PROPOSALS FOR MORE EFFECTIVE DISTRIBUTION PROCEDURES

by

STUART ARTHUR GILL

This thesis is submitted for examination for the award of

MASTER OF PHILOSOPHY

through the Interdisciplinary Higher Degrees Scheme of the University of Aston in Birmingham

MAY 1973

SYNOPSIS

The physical distribution management function of Vono Ltd. has been investigated, the main conclusions being that the function was ill-defined and data bases from which control could be exercised were not available.

Procedures were installed to monitor vehicle operations and to compare the actual carriage charges with the budgeted ones.

Definite regional tastes in upholstery and bedding were indicated, which contradicted with the Company's beliefs. The service provided by the Company was also shown to be worse than believed, and this was shown to not improve with order processing changes.

Linear programming and multiple correlation and regression techniques were applied to the load building model problem with no success. A model was developed which was shown to be useful and the recalculation of all budgeted carriage allowances was accepted by the Company.

Alternative forms of transport were shown to be capable of reducing the actual carriage charges by over 8%. This saving relied partly on more efficient warehousing. Investigations into the warehousing function led to proposals for improved stock recording and control and also assisted in re-siting the warehouse within the Tipton factory.

Stock recording and control of finished products was shown to be very poor. A simulation program was developed to indicate to the management the interaction of production and inventory

decisions for bedding.

Attempts at producing a theoretical transport cost model were only partially successful because of the simplyfying assumptions.

Towards the end of the research programme it became evident that the company appreciated the complex nature of physical distribution management.

"There is nothing more difficult to carry out, nor more doubtful of success, nor more dangerous to handle, than to initiate a new order of things. For the reformer has enemies in all who profit by the old order, and only luke-warm defenders in all those who would profit by the new order. This luke-warmness arises partly from fear of their adversaries, who have the law in their favour; and partly from the incredulity of mankind, who do not truly believe in anything new until they have actual experience of it".

Machiavelli in 'The Prince' (1513)

PROPOSALS FOR MORE EFFECTIVE DISTRIBUTION PROCEDURES

by

STUART ARTHUR GILL

Industrial Supervisor	G.A.D. COGHLAN	Duport Ltd.
Supervisor:	Dr. D.J. van REST	University of Aston in Birmingham
Associate Supervisor	T.D. LAW	ditto
Adviser:	PROFESSOR S. L. COOK	ditto
Company:	VONO LTD.	
Start date	October 1970	

PROPOSALS FOR MORE EFFECTIVE DISTRIBUTION PROCEDURES

TABLE OF CONTENTS

APPENDICES

1. INTRODUCTION

Vono Limited is a member of the Domestic Products Division of Duport Limited, manufacturing metal framed and upholstered beds and wooden framed and expanded polystyrene shell upholstery at Tipton, Staffordshire.

The company operates two factories at Tipton, the distance apart being approximately half a mile. Communications between the factories is poor due to insufficient telephone lines. The smaller factory, called No.2 factory, produces the shell upholstery, while the wooden framed upholstery and all beds are made at the larger factory, No.1 factory. No.1 factory also houses the central finished goods warehouse, although the majority of shell upholstery is despatched direct from No.2, and is the registered office of the company.

No.2 factory has only figured slightly in the research programme. Upholstery products at No.2 are made to order hence finished goods inventory control was not a problem. Delivery lead times on No.2 products are at least 8 weeks giving sufficient time for route planning.

However, the delivery lead time quoted on bedding in September 1970 was 7 days, and bedding and upholstery products were despatched on the same vehicles. Some upholstery products produced at No.1 factory were also offered on short delivery times and consequently inventory control and vehicle scheduling and routing could be problems.

During the first months of the research the average number of loads despatched from No.2 was approximately 4 per day compared with approximately 33 per day from No.1.

The company supplied its customers, retailers, or, in the case of metal framed beds, other manufacturers, and the Government and other bulk buyers either direct from its sites at Tipton or one of its regional depots.

During the early part of 1970 a new board of directors was appointed. Their preliminary investigations indicated that a restructuring of the company's operations would lead to a more profitable future. While the board had experience of the bedding consumer durable industries in general certain symptoms indicated a large problem area of which they had little detailed knowledge.

These symptoms:

i) poor delivery performance

ii) high transport bills

were not quantified but were thought to be severe enough to warrant deeper investigation.

The reaction of the company was two-fold. They appointed a firm to control the distribution function while at the same time safe-guarding the livelihood of the vehicle owners by not severing their contracts and they also agreed to an analysis of the operation by Head Office personnel.

Discussions between Duport Ltd. personnel and the Interdisciplinary Higher Degrees Scheme senior tutors resulted in agreement to establish a research programme to investigate and recommend improvements in Vono's distribution problem. No discussions were held between the I.H.D. Scheme tutors and Vono Ltd., until after the research programme had been operational for over 6 months.

Vono's objective in agreeing to the research project with Duport Ltd. was to reduce their distribution costs. It was considered, by them, that computerised vehicle scheduling and routing would lead to dramatic reductions in miles travelled and consequently satisfy the objective.

An attempt to formulate the problem to meet the objective led to the following tabulation of constraints and variables.

Constraints

Factory site at Tipton
Warehouse at Tipton
Vehicle size, to be fixed as a matter of policy to allow systematic load building.

Controllable Variables	Uncontrollable Variables
Number of vehicles	Number of orders
Type of vehicles	Component delivery times
Minimum economic van loads	Delivery trip times
Delivery routes	Competitors' reactions
Warehouse policies	
Production rates	
Investment levels	
Information flow	
Sales effort, especially special promotions	

It became apparent at this stage that the inter-relationship between controllable and uncontrollable variables was little appreciated by the management, for example the relationship between the number and type of orders and the minimum economic van loads, and also between the type of transport and the number of vehicles required.

However, to gain experience of vehicle scheduling the I.C.L. Mk II Vehicle Scheduling Package was run on an actual day's order intake received by the distribution department.

Routes were produced which the transport manager considered reasonable but the exercise highlighted further problems.

i) the load building model was not uniform and consequently difficult to apply

ii) stock recording and control was inadequate

iii) delivery service was worse than realised

iv) arrangements with the depots were ill-structured

v) arrangements for agreeing mileage claims for delivery journeys were unsatisfactory

It was subsequently agreed between Duport Ltd. personnel, the university supervisors and the author that the preliminary research had indicated a problem area larger than the company first realised. The narrow definition of distribution costs, monies paid to vehicle owners, was broadened to include all aspects of handling, storing and delivering products from the moment they left the production line. Consequently the objective of reducing the distribution costs could still be applied although distribution costs had been re-defined.

It was accepted by the company that such a definition would involve almost every section of the company's management and consequently no single decision maker, other than the managing director, could be nominated. The list of Dramatis Personnae indicates the involvement of members of the senior management who were involved as decision makers at various times during the programme.

The courses of action open to the company cannot be stated because the problem definition included areas about which little was known. It is reasonable to record that the

DRAMATIS PERSONNAE

L. Jones	Distribution Manager Vono Ltd.	Replaced by agents 1.11.70
P. F. Everard	Duport Group Marketing Advisor, Duport Group	Acting industrial supervisor 1.10.70 to 1.4.71, when he was appointed marketing manager of a subsidiary company.
N. Little	Managing Director Vono Ltd.	Throughout
D. W. Wilson Ltd.	Distribution Consultants cum Agents	Appointed 1.11.70 Responsible for all aspects of distribution. Warehousing eventually dropped. Name changed to Vehofreight Ltd. 1.2.72. August '72 no longer responsible for any Vono staff.
C. K. Mellor	Marketing Director Vono Ltd.	Responsible for part of distribution from 1.3.71 - resigned 1.9.71
D. F. Layton	Financial Director Vono Ltd.	Responsible for stocks and computer applications from 1.3.71
P. C. Jones	Works Director Vono Ltd.	Responsible for warehouse resiting and systems but not stock levels 1.12.71 Appointed to another company 1.10.72
J. McKillop	Works Director (designate) Vono Ltd.	Responsible for production scheduling but not warehouse from 1.8.72. Responsible for warehouse and loading bay staff from 1.10.72.
G. A. D. Coghlan	Head of Management Services Duport Ltd.	Industrial supervisor from 1.10.70.

only feasible course of action open to the board was to provide assistance in defining the problem area and consequently to appraise recommendations for improving the operations.

The author's courses of action were

i) to develop a suitable frame of reference for the consideration of physical distribution management

ii) to investigate Vono's distribution operations in the light of the above

iii) to recommend where necessary alternatives to the present method of storing, handling and distributing products to improve the distribution function.

Defining physical distribution to cover all aspects of handling, storing, delivering and controlling stocks of finished products, gave a cost base of 100 for the 1971 financial year, excluding stock financing costs. Of this total 57% was accounted for by transport payments, the remainder being depot expenses, warehouse costs at Tipton and staffing costs, table 11.

The company requested that actual cost figures be excluded from the thesis. Consequently the use of indices was agreed between the company and the university. Although a base value of 100 is quoted it is possible to record that this lies between £½ million and £2 millions.

Of the 64 vehicles operating from Tipton 61 were hired from vehicle owners on an exclusive use contract. Payment was based on miles travelled, or for local deliveries on hours spent delivering. There was no allowance for time spent at Tipton awaiting a load and very little incentive to complete a journey within a specified time. Deliveries to depots, Government contract bulk deliveries, export deliveries to docks, were paid at cheaper rates than the mileage allowance because they were single delivery loads.

The company's view was that savings of the order of 10% could be made in the transport bill by the use of computerised vehicle scheduling packages. However, depot deliveries, Government contract deliveries and export deliveries to docks, would not be included in scheduling packages as they are single delivery loads at cheap rates. This would reduce the hoped for 10% to a possible 6.7% of the transport bill, approximately 3.7% of the distribution bill - excluding stock values. Computer time and manual filing and checking of the orders to which products had been allocated would eat into this saving.

The company budgeted in 1970 for a transport bill of 5.6% of total sales turnover. However, massive increases in rates from 1s.11d. to 2s. 8d. (10p to 13p) necessitated raising the ratio to 6.5%. Figures for 1971 indicated an actual ratio of 6.7% overall. If products not carried by Vono paid transport are excluded, e.g. Mail Order, this ratio became 8.05% as opposed to a budgeted 7.9%.

The company had stated that they considered a transport cost to sales ratio of 5% as possible. However, to achieve this would mean a reduction of 25% in the rate paid to vehicle owners. An alternative was to increase selling prices or improve loading efficiency.

Chapter 3 and 4 provide a background to the sales of the company's products and regional variations and also the customer service level criterion. Work on determining the feasibility of depots and their operating systems formed part of this work. Investigations into the physical distribution system fell into easily definable sections, which nevertheless interacted with each other, as

Transport
Warehouse Layout
Stock Information Systems
Load Building
Management Information Systems

A section, chapter 11, on a theoretical approach to transport costing and an ideal information handling system is included to indicate how the management information already available could be utilised.

The order of investigation was arrived at from a preliminary analysis of the overall problem. Possible savings in transport rested on efficient use of personnel and vehicles. Efficient use of vehicles is a function of the type of vehicles used; literature on distribution management had indicated that alternatives to the present vehicle fleet could considerably reduce the total transport bill.

Warehouse layout was considered before detailed inventory control procedures because the benefits to come from alternative forms of transport depended on rapid vehicle turnaround. Rapid turnaround could be achieved by reducing the time to select beds from storage locations within the warehouse. It was considered by the author that disciplining personnel to store certain beds only in certain locations would lead them into considering inventory control as a beneficial factor. A company decision was taken to cease producing metal framed beds and to concentrate on the more profitable upholstered beds and Home Retail Market.

Metal framed beds were almost exclusively supplied to other manufacturers or the Government against very tight margins, and to the Export Market.

Cessation of metal frame production at No.1 factory and subsequent reduction in the Export Markets released space within that factory and consequently the feasibility of combining No.1 and No.2 factories was considered by the board. Being proved feasible with regard to production facilities a decision was needed regarding the warehouse operating procedures.

Diagram 1.1 illustrates the No.1 factory at Tipton as it was in September 1970. There were decisions regarding the bed production taken at the same time as the metal bed cessation decision and consequently advice was needed on whether to site the warehouse as diagram 1.2 or 1.3

Alternative sites within the factory were considered along with alternative operating and manning procedures and evaluated on a cost basis. Based on the warehouse inventory control procedures operating in 1970 an operational saving of £30,000 per annum, after 2 years, over the present warehouse management procedures was anticipated. A procedure based on first-in-first-out inventory procedures was also costed out and again, discounting inventory levels savings, resulted in around a £30,000 per annum saving, after 2 years.

