered on stock. That means that the service level, which is offered by the forwarder, must be guaranteed throughout the whole operation. To fulfil these criteria carefully and continually, is prerequisite for the carrier to stay in the business permanently and to withstand the competition.

That means for the carrier that the whole process must be supervised and administered much more carefully and on a real time basis. This does not necessarily mean that more people need to be employed but they have to be aware of the strict criteria and the significance of the accurate fulfilment of their duties. The process of monitoring the operation is facilitated by the means of the computer systems. Yet, all carriers had at least one member of staff dedicated mainly to the supervision of the operation and dealing with irregularities. Depending on the volume and complexity of the contracts, this is not exclusively a JIT related measure but often necessary for other contract customers as well.

The dealing with irregularities rates especially high in JIT projects. Measures and responsibilities for all possible incidents must be defined in advance. However, the costs for emergency measures are charged to the account of the party who caused the incident. The case studies have shown that, apart from small vans in the warehousing projects, no other reserve capacities are held by the carriers.

In spite of strict time criteria, none of the carriers regarded traffic congestion as a major problem or threat to punctual delivery. Permanent connection with the truck drivers as well as contact to the central Traffic Information Service ensure early warning in the case of problems occurring. Scheduling of deliveries during off-peak hours is the most common way to avoid any delay. It turned out in all case studies that basically the usual clauses of carrier's liability are applied in JIT. The risk of a line stop in the case of delayed delivery is taken by the manufacturer.

Summarising all points concluded from the results of the case studies, it appears that although the introduction of the JIT strategy is a major change for most of the manufacturing companies, having an impact on all sectors of the business, the carriers involved do not need to change their own business to the same extent. The demands of a JIT scheme can mainly be met by the standard logistics services of the carriers although a higher degree of specification and quality must be guaranteed at any time. Emphasis is laid on operational planning according to the time criteria, process monitoring and dealing with irregularities. None of the carriers questioned could, however, assign extra costs to these aspects.

Finally, in the course of the research it turned out that the initial plan to make a cost comparison between JIT and non-JIT projects of a carrier could not be executed in the comprehensive and detailed way as was intended. This was the result of several factors. Firstly, the results gained in chapters 6 and 7 show that there is no significant difference in resources and costs of operation between 'ex works' JIT collection and non-JIT schemes. The utilisation of mainly large vehicles can be even higher than in non-JIT.

Secondly, it appears that special efforts in connection with the JIT factor itself are mainly of a qualitative nature and could not be quantified exactly in term of resources and costs. None of the carriers questioned could define such cost factors assigned to the JIT aspect of the scheme or separate those in comparison to other businesses. An exception are the costs of preparation for certain projects pointed out earlier. This, however, must not be regarded as an obstacle to the research but as one of its major findings.

Thirdly, a detailed comparison proved difficult because of the fact that confidential business data was only partly released. Therefore it was not possible to define a common basis for comparison of all projects to which the provided data could have been related. Still, the provision of more detailed data would not have changed the fact explained in the previous paragraph that only very little of the special efforts in connection with the JIT factor actually result in extra costs.

Summarising the criteria of a successful 'JIT carrier', the ability to offer a wide range of high standard logistics services including information technology, modern equipment and excellent planning capabilities are most important. Providing a dedicated fleet, as well as a sufficient network of backup facilities are necessary. International presence is essential for extensive businesses, especially with regard to the European Single Market. Yet, most of the large production companies do not expect any major changes of their

suppliers base, as they already have selected the best available sources for their business. The future challenge for manufacturers as well as carriers is to include all European suppliers into the JIT strategies and operate smooth delivery services.

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APPENDIX

Questionnaire for the preparation of interviews

1. What demands does a JIT regime place on transportation and distribution systems ?

1.1. Criteria of quality

1.2. Quantity and frequency of delivery

1.3. Location of suppliers (local, European, non-European; single sourcing; effects of the EC Single Market)

1.4. Range of components

2. How are forwarders/carriers involved in the initial development and implementation of JIT systems ?

2.1. Third party carriage

2.2. Consultancy services

3. What changes in transport operation and costing arise for carriers from doing business in a JIT environment compared to non-JIT delivery ?

3.1. Stage of preparation:

3.1.1. How much time does it take to develop an appropriate system for JIT and to prepare the implementation ? How much time does it usually take in non-JIT ?

3.1.2. Special efforts in terms of setting up an extra team for development (how many people; who ?) [costs] Do project development teams work in non-JIT ?

3.1.3. Are special instructions/training necessary for staff involved ? [costs]

3.1.4. Establishment of new computer systems and links with the customer (hardware and software) [costs] Compare: efforts and level of computerisation in non-JIT

3.2. Stage of operation:

3.2.1. Was a special division set up newly for the JIT project /for this customer ? (additional staff ? special intructions ?) [costs] Does JIT demand more workforce ?

3.2.2. What kind of delivery service is operated (milkround, consolidation, warehouse, direct; frequency) ? Are these new kinds of services compared to the general business ?

3.2.3. Is there only one manufacturing site to be served or how can requirements of several plants of one or even of different customers be combined and coordinated ?

3.2.4. Is the fleet working to capacity ? (average utilistion; comparison to non-JIT) [costs]

3.2.5. How much and what kind of reserve capacity is held ? Special efforts for a better maintenance of the vehicles in order to increase reliability ?

3.2.6. What are the costs of small and large vehicles compared (price; operation/ maitenance, drivers etc.) ?

3.2.7. What is the proportion of the number of small to large vehicles being in use ? Was the proportion of smaller vehicles increased because of JIT ?

3.2.8. Does the customer require a special design of the vehicles in connection with loading and unloading operations ? [costs]

3.2.9. Can a dedicated fleet be used for other business if it is temporarily not used for this JIT project ? (e.g.holidays of the customer) [losses]
Are there usually dedicated fleets for non-JIT ?

3.2.10. Is there a transfer of storage from the manufacturer into the sphere of transportation ? [costs of establishing new consolidation points or even warehouses] Was warehousing started up newly for JIT or has it been part of the usual business beforehand ?

3.2.11. Are there special clauses in the contract concerning insurance and liability ?

3.2.12. Approaches to adhere to schedule under conditions of increasing traffic congestion

benefits:

3.2.13. Higher prices for better quality of service ?

3.2.14. Higher competitiveness ?

4. What kind/size of transportation enterprises are predestined to take up business in an JIT environment?

4.1. Number of depots

4.2. International or domestic

4.3. Dedicated fleet