These investigations relied on reducing the storage space allocated to products and implementing rigid production discipline by the production director. Information on stock levels of finished beds was essential if any efficiencies in distribution were to be achieved. Consequently, alternative stock location layouts were considered as these would improve the efficiency of order picking and also introduce rudimentary inventory control techniques by ensuring that warehouse management were informed when a given beds storage area was full.

The method of allocating products to orders was considered to contribute to inefficiencies in the distribution area. By controlling production tightly it was shown that allocating products for orders before they were produced (pre-allocation) finished stocks could be reduced by between 10% and 15%.

Load building affects the company in that inefficiently loaded vehicles create a high transport bill. Standard computerised vehicle scheduling packages assume homogeneous products with respect to volume or weight. Vono's load building model used two types of load units and some products, e.g. headboards, had no load unit value. This complex model caused difficulties over defining a van load in load units and also in stating the percentage occupacity of any van.

Associated with load building is the carriage allowance built into the selling price of all products. Modifications to this would affect the relative profitability of products and while not reducing the transport or distribution bills could influence the company's sales effort by concentrating attention on the more profitable items.

Lack of information available to management indicated that reporting and action systems were necessary.

The overall problem was considered as too complex to be treated as a whole and hence sub-problems were formulated.

Tables 1.1 and 1.2 indicate the distribution costs for 1971 and the savings estimated from preliminary analyses. For security reasons the costs have been reduced to indices but the ratios between the costs have not been changed.

Total distribution bill		100
Depot Costs (Annual Basis)		
Attleborough		1
Belfast		2
Bovey Tracey		1.5
Glasgow		4.5
London		7.5
Ynysybwl		1.5
Tipton Costs		
Labour: Warehouse and Distribution	13.7%	
Heating, rates, equipment, etc.	11.3%	25
Transport Costs		57

Table 1.1 Distribution Costs for 1971

Cost Area	Proposed Saving
Transport Costs	Company view that 10% saving possible by computerised routing. Researchers view maximum 3% Reverting to Vono management of distribution function 8% minimum. Alternative forms of transport 8%
Warehouse Costs	Alternative site and procedures after first two years. £30,000. Pre-allocation of bedding to orders, 16% of finished bed stock value.

Table 1.2 Table of Possible Annual Savings From Preliminary Research Findings

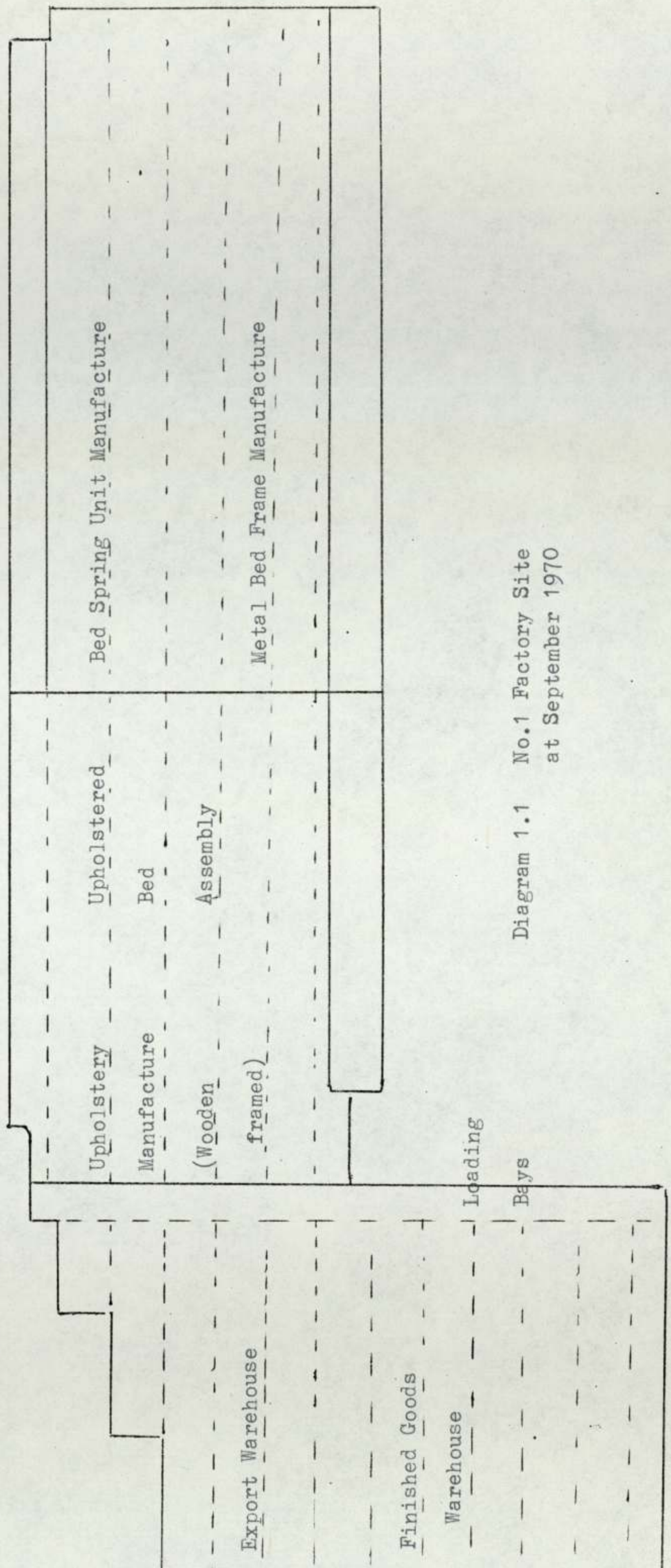


Diagram 1.1 No.1 Factory Site
at September 1970

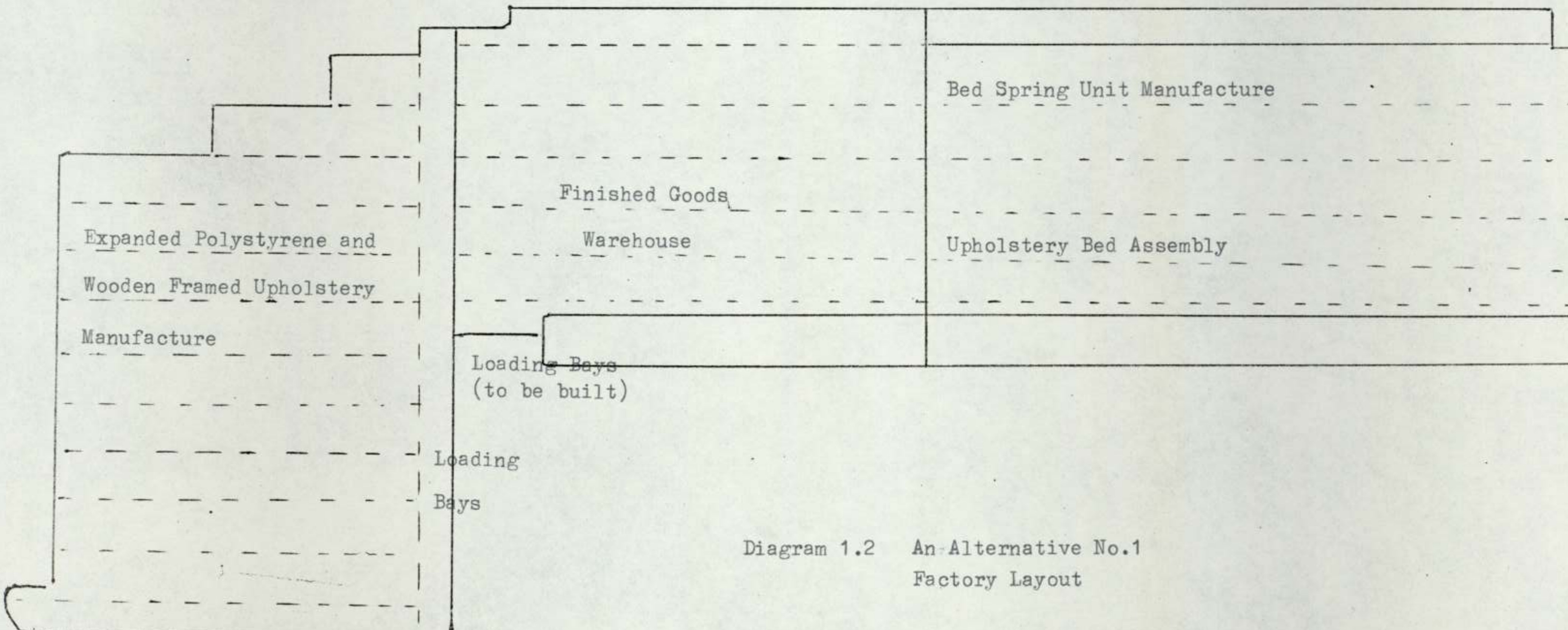


Diagram 1.2 An Alternative No.1
Factory Layout

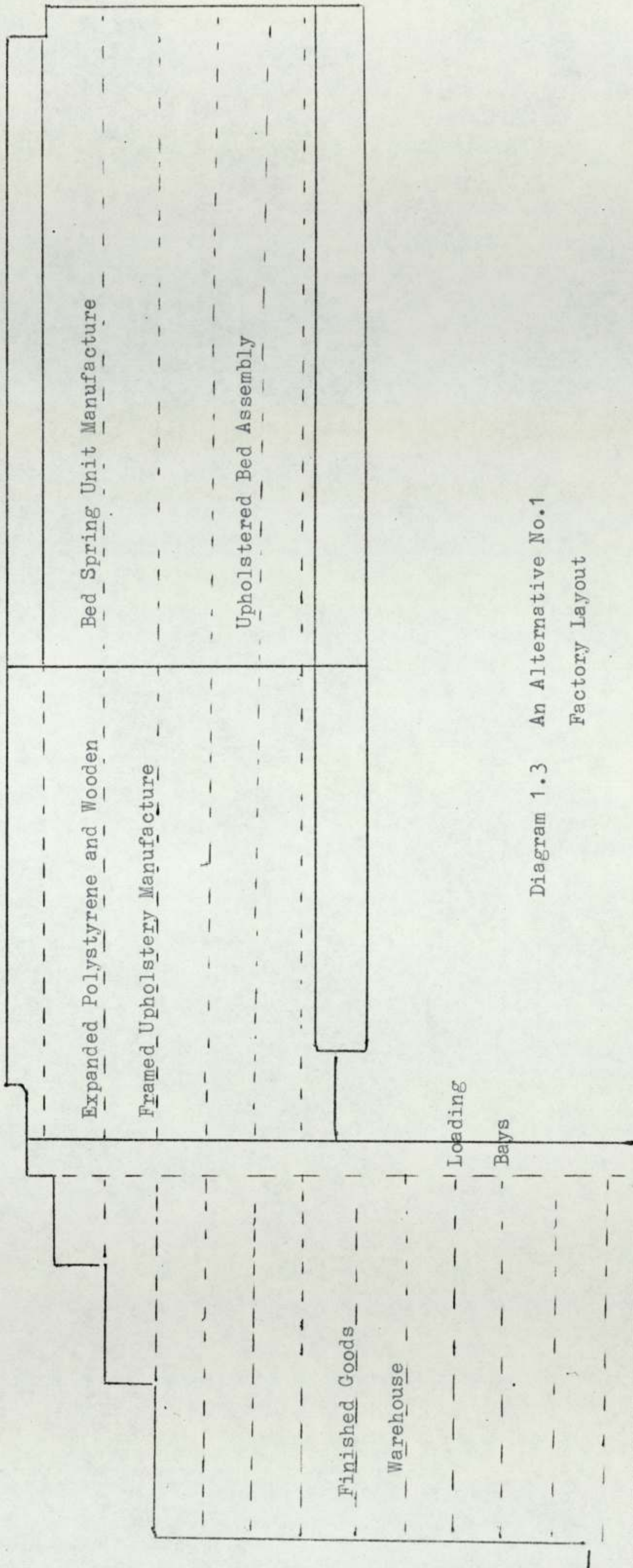


Diagram 1.3 An Alternative No.1
Factory Layout

2. LITERATURE REVIEW

The distribution function appears to have attracted little attention from management scientists before 1960, the need to store and distribute goods having been taken for granted.

During the last decade operational research workers began to investigate the subject. Although extensive literature was produced, this related mainly to two aspects, depot siting and vehicle scheduling. These aspects offer scope for sophisticated mathematical approaches and have been investigated primarily because the latter was considered to be of major importance to the company.

However, physical distribution management is a relatively young area of study and tends to be beset with problems of definition and consequently appears to be based on practical approaches rather than high flown theoretical concepts.

The armed forces have made quite a study of supplying the correct products to the correct places in the desired amounts at the right time (logistics), and consequently the term logistics has come to be associated exclusively with them.

However, the supply of goods and services is also a vital factor in commerce and industry where the term physical distribution management has been used. The National Council of Physical Distribution Management in the United States of America has adopted the following definition of physical distribution

(1) "physical distribution is the broad range of activities concerned with the efficient movement of finished products from the end of the production

line to the consumer - and in some cases includes the movement of raw materials from the source of supply to the beginning of the production line. These activities include freight transportation, warehousing, materials handling, protective packaging, inventory control, plant and warehouse site selection, order processing, market forecasting, and customer service."

Fig.21 illustrates the physical aspects of a logistics system and it can be seen how readily the above definition compares with it.

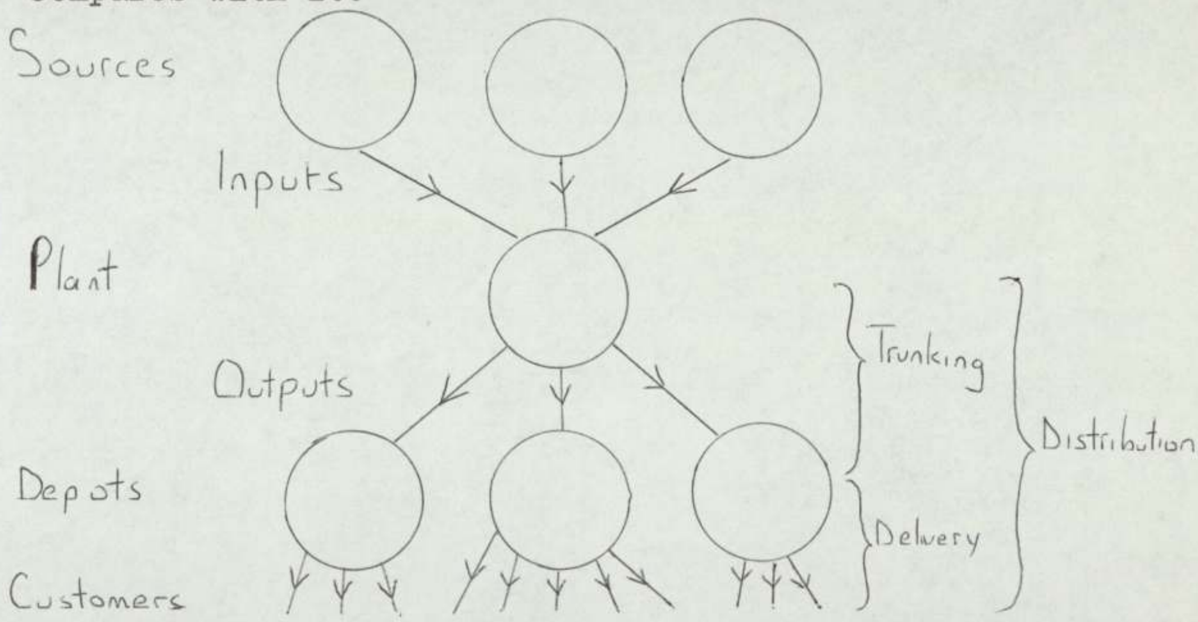


Fig 2.1 <u>A Logistics System</u>

The definition could be said to contain functions normally considered the realm of marketing and production management. Unfortunately this idea appears to have evolved from the concept of vertical separation of functions into manageable pieces. Basically marketing concerns itself with demand creation through advertising and design of the products based on research into the consumers' attitudes, distribution is concerned with satisfying this demand by delivering the products to the consumers. Production imparts form utility to products while distribution imparts time and place utility.

Therefore distribution is a real and positive contributor to the product vis-a-vis the consumer. Unfortunately distribution costs usually appear as overheads in company profit and loss statements and have given the impression of being something eating into gross profits to leave much reduced net profits. The view of them as an inevitable and burdensome expense is less than fair to distribution management and also fails to recognise the inherent potential within the distribution function to act as an aid to the marketing effort, and for cost reduction and profit improvement.

The one aspect of distribution which has probably received most attention from O.R. workers is vehicle scheduling and routing. Appendix I reviews not only the mathematical formulations but also the commercially available computer packages relating the vehicle routing.

Closely associated with vehicle routing is depot siting, although workers usually consider the two topics separately. Depot siting exercises have been reported since 1647 (2) and is consequently the older subject. It is intended to give very brief comments on depot siting as it did not form part of the research programme. As problems associated with distribution management show through in the approaches to the problem it was felt necessary to analyse the formulations.

There are basically two approaches to depot siting, the infinite set approach and the feasible set approach. The infinite set approach seeks to determine the optimum location of depots without any previous selection of a priori attractive sites. The feasible set approach seeks to determine the depot location from a set of possible sites and consequently the choice may not be the optimum. This latter approach is equivalent to a company selecting from its existing depots those to close.

The characteristics of the infinite set approach are

i) it is possible that the proposal will be infeasible

ii) it does not require that locations selected for analysis are a priori attractive

iii) alternative solutions are possible in multi-site selection problems

iv) it assumes that transport costs are a monotonic function of distance, i.e. the relationship between transport cost and distance is constant and unaffected by distance.

The characteristics of the feasible set approach are

i) it incorporates costs which are related to specific geographical locations

ii) it does not require that transport costs be any function of distance

iii) it requires a set of sites known to be feasible and for which all costs are available

iv) the set of feasible sites may not include the optimum location

v) the number of sites must be finite but not too large for computational efficiency.

The infinite set approach is the older of the two dating from the work of Weber (3) in 1909. However, the most widely known model is probably the mechanical analogue, or weight and strings method.

This method has been described by Burstall, Leaver and Sussams (4), Hepburn (5), Haley (6), and Shea (7). A map is pasted on to a table and holes drilled at demand point locations. Strings are passed through these holes and weights proportional to each locations demand are attached to the ends beneath the table, while the other ends are attached to a small ring. By moving the ring to one side and releasing it the weights will cause the ring to settle at the point of minimum potential energy, which is the position of minimum transport costs.

It is useful in single depot location problems, its main advantage being the visual impact of changes to customer demands. Because it cannot yield the costs of a particular solution it must be used in conjunction with a costing procedure. There are, however, more serious drawbacks, friction between the strings and holes can, with a large number of customers, lead to an indeterminate location, because town and country journeys cannot be considered, inaccuracies may also occur in selecting the depot unless the weights are adjusted to take account of this fact.

The numeric-analytic procedure of Miehle (8) is the mathematical equivalent of the above method. This method can be used with cost functions and it is also possible to incorporate different transport rates for different customers. A depot is chosen and the relevant cost parameters obtained. The depot location parameters are inserted into the cost model and new estimates of the depot location determined by partial differentiation. If this choice produces lower costs then its location is substituted for the original and the procedure repeated until no further improves are obtained.

Problems larely ignored by all workers concern depot fixed costs, the non-linearities of cost functions and the problem of constraints on depot sizes.

Branch and bound techniques have been applied by Efroymson and Ray (9) to the feasible set approach in an attempt to cater for the above problems. The lower bound was selected by ignoring the integer constraints and solving as a linear programme. Because a large number of linear problems needed solving the problem was reformulated in a simpler manner. This caused the number of customers served by each depot to be small in relation to its potential number and caused the amount of fixed charges absorbed by depots to be small.

It is possible that simulative approaches to the selection of depots, based on the feasible set, have been more widely used than is evident from the literature. One such approach for the H. J. Heinz Company in America is described by Schycon and Maffei (10). This model includes production capacities on the factory but has no constraints on depot sizes. It also assumes straight line distances rather than point to point cost. As with all models the validity of the result depends on the availability of accurate data and the capacity of the computer.

Regardless of the type of approach used by workers their efforts have been based either on simple cost models and complex optimising procedures or complex cost models in which the real world is expressed in as much detail as possible and fairly rudimentary heuristic minimization techniques. All programmes developed obviously refer to particular cases and consequently formal presentation of the formulations has not been made.

Very few of the papers discussed the role of the depot with regard to use as a forwarding function, bulk storage, or even a production function. The actual operations at depots, e.g. materials handling, are not discussed either. Despite the techniques available it has been recognised (11) that inevitably each location being a compromise, it being rare for a company to build at the optimum for planning or access problems.

One further complication of depot location is the uncertain demand patterns of customers and also the variability of customer locations through branch closures or, as in the case of Vono, a reduction in the outlets the company intends to serve.

Attempts at solutions have been made using standard total demand patterns by customer. This approach is hardly satisfactory in the majority of cases. If the size of an order is a random variable and the order itself time independent, then the problem is complicated beyond reasonable solution.

Recognition that distribution is being considered as a total system, in line with the definition at the beginning of this chapter, is becoming apparent mainly from published American work. Costs are beginning to be controlled by accountants on a cost centre approach, the cost centre being distribution in total, with the functions as transport warehousing, etc., as sub-centres. As yet there is no gross minimization procedure developed as the complex interrelationship of functions has not been fully documented.

Companies are reluctant to disclose details of their distribution operations although it is possible to draw some inferences from published work. J. Lyons & Co. Ltd. (12) have published detailed results of a compter versus a manual routing investigation performed at one of their depots. The computer system was rejected by the company as being too inflexible. For example late orders could not be built into a delivery route; the order of delivery in towns necessitates detailed knowledge of street conditions; time constraints and speed restrictions led to hold-over of orders; and on long journeys the drivers had a reluctance to accept strange routes.

The manual system selected was an improvement over their original system and is very similar to the system proposed by the author for Vono. Basically a large scale map was used with customers identified on it. As orders were received by the despatch office notes were made against each customer. Consequently the despatch clerks could see routes building up and work accordingly.

Certain companies, e.g. Dorothy Perkins Ltd. and Buxted Chicken Co. Ltd. run a vehicle scheduling programme to produce standard routes for a period of relatively stable demand. This use of sophisticate programmes appears to bear out the author's views in Appendix I. Vehicle routing is a very difficult area of computer applications, but the majority of sophistications offered by the computer software salesmen fail to approach the basic need of routing, flexibility.

Other companies, e.g. Schweppes, Cadbury Bros. Ltd. and J. Lyons & Co.Ltd., have investigated computerised techniques but selected manual alternatives. Reasons have ranged from programme rigidity to high fixed costs.

There is one oil company using its own version of vehicle routing based on a savings technique to schedule daily deliveries from a London depot.

It is noticeable from the literature that little research has been performed into the acceptability of computer developed routes to drivers. Programmers and systems analysts have, I feel, not fully understood the functioning of traffic office and despatch clerks, but have sought to overcome this by sophisticated routines involving for example waiting restrictions at individual delivery points.

One well publicised depot siting exercise, that of United Biscuits Ltd., indicated the compromises necessary in a distribution investigation. As part of a general rationalisation programme they spent 5 years analysing their depot operations. The country was divided into 5 mile squares, into which were inserted weekly deliveries based on sales forecasts, growth potentials and estimated population movement data. The majority of the time was spent collating data from work study investigations into loading, etc., and cost data on all aspects of the company's operations. It was interesting that analysis of the data was performed without computer programmes for depot siting. Although computerisation would obviously have reduced the calculation time development time and costs of a programme were considered to have been such that any benefits would have been minimal. This approach indicated yet again the individual nature of depot siting operations.

The overall view of physical distribution management is that little is known of the complex interactions between the differing managerial functions it comprises. There is not general acceptance that the definition at the beginning of this chapter is correct, managements generally regarding distribution as the management of a fleet of vehicles.

Attempts at depot siting are different in every case, although it is possible to catagorise them into the infinite set or feasible set approaches. Vehicle scheduling is probably the most sophisticated mathematically, of all distribution functions but evidence is that the use of computerised vehicle scheduling packages is much less than one would expect from a cursory review of literature.

However, the power of the computer comes into use in the preparation of analyses of sales by value per vehicle or regional sales, etc., to provide operational management with data concerning the distribution efficiency. Linking such analyses to inventory control and product allocation procedures will be special uses for each customer and consequently slow to develop.

The main problem with distribution management is that companies are not very willing to discuss their operational procedures and management responsibilities in detail and hence procedures may already be in use covering the whole field of physical distribution.

3. SALES AND SALES TERRITORIES PREVIEW

Duport Ltd. Domestic Products Division contains two companies, Vono Ltd., and Slumberland Ltd., which between them account for between 30%and 33% of the U.K. bedding market. Vono Ltd. also produces a range of upholstered furniture.

To provide a background to the distribution problems faced by Vono Ltd. in delivering nationally from a single factory it is necessary to examine the sales pattern by sales areas. Although it is acknowledged that Slumberland Ltd. is 4 to 5 times more powerful in the bedding market the relative strengths by sales areas are unknown.

An analysis of the cost of maintaining depots should assist in obtaining a clear picture of the value to the company of depots and the distribution philosophy of the company.

Vono sales areas do not coincide with the standard regions used by the Government information and statistical services. These sales areas also differ from Slumberland's and hence approximations must be used in making comparisons.

3. SALES AND SALES TERRITORIES

3.1 Introduction

Vono Ltd. is active in the Home Retail, Mail Order, Contract, and Export markets. During the research period Contract and Export market sales have been reduced as part of company policy.

Contract sales were primarily Government contracts on low profit margin beds, the intention being to utilise production facilities. Export sales have been replaced, to a large extent, by licensing agreements.

Only Home Retail and Contract sales are delivered by Vono contracted transport* and only the former are considered for this analysis.

Although Slumberland and Vono sales figures are compared the former are approximates by region although the total is actual. Slumberland sales areas are based more closely on Geographia marketing regions than Vono's. The latter are influenced to a large extent by the location of representatives' houses. Consequently Slumberland sales were estimated from sales to Geographia marketing regions but were not validated by Slumberland.

Diagram 3.1 illustrates the standard regions used for Government, statistical and economic planning purposes and has the Vono sales areas (of 1970) superimposed on it.

Since 1970 Vono Ltd. has modified its sales areas to such an extent that a comparison with Slumberland would take longer than the 4 to 6 weeks' work involved in the original analysis. During the two years Slumberland Ltd. has closed four small factories and Vono Ltd. has reduced its sales outlets from 9,000 to 6,000 and closed three depots. By February 1973 it is hoped to reduce this number to between 3,000 and 4,000. Vono Ltd. has also ceased production of a lot of metal products and concentrated more on upholstery. Because of these changes a direct comparison of present sales figures with 1970 figures would be of little significance.

Prior to September 1971 Vono Ltd. was operating depots at Attleborough (area M31), Bovey Tracey (S21), Belfast (S54), Glasgow (S51, S52, S53), London (bedding only for S25, S26, S27, S28) and Ynysybwl (M34). An agreement with Northern Warehouse Services, a P & O subsidiary, to service N47 from their Stanley depot was also operating. All depots carried limited stocks of bedding products to provide a better service than was possible from Tipton. Stock levels and policies were determined by the depot manager and the area sales representative, without reference to Tipton.

Customers within these areas were meant to order bedding and standard upholstery (mainly black penthouse chairs) from the depot although a preliminary analysis of loads indicated that ordering directly on Tipton was common. All orders for depot area customers were channelled through the relevant depots.

---

* For the purpose of the research contracted transport is defined as transport owned by persons who have a long term contract with Vehofreight Ltd. limiting the use of stated vehicles to delivering Vono products.

Appendices II and III are reports issued on the North East Depot and Ynysybwl Depot operations respectively. Both depots were badly managed from a control aspect and analysis of stock policies and levels and delivery service was difficult to perform.

During the research period the company has moved more toward promotional selling of its beds. Promotional offers are directed at the retailer and range from straight cash discounts to free gifts (e.g. a free Goblin Teasmade with every order for a particular bed). The company has also swung more effort to upholstery production and sales due in part to the higher contribution to general overheads per man hour of production.

3.2 Analysis

Table 3.1 explains the sales area code numbers and table 3.2 details the sales per area and per capita for Vono Ltd. and Slumberland Ltd. for 1970. Later sales figures were not available.

For completeness approximations other than those mentioned above were necessary:-

i) Vono sales value for M34 is the sales director's projection for the year based on 8 months accurate data. Actual sales figures issued by the sales department indicated no sales for 19 towns.

ii) Population figures for areas S25, S26, S27, S28 were obtained from London postal district figures. Vono sales areas do not coincide with the postal districts but as London is an atypical area the approximation was felt to be valid.

Table 3.3 indicates

i) the numbers of each bed sold in each sales region

ii) for each bed name the percentage sold in each region

iii) for each region the percentage of its sales accounted for by each bed.

For this table a bed unit has been defined as

$$\frac{ISM + DVN}{2}$$

Table 3.4 indicates similar points for upholstery sales; for convenience the upholstery range was broken into 5 groups based on price and type as

Group 1 Madeley settee and chair
Iverley settee and chair
Lynwood settee and chair
Wilton settee and chair

Group 2 Evesham fixed settee, sofa bed and chair
Waldorf fixed settee, sofa bed and chair
Suffolk fixed settee, sofa bed and chair
Chesterfield sofa bed
Windsor fixed settee and sofa bed
Frank Wardle settee and chairs
Saro settee
Viscount settee

Group 3 Penthouse settee and chair
Pentette chair
Pentagon settee and chair
Comfort chair
Galaxy chair
Petit Hog chair
Swinger chair
Teddy Bear chair

Group 4 Penzance studio couch
Plymouth studio couch
Studio
Swinger day bed

Group 5 Episode chair
Frank Wardle unit seating

3.3 Discussion

Distribution from a single delivery point to the whole of the U.K. is complicated by the nature of Vono's business. Dealing with national companies means that standard delivery forecasts are expected.

The product range produces loading problems as metal bed frames can damage expensive upholstered products if a load were to shift in transit.

As long as depots operate their stocking policies on an ad hoc basis firm control is unlikely. Part of the problem with depots is their sizes, the majority are small and cramped. The closures during the research period were based partly on the belief that, as orders were being placed directly on Tipton, a more efficient delivery service could be operated from Tipton. Also the company believed that depots were a symptom of poor distribution management; closing depots would not, however, improve the quality of management.

Reference to the Price List for 1970 highlighted problems other than maintaining a standard delivery performance. The Scottish market demanded cheap products although it is the farthest from Tipton. Operating costs for the Scottish depot are high and because of the difficulties of stacking upholstery in containers full use cannot be made of this cheaper mode of transport.

Cheap products mean low contributions to general overheads which, coupled with high delivery charges, should mean increased selling prices. However, increased prices only operate in the north of Scotland. Discussions with the company on regional prices were fruitless because the company's policy is to have a standard selling price for all products except in the north of Scotland. Apart from maintaining only one price list with the benefits in invoicing the company cited the fact that its major customers were national companies.

A fixed price leads to complications in fixing a carriage charge to build into the selling price. By law (The Purchase Tax Act 1963) all products must have a carriage charge built into the purchase tax calculating price and consequently for Vono these charges must be based on national average costs. Any analysis of the value of sales areas will, therefore, be complicated as the delivery costs for areas near Tipton or areas demanding expensive products will be masked by the overall averaging of delivery charges.

Table 3.2 will not coincide with tables 3.3 and 3.4 if the catalogue selling prices are used to arrive at sales turnover. Because of the promotional selling policy catalogue prices are inflated so that large discounts can be offered. The company will sell at the catalogue price if orders are received 'out of season'. There are also settlement discounts and even special discounts to important customers. Certain promotions are built round special beds to selected customers. This promotional selling policy does not apply to upholstery sales but these are distorted by the other forms of discounts.

The location of heavily discounted accounts will further complicate the demand pattern if only sales by value were used.

Data useful to the market research department of both Vono and Slumberland Ltd. can be obtained from the tables presented. The market research department of Vono Ltd. in 1970 concerned itself mainly with the collation and presentation of sales figures rather than background analysis.

Table 3.2 confirmed the belief that Slumberland was 4 to 5 times more powerful on average in the bedding market, although the ratio ranged from 10.5 to 0.53. Also the table indicated that per capita Vono's market was the 'Midlands', while total turnover considerations indicate that it was the South. Inter-firm co-operation on analysis of table 3.2 should be useful in planning sales strategies.

Because Vono sales management believed that Slumberland's delivery policy in the Birmingham area led to a large turnover an experimental delivery procedure was proposed. Deliveries were to be made in an area bounded by Wolverhampton, Sutton Coldfield, Coventry, Solihull, and Dudley, twice per day. Small vehicles leased by Vono with Vono drivers would be used to overcome low earnings problems with the contracted fleet. Although the monitoring procedures and delivery schedules were set up by the author the experiment never started. There was disagreement between Vehofreight and the sales department personnel.

Tables 3.3 and 3.4 should be of more use to Vono especially with regard to promotions. Definite regional tastes in both bedding and upholstery are indicated, the most significant fact being the Scottish market demand patterns. During 1971 each representative was being asked to devote an equal effort to the new range of upholstery, analysis of table 3.4 indicates that for Scottish representatives this will amount to a lot of wasted effort.

From table 3.3 and an analysis of orders to produce a size/tick analysis it should be possible to indicate which colours of beds are acceptable in the sales regions. The interesting fact on bedding was the high proportion of Clevedon, Chartwell and Arlington beds sold in the North.

One apparent weakness of the company in upholstery is the fact that 50% of sales by volume were Group 3 (shell) and of these 50% were to the South. Fortunately the company felt that shell furniture would be the new market leader and was developing other shell suites. However, it was still at risk because the shell range, until the new suites were introduced in 1972, comprised effectively two types of chair. The new range introduced in 1972 was well received although analysis similar to table 3 had not been performed.

One other interesting upholstery fact is that as one moves from the South to Scotland the ratio of chairs to settees in Group 2 (conventional), increases. Not only does it indicate a marketing trait, but also a distribution problem.

From the Price List one general point emerges. After discounts, etc., the prices of certain beds are within £2 of each other, indicating that the company could compete with itself in a state market. However, the marketing policy is to have certain beds on offer at different times to stimulate the consumer into buying and also to encourage the retailer to stock their products.

S54	Northern Ireland (depot)
S51	Scottish border Dumfermline Stirling Airdrie Wigtown
S52	Wigtown Ayr Renfrew Glasgow Scottish Isles
S53	Northern Scotland (all Scotland served from Glasgow depot)
N41	Lincoln Derby York Hull
N42	Cheshire (part) Manchester Staffordshire (very small part)
N43	Anglesey Caernarvon Denbigh Flint Cheshire (part)
N44	East Yorkshire York
N45	West Yorkshire Oldham Rochdale
N46	Cumberland Westmorland Lancashire
N47	(North East depot) Northumberland Durham Whitby

Table 3.1 Boundaries of Vono Sales Areas 1971

M31	(Attleborough depot) Norfolk Suffolk Colchester Nr. Cambridgeshire Peterborough
M32	Northampton Bedford Hertford Buckingham Cambridge Warwick
M33	Hereford Worcester Oxford Gloucester Wiltshire
M34	(Ynysybwl depot) Pembroke Carmarthen Glamorgan Monmouth Brecon Cardigan
M35	Lincoln Leicester Derby Warwick Burton-on-Trent
M36	Birmingham Dudley Walsall
M37	Montgomery Shropshire Stafford
S21	Bovey Tracey depot Devon Cornwall
S22	Somerset Dorset Wiltshire Southampton
S23	Berkshire Hampshire

Table 3.1 continued

S24	Sussex Kent Surrey (majority)
S25)	(London depot)
S26)	
S27)	Greater London High Wycombe Watford
S28	Essex

Table 3.1 continued

Table 3.2 Cash Invoice Value of Sales by Areas for 1970

Vono Bed (£)	Vono Total (£)	Slumberland (£)	TO / Vono pop (£/head)	TO / Slumb. pop (£/head)	TO / Vono bed pop (£/head)	Uph/Vono bed	Up/Tot. bed	Vono / Slumb.	Vono bed / Slumb.	Vono Total T.O. / Total pop. (£/head)	Vono Bed Total T.O. / Total pop. (£/head)	Vono Uph Total T.O. / Total pop. (£/head)
78,206	130,515	264,218	0.115	0.230	0.069	0.671	0.152	0.494	0.261			
89,224	137,592	368,571	0.058	0.157	0.038	0.545	0.106	0.372	0.242			
60,166	101,801	350,345	0.050	0.173	0.029	0.692	0.101	0.288	0.171			
40,949	87,409	367,805	0.035	0.148	0.016	1.136	0.113	0.238	0.112			
42,496	124,649	131,009	0.049	0.052	0.017	1.939	0.462	0.950	0.324			
32,620	78,677	23,558	0.033	0.010	0.014	1.411	0.820	3.350	1.390			
44,407	158,463	35,495	0.082	0.018	0.023	1.557	0.866	4.461	1.265			
47,890	119,962	25,913	0.039	0.008	0.016	1.305	0.848	4.600	1.875	0.049	0.024	0.025
60,504	95,262	223,333	0.064	0.150	0.040	0.574	0.122	0.428	0.261			
50,446	98,976	313,006	0.052	0.166	0.027	0.963	0.133	0.316	0.161			
69,653	103,385	221,461	0.073	0.155	0.048	0.484	0.116	0.468	0.315			
62,226	122,199	290,459	0.058	0.138	0.029	0.962	0.170	0.421	0.215			
69,579	119,557	211,382	0.049	0.086	0.029	0.719	0.249	0.568	0.329			
41,398	90,810	436,682	0.042	0.225	0.021	1.195	0.086	0.208	0.095			
56,082	86,535	72,382	0.053	0.045	0.034	0.552	0.236	1.189	0.770	0.054	0.031	0.024
73,636	117,373	Not available	0.052		0.032	0.594	-	-	-			
93,243	139,901	247,967	0.076	0.134	0.050	0.500	0.187	0.564	0.375			
88,295	131,525	56,030	0.052	0.022	0.035	0.490	0.300	0.234	0.157			
89,108	123,406	250,723	0.066	0.135	0.048	0.386	0.101	0.492	0.356			
71,274	102,317	213,382	0.044	0.095	0.032	0.486	0.109	0.481	0.335			
68,240	112,117	307,053	0.049	0.137	0.030	0.640	0.116	0.364	0.223			
98,531	150,478	353,362	0.056	0.132	0.033	0.527	0.115	0.428	0.280	0.038	0.019	0.018
57,875	97,498	123,260	0.065	0.076	0.036	0.685	0.218	0.791	0.467			
61,291	107,547	249,778	0.049	0.114	0.028	0.754	0.147	0.430	0.248			
48,265	77,660	Not available	0.057	-	0.036	0.611	-	-	-	0.055	0.032	0.022

lable

Table 33: Bedding Sales by Volume per Region
February–September, 1971

Bed Type	Region			
	South	Midlands	North	Scotland
Arran	1074 22.8% ① 6.6% ②	914 19.4% 7.7%	1658 35.2% 7.1%	1065 22.6% 12.3%
Supporta	95 21.4% 0.6%	65 14.7% 0.6%	136 30.7% 0.8%	147 33.2% 1.7%
Optima	243 30.0% 1.5%	190 23.4% 1.6%	205 25.2% 1.3%	175 21.6% 2.0%
Clevedon	172 17.4% 1.0%	133 13.6% 1.1%	542 54.7% 3.0%	140 14.1% 1.6%
Chartwell	240 25.0% 1.5%	174 18.1% 1.5%	435 45.1% 2.4%	112 11.7% 1.3%
Arlington	67 13.1% 0.4%	54 10.5% 0.5%	345 67.4% 1.9%	45 8.8% 0.5%
Meteor	2171 27.5% 13.4%	2097 26.6% 17.6%	2180 27.6% 12.0%	1446 18.3% 16.7%
Autumn Leaf	4001 29.6% 24.9%	3257 24.0% 27.6%	4441 32.8% 25.0%	1861 13.7% 21.4%
Saturn	543 34.9% 3.4%	320 20.6% 2.6%	541 34.9% 2.9%	154 9.9% 1.8%
Apollo	1033 35.5% 6.4%	832 28.6% 7.0%	820 28.1% 4.5%	212 7.7% 2.4%
Diana	2180 38.1% 13.5%	1298 22.6% 11.1%	1673 29.1% 9.2%	583 10.4% 6.7%
Jupiter	1157 37.2% 7.1%	791 26.1% 6.7%	909 30.0% 5.0%	177 5.9% 2.0%
Orion	1316 40.9% 8.1%	601 18.7% 5.1%	1157 36.0% 6.4%	156 4.9% 1.8%
No. 4	1870 22.1% 11.6%	1539 18.3% 13.9%	2601 31.0% 14.4%	2380 28.4% 27.6%

① ⟷

② ↕

Table 34: Upholstery Sales by Volume per Region
February-September 1971

Upholstery Type	Region			
	South	Midlands	North	Scotland
Group 1 Settee	1067 30.4% ① 9.1% ②	1028 19.4% 10.4%	1489 28.1% 13.0%	1169 22.1% 18.5%
Chair	1861 30.1% 10.5%	1066 17.2% 10.9%	1764 28.5% 15.4%	1493 24.2% 23.6%
Group 2 Sofa	1400 58.2% 7.9%	370 15.6% 3.8%	410 17.0% 3.6%	220 9.1% 3.5%
Fixed Settee	298 47.7% 1.7%	131 21.0% 1.3%	126 21.0% 1.1%	70 11.2% 1.1%
Chair	558 55.3% 3.1%	165 16.4% 1.7%	149 14.8% 1.3%	133 13.2% 2.1%
Group 3 Shell	9838 41.4% 55.5%	5626 23.6% 57.3%	6111 25.7% 53.4%	2214 9.3% 35.0%
Group 4 Studios	1225 31.5% 6.9%	933 24.0% 9.5%	999 25.7% 8.7%	730 18.8% 11.5%
Group 5 Unit Seating	928 44.3% 5.2%	487 23.3% 5.0%	389 18.6% 3.4%	289 13.8% 4.6%

① ↔

② ↕

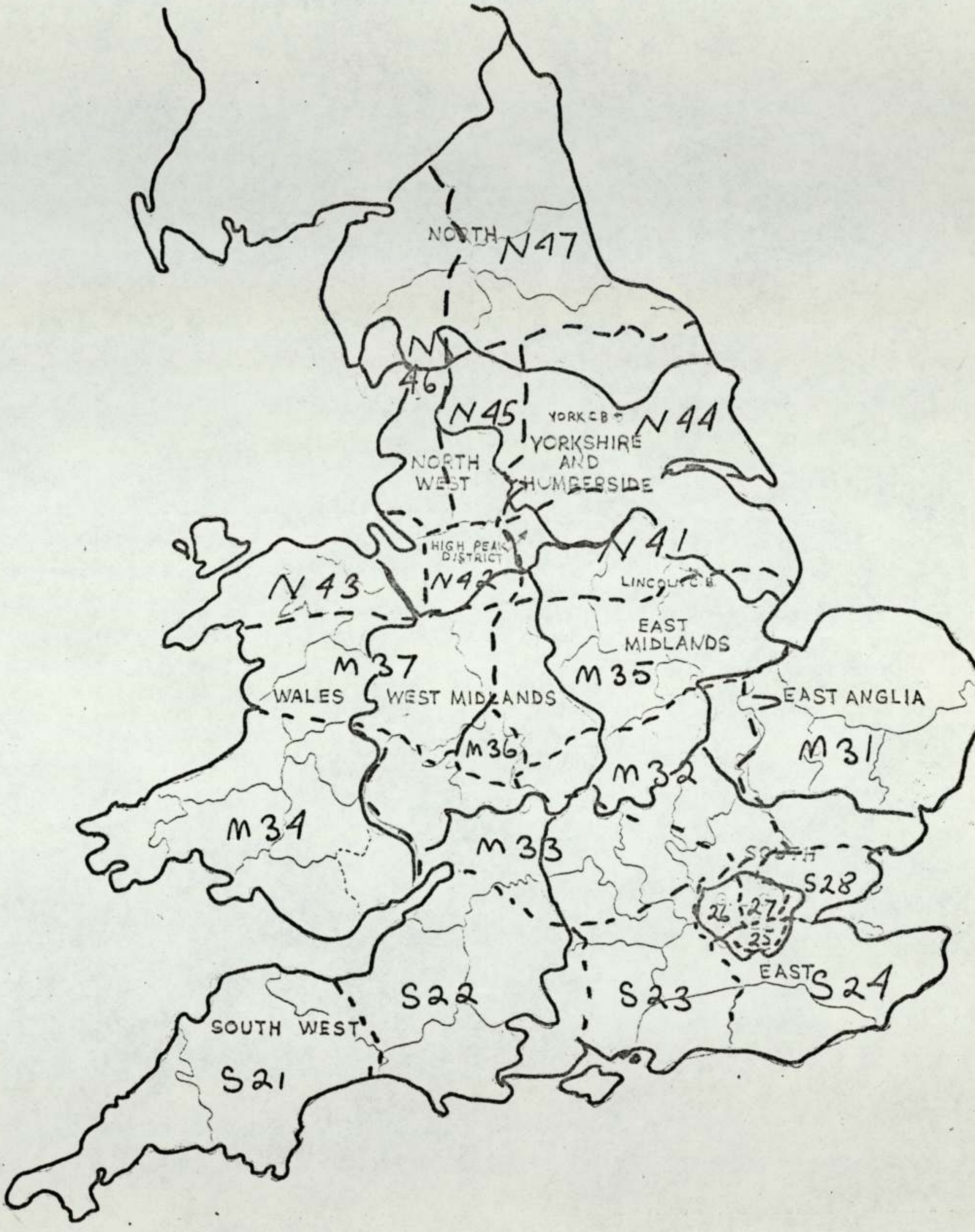


Diagram 3.1 Vono Sales Regions 1970
and Standard Regions

REVIEW

Sales demand data analysis confirmed the opinion that Slumberland was 4 to 5 times more powerful than Vono in the bedding market. However, the ratio varied between 10.5 in the Birmingham/Coventry/Wolverhampton area to 0.53 in parts of N.E. London.

Slumberland's main factory is in Birmingham and they provide a very good service in the area. It was not possible to analyse that company's operation but Vono considered that efficient and regular local deliveries were the main reason behind the sales figures.

Tables 3.3 and 3.4 indicated regional differences in demand which could lead to distribution problems. Sales areas in Scotland demanded cheaper less bulky products although the delivery costs were the highest. Table 3.1 indicates that these distant markets also had low sales revenue figures, consequently maintaining the same delivery service would mean less full van loads with subsequently higher delivery costs.

The wide spread of sales revenue figures across the sales areas also indicates the general problem of supplying nationally to a standard delivery forecast. As the largest customers are companies with branches throughout the country they expect consistent delivery forecasts.

Region tastes in both bedding and upholstery were firmly indicated although latest evidence (October 1972) indicates that the marketing policy regarding upholstery does not take this into account.

4. CUSTOMER SERVICE LEVELS: CRITERIA AND PERFORMANCE PREVIEW

The company defines good service as delivering on order within a delivery forecast specified at the time of order. In October 1970 the sales management claimed that 80% of all orders were delivered within forecast. However, the board of directors felt that this figure could be improved. An analysis of a sample of loads should clarify the service level performance of the company. Extending the analysis should also determine which factors in the service level performance can be directly attributed to physical distribution.

If the sales management claim is substantiated it would imply that, providing the orders were only just met, production was in phase with demand, stock recording was sufficiently accurate and route planning and vehicle scheduling were being performed with delivery forecasts in mind. If orders were met well under time it would indicate either pessimistic forecasts or excessive stock levels. If, however, it is not substantiated then factors attributable to physical distribution management will warrant analysis.

If the claim is substantiated but only just there is the possibility of deeper analysis into improvement vs. increased sales and also research into what customers actually expect.

Chapter 4 is a precis of the original report, Appendix IV, which was issued to the board of directors in March 1971.

4. CUSTOMER SERVICE LEVELS CRITERIA AND PERFORMANCE

The term "Service" is defined in the company as "meeting an order within a delivery forecast". The forecast is specific to each product and can change weekly.

Delivery forecasts have been issued by sales department and marketing department personnel based on experience and a knowledge of the ratio of order intake to forecast and also a knowledge of the stock position of each item. It will be shown that stocks of finished goods were not known accurately although raw material in the form of covers was closely followed. The service provided by the company and the value of depots as measured by the proportion of orders from their areas received as direct orders from customers were investigated (Appendix IV). The major finding was that the widely held belief that 80% of orders were met within delivery forecast was found to be invalid. Cumulative frequency distributions in the report indicate that slightly less than 50% of standard bedding orders were met within delivery forecast, for the 100 loads examined.

Analysis of Ynysybwl and Stanley depots, Appendices II, III and IV indicated that the depots were not functioning as sales points. This was possible because orders placed directly on Tipton were coded T before the order number. For Ynysybwl between May and October 1970 there were 1,796 orders delivered to Ynysybwl of which 1,521 were coded T. Detailed analysis of Stanley depot was more difficult as the depot is not owned or leased by Vono.

Stanley depot was originally operated by a transport contractor who delivered and stored Vono products in the North East. He had a monopoly of deliveries to the area which meant that his vehicles did not travel back from the Midlands empty. Being involved in general haulage in the North East also enabled him to deliver to customers, but Vono had no control over his operations.

This haulier sold his business to a P & O Liners subsidiary company who set the operation on a more formal basis. Analysis revealed that there was no stock control records of Vono products held by either the depot staff or Vono staff. Special beds for major customers were held in stock although that customer was ordering directly on Tipton. Approximately £3,400 of redundant stock was disposed of as a result of the investigation and tighter control was exercised over deliveries to the depot.

Ynysybwl depot was investigated because of its high mileage costs of vehicles. A comparison of the costs of running the depot as it was and delivering all products for South Wales directly from Tipton indicated that delivery from Tipton would be considerably cheaper. The savings were in the region of 25%. These savings were such that the Gross Profit derived from sales in the area could fall by 17½% before the break-even point was reached.

The marketing director repeated the author's analysis on Attleborough depot. Consequently Ynysybwl and Attleborough depots were closed and Stanley depot placed under close scrutiny.

The waiting time of completed loads was also investigated, this being defined as the time between the receipt of the latest item in a load and the loading date. Analysis showed that loads waited an average of two days in distribution before loading with 40% of loads waiting longer than four days. Some orders were noted to wait in excess of twenty days from allocation of loading.

The high incidence of NA (Not Available) and VF (Van Full) indicated deficiencies in the systems for stock recording and control and load building, and opportunities for improvement by research. It was also recommended that a system of pre-allocation* be investigated as a method of reducing stocks.

The problem as posed by the Financial Director was reformulated after this investigation to "proposals for more effective goods handling and distribution procedures."

It was hoped to repeat the service analysis towards the end of the research programme and to compare the new service levels with the major changes in personnel and sales effort.

During the early part of 1972 all green load copies of order sets were microfilmed and destroyed. Date stamping on receipt by distribution is now only performed on yellow order copies. These are filed in order number sequence which bears no relationship to load number sequence. Consequently a detailed analysis of time spent in various departments now involves a much more time consuming analysis.

---

* The allocation of products to orders before the products were produced.

Problems resulting from the micro-filming proceduring were encountered in other sections of the work, notably testing the theoretical transport cost model against actual. To arrive at the contents of 25 loads despatched one year ago cost the company approaching £50 in time and materials.

To overcome this problem one month's (February 1972) copies were collected after micro-filming and before destroy--ing. These were sorted into loads and 50 selected.

These were analysed for

i) delivery date - promise date

and ii) delivery date - order date

with the following results

Number orders:	502	:	260 of which were met within delivery promise date
Average orders per load:	11.5	:	(3 loads were metal underbars)
Bedding orders:	174	:	99 of which were loaded within delivery promise date
Upholstery orders:	328	:	161 of which were loaded within delivery promise date

Percentage figures are:

51.5% of all orders met within delivery promise date

57% of bedding orders met within delivery promise date

49% of upholstery orders met within delivery promise date

Upholstery orders were not analysed in the original report because delivery forecasts were not printed on the order sets and published data by the company at that time were not accurate.

The customers were promised delivery on bedding within 7 days in 1970. From the 1972 data only 14.9% of orders were met within this period compared with approximately 50% in 1970. It should be noted that delivery is now only offered within 21 days.

Distribution management have maintained the system of delivery within 6 days of allocation, consequently the apparent decline in service must result from reduced effectiveness of the administrative systems for processing orders and allocating stock.

Hence a serious decline in distribution effectiveness is indicated.

REVIEW

The claim that 80% of orders were met on time was not substantiated. Even in 1972, when the delivery forecast stood at 21 days as opposed to 7 days in 1970, service was less than 50% successful. Consequently the factors attributable to physical distribution management must be analysed.

Products found to be not available (NA) when required for loading, although having been allocated to an order, highlighted the stock recording problem. The incidence of van full (VF) occurring in the middle of loading sequences posed management control problems, which were outside the scope of the research. Alternative problems, also outside the scope of the research involved the motivation of a work force not directly controlled by Vono.

VF occurrences also indicated that the load building model, or its application, was faulty.

No record of service level performance was maintained anywhere in the company although computer printouts were available of lists of overdue orders. A thorough re-appraisal of the order processing and sales management functions was suggested if the company were to monitor this aspect of its business.

The work indicated the extent of the interaction between load building, inventory control and recording, and service level. Although the full implications of the total distribution concept was not appreciated by the middle management, the board used these early findings to tighten control in the sales administration and warehouse functions.

5. TRANSPORT OPERATIONS PREVIEW

A knowledge of the load building, vehicle routing and scheduling procedures is essential to understanding reasons for confusion in defining distribution management at Vono. These procedures will therefore be studied with the object of investigation rather than change.

VF and NA situations reported in chapter 4 highlighted certain areas of concern.

Agents took over the narrowly defined distribution management function in November 1970. Their fees are calculated according to miles travelled by vehicles with little incentive for mileage reductions. Consequently a comparison of Fees paid to them and the costs Vono could have expected to meet had their management remained in charge will be performed.

This comparison should indicate the overall cost to Vono to assist the company in deciding the long-term future of the distribution function.

5. TRANSPORT OPERATIONS

The method of load building, routing and allocating loads to vehicles has remained unchanged through managerial changes, depot closures and office system changes.

5.1 Load Building and Routing

Orders to which products have been allocated (allocated orders) are filed into broad delivery areas. It should be noted that these delivery areas do not correspond to the sales areas. Upholstery and bedding orders from No.1 factory were originally filed separately from those from No.2 factory but now the split is on broad delivery areas. Depot area orders and requisitions are filed separately. All orders are date stamped, on the reverse side, on receipt by the department.

The load building clerks check the files to build loads, according to the model below, which are then routed, bearing in mind early closing days.

Load Building Model

1 4'6" bed complete	= 2 units**	1 3' bed complete	= 1 unit
1 bunk bed	= 1½ units	1 stowaway	= ½ unit
1 settee	= 2 uph units**	1 chair	= 1 uph unit

60 units = van load (1750 cu ft)

40 uph units = van load (1750 cu ft)

mixed loads and smaller vans by experience

** These are load building units; the uph unit is applied only to upholstery products.

After completing the AP book* these loads with associated way bills are passed to the traffic office.

5.2 Allocating Loads to Vehicles

On arrival at the factory the drivers book in at the traffic office and then wait until their vehicles are to be loaded.

Loading is on a first come first served basis, drivers taking whatever the next load happens to be.

Exceptions to the rule are:-

i) loads to Belfast by container

ii) bedding loads to Glasgow by container

iii) Mail Order loads are either by NCL or Bullen's Transport vehicles

iv) loads to the North East are by Northern Warehouse Services Ltd.

Vehicles for the above are ordered by the traffic clerk when required.

5.3 Vehicle Utilisation

A report was prepared for the financial director of Vono Ltd. in October 1970 concerning the number and type of vehicles operated, types of licences, utilisation, and the method of calculating payments to vehicle owners.

Loads were allocated to vehicles observing first-in-first-out principles except for loads to the Stanley, near Newcastle-upon-Tyne, depot.

---

* AP book - a book containing all order numbers, the load number is entered against an order number to provide a quick answer to customer delivery queries.

There are 11 contractors under contract to operate from Tipton using open 'O' licences. A total of 58 pantechnicon vehicles were involved, 44 having 1,750 cu. ft. capacity bodies, and 14 having 1,500 cu. ft. capacity bodies.

Casual operators who were used almost exclusively accounted for 2 2,250 cu. ft., 1 1,850 cu. ft., and 2 1,750 cu. ft. vehicles.

Vono itself operated 3 1,750 cu. ft. and 3 1,500 cu. ft. vehicles from Tipton although only 5 were on the road at any one time.

Hence a total of 69 vehicles were employed in delivering products from Tipton.

At its depots Vono operated a total of 11 1,500 cu. ft. and 1 1,750 cu. ft. vehicles in addition to the 4 1,200 cu. ft. and 1 1,750 cu. ft. vehicles operated by a contractor from Vono's London depot. Delivery of Vono products from the Stanley depot was by Northern Warehouse Services vehicles and was in no way controlled or influenced by Tipton management.

For the month of September 1970 all contractors operated the vast majority of their vehicles all the time and an average of 702 miles per vehicle per week was recorded.

The average deliveries per load was 9.23 but discounting depot deliveries was 13.7, and the average number of loads per vehicle per week was 2.15.

Calculation of payments was based on miles recorded for each journey, or, if a local delivery on hours worked, or, for depot deliveries on a flat payment. No checks were made on the accuracy of mileage figures recorded by drivers. If no mileage were recorded by the driver then the road mileage between towns, taken from the A.A. Members Handbook plus 2 miles for each delivery over the first in a town was used. This calculation was performed by one of the traffic clerks.

Mileage, hourly, and depot delivery rates were negotiated annually between each contractor and the traffic manager.

After the change to Vehofreight mileage and hourly rates were agreed between Vehofreight and the contractors and then Vono and Vehofreight. From this date the contractors invoiced Vehofreight who then invoiced Vono.

A year later the average mileage per vehicle was only 575 miles per week, but this was confused by vehicles doing only one load per week. At this time, December 1971 to February 1972, there was conflict between Vehofreight personnel and the contractors and also a shortage of drivers. A system of monitoring all vehicles to regularly report on vehicle utilisation was installed in February 1972, the details are given in chapter 10.

5.4 Office Procedure

After studying the office procedure and the inter-action of D. W. Wilson Ltd. with Vono Ltd. paperwork systems and personnel, it became apparent that improvements could be made.

As the functions of the department had never been clarified the following were proposed as necessary functions of the despatch department in Vono Ltd., and were accepted by the management.

i) to receive allocated orders

ii) to despatch such orders as efficiently routed loads

iii) to prepare invoice copies of order sets for processing prior to charging by other departments

iv) to maintain a file of orders loaded and journey waybills to answer delivery queries

v) to deal with invoices from D. W. Wilson Ltd. to Vono Ltd. for the delivery of orders

vi) to prepare statistics meaningful to the efficent operation of the distribution system, table 5.2

The proposals were implemented in May 1971.

The clerical procedures were dealt with in detail but it is not possible to indicate any decrease in the time between allocation and loading. As discussed elsewhere orders can wait over six days in the department before loading because of insufficient orders for delivery to a specific area.

One clerk was found to be counting all pieces of bedding, chairs and settees from the order sets and issuing a weekly total of products loaded. The managers who received this information had had no use for it for well over six months. This time consuming task was stopped but it had highlighted yet again the lack of interdepartmental co-operation within the company.

By re-allocating the agreed functions between the staff it was possible to perform them and others considered to be part of the department's responsibility (e.g. wage calculations for warehouse staff) with one less person, i.e. nine instead of ten.

Throughout the research help at a low level has been found to be more successful in initiating change than presentations of theoretical concepts to the directors. This can best be illustrated by the clerks responsible for checking Vehofreight Ltd. invoices.

No tables of miles and cost or hours and cost were provided although an adding machine was available. As the mileage rate was 18p, 18 additions per mileage claim were needed. The hourly rate was £1.75 and hence the number of additions depended on the claim.

A computer programme was written which simply printed out the mileage and cost and hours and cost. Whenever rates change the relevant card is altered. This was well accepted by the clerks and management.

One problem not foreseen at this stage was the errors in mileages claimed by D. W. Wilson Ltd. personnel. Later work reported in chapters 10 and 12 indicated the extent of these errors and resulted in modifications to the distribution department's functions.

5.5 <u>Management Changes</u>

Until November 1970 there was a distribution manager and a transport manager, the former being the more senior and reporting directly to the managing director.

The distribution manager concerned himself mainly with the warehouse while the transport manager dealt with the vehicle owners.

In August 1970 the Board of Directors of Vono Ltd. changed; one of the first decisions of this new board was to bring in a firm, D. W. Wilson Ltd., later Vehofreight Ltd., to handle all aspect of distribution. This was to give the new board time to fully appraise the production and product range problems with the knowledge that distribution would not be disrupted. This firm would charge Vono Ltd. X pence per mile travelled, and pay the contractors A pence per mile, where $X > A$. Effectively therefore they were to be paid a fee per mile travelled although they would own no vehicles themselves. They would also be provided with office space within Vono Ltd. and would receive an extra fee for warehousing and distribution office expertise.

All distribution office procedures remained as before this change until the re-organisation mentioned above.

March 1971 saw the appointment of the marketing director as the director responsible for distribution although the agents (Vehofreight) continually dealt with the managing director. The marketing director resigned in September 1971.

5.6 Distribution Costs

The Distribution Department maintained costs of all Vono leased vehicles while the Accounts Department had records of amounts paid to contractors. Other costs including warehouse and office staff, and depot expenses were also available.

Appendix VII is an attempt at comparing the charges by Vehofreight Ltd. with the costs Vono Ltd. could have expected to pay had the previous management been in control. The differences over 4 months was £7,000 giving an expected cost to Vono of £21,000 per year, assuming a 5% reduction in miles travelled an extra saving would be £14,000 giving £35,000 per year. This figure was acceptable to the Vono board and it is considered insurance against problems in the distribution area.

	Nov.70-Mar.71 Vono to Vehofreight	Nov.70-Mar.71 Vehofreight to Contractors	Mar.71-Dec.71 Vono to Vehofreight	Mar.71-Dec.71 Vehofreight to Contractors	Dec.71-Dec.72 Vono to Vehofreight	Dec.71-Dec.72 Vehofreight to Contractors
	A1	B1	A2	B2	A3	B3
1750 cu ft van/mile	100	100	106	100	112	106
1500 cu ft van/mile	100	100	113	100	120	106
Attleborough						
1750 cu ft van	100	100	104	108	Depot Closed	
1500 cu ft van	100	100	108	114		
Belfast	100	100	Depot Closed			
Bovey Tracey						
1750 cu ft van	100	100	103	103	103	103
1500 cu ft van	100	100	113	114	113	114
London						
1750 cu ft van	100	100	105	105	105	105
1500 cu ft van	100	100	107	104	107	104
Glasgow						
1750 cu ft van	100	100	103	101	103	101
1500 cu ft van	100	100	106	101	106	101
Freightliner	100	100	100	103	100	103
Ynysybwl						
1750 cu ft van	100	100	106	104	Depot Closed	
1500 cu ft van	100	100	115	101		

Table 5.1 Transport Rates

The actual rates paid have been reduced to indices.

It must not be assumed that index A1 = index B1.

During February 1971 the monetary system of the country changed and hence the rates payable were modified accordingly. However, the rate payable by Vono to Vehofreight increased by 6% after only three months operation.

Table 5.1 illustrates the rates paid to Vehofreight and the rates paid to the contractors from November 1970 to December 1972.

For the year ending February 1972 the total transport costs, made up of monies paid to Vehofreight for the delivery of products, represented 57% of the total distribution bill. Of this 57% approximately 9% was Vehofreight fees, as table 1.1.

Depot rents and an assumed rent for the Tipton warehouse, all rates, heating and lighting represented approximately 18%.

Consequently Vono management were able to exert control over 25% of the total distribution bill, Vehofreight management were able to exert control over 57% and 18% was accounted for by fixed expenses.

Table 5.2 Statistics required by Distribution Management

February	Contractor Reference												
	A	B	C	D	E	F	G	H	I	J	K	L	M
Vehicles Total	2	2	9	2	12	4	11	4	13	4	2	11	5
Op. All Period	2	1	1	2	9	1	5	3	7	2	0	5	2
Total Loads in month	18	16	39	14	83	19	65	34	62	22	4	55	29
Av. loads/week per vehicle	2.25	2.25	1.8	1.75	2	1.75	2	2.33	1.3	1.5	2	1.8	2
Range of loads/week	2.25	$2\frac{1}{3}-2\frac{1}{4}$	$1-2\frac{1}{4}$	1.75	$1\frac{1}{2}-2\frac{1}{2}$	$1\frac{1}{3}-2\frac{1}{4}$	$1-2\frac{1}{2}$	2-3	$1-2\frac{1}{4}$	$1\frac{2}{5}-1\frac{3}{4}$	2	$1\frac{2}{3}-2\frac{1}{4}$	2
Av. drops/load incl. Depots	9.2	9.9	10.3	9	7.5	9.15	7.7	5.3	7.85	9.5	7.25	11	10.5
Av. drops/load excl. Depots	15.3	13	12.9	13.5	11	12	11.7	6.15	11.4	13.5	9.3	15.2	13.6
Depot loads (+ single drops)	7	4	11	5	26	5	25	5	21	7	1	14	8
Vehofreight Payments 1) Total £	872	775	1786	910	3907	1035	3144	1743	2789	1114	162	4148	1223
2) £/veh/week (if assume all vehicles all time)	109	97	47	114	81	64	71	105	55	140	20	93	62

REVIEW

The load building and vehicle routing and scheduling procedures were considered by the company as separate from the allocation of products to orders and from the inventory control procedures.

Briefly allocated orders were filed into broad delivery areas, depot deliveries being filed separately, these files were regularly checked to determine whether a van load, according to a load building model, could be formed. Once loads were formed they were routed.

Loads were allocated to vehicles on a first-in-first-out basis and scheduling of each driver's work load per week was not performed.

Having 4 sizes of vehicles operating from Tipton indicated one reason for the incidence of VF situations because only one load building model was used.

The clerical procedures for filing orders and dealing with data for distribution were modified with the result that a 10% reduction in the work force was achieved. Lack of management co-operation was evident during this analysis.

A computer programme was written to provide clerks responsible for checking Vehofreight invoices with a printout of mileage and hourly costs. These clerks previously had an adding machine only which led to tedious checking of mileage claims.

This emphasised the fact that checking whether the mileage claim was reasonable for a particular load was not performed. In thelight of evidence that Vono could expect to run the transport operations for £35,000 per year less this appeared a serious omission. Chapter 10 indicates the management information system regarding vehicle monitoring, one result of which was close scrutiny of all mileage claims.

6. ALTERNATIVE FORMS OF TRANSPORT PREVIEW

Vono Ltd. were using rigid chassis vehicles with box bodies to deliver their products throughout Great Britain, deliveries to the docks for export being on flat vehicles.

Following the concept of the project in terms of the definition of physical distribution management offered in the introduction it is appropriate to compare the costs of operating alternative forms of transport with the existing cost. Vono's requirements of a distribution fleet will play an important part in the comparison and will therefore be discussed, bearing in mind constraints imposed by the existing depot sizes.

The objective will be to reduce the transport bill without adversely affecting the operations of the fleet.

Only alternatives considered feasible after preliminary considerations will be evaluated, as for example hundreds of small vehicles delivering to one or two customers each may improve service but the cost would be prohibitive.

6. ALTERNATIVE FORMS OF TRANSPORT

In deciding what type of transport is best suited for a distribution system one is ultimately concerned with relative operating costs.

However, any comparison must be concerned with the type of transport suitable for the task. This type must then be fully analysed.

There are two types of operation to consider for Vono Ltd.

i) composite deliveries to depots - not bulk movement in the conventional sense but a mix of a multitude of small items. This arises partly because depots are small and do not carry a comprehensive stock and do not use inventory control and forecasting techniques, partly because upholstery products are not carried as stock, hence inidividual pieces are ordered and partly because customers within a depot area order directly from Tipton.

ii) High Street deliveries - a complex mix of small orders loaded in reverse delivery order.

Products for the Home Retail Market are distributed by rigid chassis vehicles and Freightliner (to Glasgow) while Mail Order products are distributed by National Carriers Ltd.

6.1 Freightliners Ltd. Containers

Table 6.1 illustrates the charges of Freightliners Ltd. for delivery to those depots which Vono Ltd. was operating in December 1970 compared with the charges of Vehofreight Ltd. Based on this analysis and the volume of business at the time it was shown that a 16% increase in business volume would have been accommodated with the existing fleet size by using Freightliner containers to deliver to all depots at no extra charge. Vehicles under contract have a 700 miles/week guaranteed minimum payment and could therefore be expensive if business declined, whereas Freightliner containers are sent only on demand. Unfortunately, it is not possible to stack upholstery more than one high without the provision of special racking, which does not form part of the contract with Freightliner Ltd. The responsibility for design and supply of special racking rests with the user.

As an illustration, the racking in the present fleet costs in excess of £100 per van. For Freightliner containers the racking must be removable otherwise the company would be charged for bringing the container back from a destination to Tipton, effectively doubling the transport costs. Alternatively, the racks could be stockpiled at depots and be brought back by vans.

Doubts were expressed regarding the service provided by Freightliners Ltd. but a 24 hour delivery service to depots was guaranteed by their representatives. Bovey Tracey was the major cause of these doubts as the nearest Freightliner terminal is at Avonmouth, delivery onward would then be by road.

To make full use of containers the 30 feet long one would be needed. Unfortunately London depot can only accept 24 feet long vehicles. Attleborough and Ynysybwl depots were also too small to accept large vehicles while Bovey Tracey could accept them but not easily. Northern Warehouse Service Ltd. refused to act as Vono's North East Depot if they could not backload from Tipton. The operations of this depot were deeply analysed in September 1971 (Appendix II) but since then the situation has deteriorated.

As Freightliners Ltd. only deal with deliveries to one point they were not considered for High Street deliveries.

The outcome of the analysis was that Freightliners Ltd. began delivering the majority of bedding orders to Glasgow depot. As Vono Ltd. must deal through Vehofreight Ltd. the charge per container was £67 instead of £55.50.

6.2 National Carriers Ltd.

Mail Order products are delivered by National Carriers Ltd. directly to individuals in Great Britain at a cost borne by the mail order companies. Table 6.2 is a copy of their charges as of July 1971. Delivery service has been found to be worse than van deliveries, mail order companies allowing 14 days for delivery from the date of despatch from Tipton. Delivery dates quoted by N.C.L. representatives were in the order of one week. One benefit of the service is that orders would not have to form loads but could be despatched immediately they were allocated.

On the face of it N.C.L. rates are complicated, depending on weight (minimum 28 lbs.) and destination distance from a given N.C.L. despatching depot. No doubt the company could arrive at an arrangement with N.C.L. if all deliveries were handled by them as has one furniture and household mail order concern. The charges in Table 6.3 would have to be increased for Vono Ltd. as its products are bulky and come within the 100% surcharge range. Based on the Evesham settee, 40 cu.ft., approximately 160 lbs., the density would be 560 cu.ft. per ton. At this time the company was concerned about the amount of damage caused by N.C.L. Strict packaging requirements would also have added a minimum of 50p to each product. Analysis of the service provided by the company (Appendix III) indicated that the majority of orders were loaded within 8 days of allocation and hence the company saw no particular service advantage using N.C.L.

It is almost impossible in a fragmented market to determine the increase in sales due to decreased delivery times if this is associated with increased damage claims.

Therefore, because

i) the charges, before applying the bulky item clause, were higher than existing carriage allowances

ii) the selling prices would need to increase to cover cost of packaging

iii) the amount of damage experienced was high

iv) service improvements were doubtful

it was decided to proceed no further with N.C.L. carriage investigations.

6.3 <u>Articulated vehicles</u>

One alternative to the present van fleet was to change to articulated vehicles. Vono's products are bulky and on a pure weight basis do not call for the increased loading weights possible with articulated vehicles. Without weight considerations equivalent carrying capacity can be obtained more cheaply on a rigid chassis (rigids).

From a loading/off-loading point of view an articulated vehicle would be the same as a van. Bulk deliveries to depots suffer from the depot size constraints mentioned in the Freightliners Ltd. discussion. High Street deliveries would be possible with articulated vehicles but difficulties could be experienced as there is a limit to the size of vehicle acceptable in large and small towns because of the need to sometimes double park to deliver or to manoeuvre into small loading bays better suited to small local delivery vehicles. Vehicles with the same overall length as the existing rigids could offer benefits in turn round times but the carrying capacity would be reduced while running costs would be increased.

The company decided that further analysis would be of little value in the light of evidence of reduced costs resulting from demountable body vehicles.

6.4 Demountable body vehicles

Demountable body vehicles offer the advantages of better time utilisation and a constant work level at the loading bay offered by articulated vehicles combined with the running and maintenance costs of rigid chassis vehicles.

Appendix VIII is the report submitted on the theoretical costing of demountables for Vono operations. It was shown that running costs/mile would be the same as for rigids but that fixed costs per mile would be approximately 2p/mile less while providing the operator with an equivalent profit per vehicle.

The analysis was based on reducing the number of vehicles, reducing turn round times at Tipton, providing incentives for drivers to return late in the day and improving the warehousing functions to meet these transport improvements.

Demountable body vehicles are now being phased in for all Vono work but unfortunately with less than whole-hearted support from Vehofreight personnel.

6.5 General

Services offered by many companies involving leasing of their vehicles instead of buying one's own were not considered. The majority of these schemes involve the company (in this case Vono Ltd.) employing drivers and leasing vehicles.

Vono Ltd. has no capital tied up in transport and has no transport drivers' wages except at one depot. Hence the main selling point of these services, that of releasing tied up capital, does not apply to Vono.

Depot	Freightliners *		Vehofreight	
	£/container	£/cu ft	£/van	£/cu ft
Attleborough	64.00	0.2256	60.50	0.243
Bovey Tracey	76.50	0.306	73.20	0.293
Glasgow	55.50	0.220	.75	0.300
London	35.25	0.141	54.00	0.180
North East	39.25	0.157	charge now includes warehousing and delivery, well in excess of Freightliners.	
Ynysybwl	45.25	0.181	42.50	0.170

* reductions up to £4 per container are possible if 5 per day average are used to one destination

Table 6.1 Freightliners Ltd. charges compared with Vehofreight charges for loads to depots

Table 6.2 N.C.L. charges

Weight c.	q.	lb.	Codes 1 £	2 £	3 £	4 £	5 £	6 £	7 £	8 £	9 £	10 £	11 £	12 £	13 £	14 £	15 £
	1	0	0·47	0·55	0·60	0·63	0·67	0·75	0·77	0·80	0·83	0·85	0·87	0·87	0·90	0·90	0·95
	1	14	0·55	0·63	0·65	0·73	0·77	0·83	0·85	0·87	0·90	0·97	1·00	1·03	1·07	1·10	1·17
	2	0	0·60	0·67	0·73	0·80	0·85	0·95	0·97	1·00	1·05	1·07	1·15	1·17	1·25	1·27	1·35
	2	14	0·65	0·77	0·80	0·90	0·97	1·03	1·05	1·10	1·17	1·23	1·27	1·35	1·43	1·47	1·50
	3	0	0·73	0·83	0·87	1·00	1·05	1·10	1·17	1·23	1·30	1·37	1·43	1·50	1·60	1·65	1·75
	3	14	0·77	0·90	0·97	1·07	1·15	1·23	1·27	1·35	1·43	1·50	1·60	1·70	1·77	1·85	1·95
1	0	0	0·83	0·97	1·05	1·17	1·23	1·35	1·40	1·47	1·57	1·65	1·77	1·87	1·97	2·05	2·15
1	1	0	0·95	1·07	1·23	1·35	1·43	1·57	1·63	1·77	1·87	2·00	2·15	2·23	2·30	2·45	2·53
1	2	0	1·05	1·20	1·40	1·55	1·65	1·80	1·87	2·03	2·17	2·30	2·47	2·60	2·67	2·85	2·97
1	3	0	1·17	1·30	1·57	1·70	1·87	2·03	2·15	2·27	2·47	2·63	2·85	2·93	3·07	3·23	3·40
2	0	0	1·27	1·47	1·75	1·90	2·07	2·25	2·37	2·53	2·73	2·93	3·17	3·30	3·45	3·60	3·73
2	2	0	1·60	1·83	2·05	2·27	2·47	2·77	2·87	3·05	3·30	3·53	3·75	3·93	4·10	4·33	4·45
3	0	0	1·95	2·17	2·45	2·67	2·93	3·25	3·43	3·63	3·87	4·10	4·40	4·67	4·85	5·07	5·37
3	2	0	2·10	2·37	2·67	2·93	3·20	3·53	3·73	3·90	4·20	4·45	4·73	5·03	5·27	5·53	5·87
4	0	0	2·30	2·60	2·93	3·23	3·50	3·85	4·07	4·23	4·60	4·90	5·17	5·50	5·83	6·13	6·47
4	2	0	2·53	2·83	3·23	3·60	3·83	4·20	4·45	4·63	5·07	5·37	5·73	6·05	6·47	6·77	7·13
5	0	0	2·77	3·10	3·53	3·95	4·13	4·50	4·85	5·07	5·55	5·87	6·27	6·67	7·07	7·40	7·80
6	0	0	3·00	3·40	3·90	4·27	4·47	4·87	5·23	5·63	6·03	6·37	6·80	7·20	7·60	8·03	8·37
7	0	0	3·27	3·70	4·23	4·60	4·83	5·30	5·67	6·10	6·55	6·95	7·45	7·85	8·20	8·70	9·07
8	0	0	3·53	4·00	4·50	4·90	5·15	5·75	6·07	6·57	7·00	7·50	8·03	8·43	8·80	9·40	9·93
9	0	0	3·75	4·25	4·75	5·23	5·50	6·15	6·47	7·00	7·40	8·03	8·53	8·95	9·40	9·97	10·50
10	0	0	4·00	4·47	5·07	5·53	5·87	6·50	6·85	7·40	7·87	8·50	9·03	9·50	9·95	10·45	11·07
12	2	0	4·55	5·13	5·75	6·30	6·75	7·45	7·87	8·50	9·13	9·73	10·33	10·93	11·60	12·15	12·80
15	0	0	5·17	5·87	6·53	7·15	7·85	8·57	9·03	9·77	10·57	11·25	11·95	12·70	13·40	14·20	14·83
17	2	0	5·75	6·37	7·27	7·90	8·75	9·55	10·10	10·95	11·77	12·65	13·40	14·33	15·05	15·85	16·63
20	0	0	6·15	6·85	7·90	8·53	9·45	10·33	10·95	11·87	12·80	13·97	14·53	15·75	16·33	17·23	18·07

Notes

1. Charges are increased by—
   10% for vulnerable traffics such as wines and spirits, tobacco, etc.
   50% for bulky articles (150 to 450 cubic feet per ton).
   100% for bulky articles (450 to 1,000 cubic feet per ton).
   Articles over 12 feet in length may be subject to special charging.
2. The rates are based on the total weight of each consignment (minimum 28 lbs.).
3. The charges apply to all traders who have credit facilities with National Carriers Limited.
4. Rates include collection and delivery.

June 1971

REVIEW

The analysis indicated that for the alternatives considered demountable body vehicles could result in a lower transport bill for Vono Ltd. Based on increased mileage per vehicle per week and consequently fewer vehicles, the cost per mile was calculated as 10% lower than the present cost. This saving is the entry in table 1.2 of the Introduction of approximately 9% of the total transport bill.

Demountable body vehicles are being phased in at present. Unfortunately problems with vehicle monitoring and the supply of a slave unit and the provision of a vehicle park for the demounted boxes mean that the savings envisaged in Appendix VII are not yet being realised. Although the units are being phased in there appears to be less than whole hearted support from Vehofreight personnel.

Indications are that once these problems are resolved savings will become apparent. Drivers are already picking up boxes at 5.30 a.m. to miss the rush hour traffic. This aspect, the incentive to drivers, was unquantifiable in the analysis but appears to be an important factor.

7. WAREHOUSE SITES AND LAYOUTS PREVIEW

NA situations reported in chapter 4 highlighted apparent stock recording problems. An alternative problem could be that products were not found by the loaders in the warehouse. This would imply inefficient stock location plans or motivational problems facing the warehouse management.

Preliminary observations indicated that stock location was not planned and could contribute to NA situations. The warehouse layout will therefore be analysed to determine whether a more logical layout can be obtained.

While the above would be a short term measure the amalgamation of the two factories into the larger one would have long-term effects on the warehousing function. Although upholstery is generally made to order, finished products were held an average of 4 days, see chapter 4, between production and despatch.

The sites available for the warehouse were different areas within the Tipton factory, which together with manning levels and operations procedures will be analysed to produce detailed recommendations for consideration by the board.

The following chapter is a précis of the report issued to the board of directors.

7. WAREHOUSE SITES AND LAYOUTS

7.1 Introduction

There were two finished stock warehouses operated by Vono Ltd., one at the main factory which handled bedding and non-shell upholstery and one at the shell upholstery factory. The main warehouse also housed the Export warehouse, Mail Order warehouse, repairs and returns section and also part of the raw materials store of wooden upholstery frames.

The shell upholstery warehouse was basically a section of the production area of that factory and could vary in size at will. All production therefore flowed to it without the need for trucks, etc. No entry point was used, therefore stock recording was based on production and despatch figures.

In the main factory products entered the warehouse from production areas on truck trains which visited storage locations to deposit the relevant products.

Stock recording was not accurate as chapter 4 indicated.

7.2 Mail Order Modifications

Diagram 7.1 illustrates the relative positions of the Mail Order function and repair and returns function as of September 1970.

The average number of Mail Order loads per day over a 6 week period (September to November 1970) was 6. The average daily output per loading bay was also 6. Hence by locating the Mail Order function at the rear of the warehouse and modifying the rear loading bays extra Home Retail orders could be despatched. With the assistance of a consultant civil engineer a report was produced indicating that for an outlay of less than £550 and the salaries of 2 men, approximately £4,000 gross per year, a 16% increase in productivity could be obtained (providing that orders continued to arrive at the same rate).

To achieve a 16% increase in productivity by other means, i.e. employing one extra gang, would cost approximately £6,000 gross per year.

These figures were assuming that the level of output at the time was efficient.

7.3 Stock Layouts

As a result of other work (Appendix VII) and observations an ordered stock layout was considered.

Records are available of stock locations at 21.10.71 and also layouts suggested to the management.

The approach was simply to locate high visitation areas near the loading bays. Sales by volume were analysed to give the classification by bed name. Storage space (i.e. numbers of bins) was allocated proportional to each bed's sales fraction.

The system had a further benefit in that it was possible to monitor (roughly) the stocks of all bedding items.

If each location were full of the correct bed then there was 2 weeks stock of each item according to the average sales forecast for the next 3 months (as issued in September 1971).

7.4 Alternative Warehouse Sites and Systems

Diagram 7.2 illustrates the factory site at Tipton, the warehouse at present being situated in unit 3. The only alternative site within the factory was unit 2, as unit 1 contains the wire and bedding production functions. Equipment in this unit would be expensive to move and as the unit was established and the company building in-process storage areas on the roof above it, it was considered fixed.

The analysis was essentially a two-stage process.

Stage 1 involved analysing alternative procedures for moving finished goods to the warehouse areas and storing as at present.

Stage 2 involved a detailed analysis of the board's decision.

Modified administration procedures were applied to both manual and mechanical movement systems.

7.4.1 Analysis

Factory 2 would move into factory 1 and therefore its storage and production area requirements would have to be met. Production department personnel were able to indicate that upholstery production could be performed in either unit 2 or 3 with little difference in efficiency.

Export packing would no longer be required as it would be contracted out, baling of beds would be performed in the production area and as Mail Order products would tend to be standard lines more, there would be no need to allocate space for these functions in the warehouse.

The approach was to consider the alternative sites operating at present and with a modified administration system. The alternatives considered were:-

i) existing warehouse and existing administration system

ii) existing warehouse and different administration system

iii) unit 2 warehouse and existing administration system

a. unit 2 warehouse and existing administration system using existing loading bays plus new racks and stacker trucks

b. unit 2 warehouse and existing administration system using new loading bays

c. unit 2 warehouse and existing administration using new loading bays plus new racks and stacker trucks.

iv) unit 2 warehouse and different administration system using existing loading bays

a. unit 2 warehouse and different administration system using existing loading bays plus new racks and stacker trucks.

At this stage modified stocking policies were not formulated. As there was little rationale to the existing system it was believed that any policy involving production and or warehousing discipline would reduce the space requirements rather than increase it.

For this reason storage requirements were based on the present floor area requirements for each group of products. Although the area of unit 2 is less than unit 3 reductions on Export requirements meant that the area was sufficient. Also the height of unit 2 provides for an extra storage layer.

The different administration system involves mechanical movement of the loaded trucks from the storage point to the loading bay. Associated with this are modifications to the labour force. The pickers form a mobile labour force who can change from bedding to upholstery as the work load demands and who would no longer service just one loading gang.

Warehouse supervision would become more important in controlling the work load of everyone associated with distribution.

Manpower requirements for the proposed system were obtained from theoretical considerations and consequently could be under-estimated, or over-estimated.

Costs for all the alternatives were based on:-

i) £2,000 overall costs per man per year

ii) actual costs for one type of mechanical movement system.

Discounted cash flow and pay-back analyses were used to arrive at a ranking of alternatives.

The results gave the existing warehouse site with the proposed administration systems as slightly better than the resiting of the warehouse in unit 2 with the proposed administration system, both choices using the existing racking as much as possible. All labour intensive alternatives performed badly in the analyses.

7.5 Present Situation (September 1972)

The company decided against a mechanical movement system on the grounds that it provided for a rigid warehouse layout. It was considered that a more flexible arrangement was needed with the shift of emphasis from bedding to upholstery production.

Unit 3 was subsequently questioned as a possible site because of the dependance on the present administration procedures.

Also unit 3 was the only site which could at some future date be expanded as the rear wall is not a fixed boundary. Hence if upholstery production were to increase in line with the company's five year plan unit 3 would be more favoured as a production area.

Having objections to the mechanical system meant that raw materials would need a more direct access to the production areas hence favouring unit 2 as the warehouse.

From the results of the financial analyses the company were to weight the above non-financial matters heavily and it came as no surprise that unit 2 was selected as the warehouse site.

This exercise brought home to the researcher the factors decision makers consider in real-life decisions and the value of detailed analysis. The analysis was valuable to the board in that it helped to clarify their thinking on the problem. Costs built into the exercise to cover modifying unit 3 to a production area (£17,000 to £22,000) and the cost of new loading bays (£15,000) were not included to the same extent by the company. The modification costs were considered as maintenance costs as unit 3 had deteriorated during its life. The provision of loading bays in unit 2 was considered because the old sewing rooms would be vacated and were not entirely suitable for storage facilities. A cost was built into the calculations but it was considered to be the difference between building loading bays and modifying for storage purposes.

If these costs are removed from the original financial analyses then the unit 2 with an efficient administration system is a very attractive proposition.

Stage 2 of the analysis involved detailed layouts and procedures for the board's decision. Diagram 7.3 indicates the bedding storage layout which is now being implemented by the company. Work is progressing on upholstery storage layout based on recommendations for purpose built racking made during the financial analysis work.

The bedding layout could have been implemented in unit 3 but would have been more labour intensive as the mechanical movement system was considered unacceptable. The proposed administration system regarding order picking is being considered although no final decision has been taken.

Proposals put to the board (19) for handling bedding were an amalgam of recommendations from many reports. Beds will be split into slow and fast movers with different storage facilities for each. More sophisticated storage procedures are used for fast movers, the racks being fully live with a capacity of over 200 per stock item. A single picking face will be presented to the order pickers although to ease congestion it was recommended that an auxilliary store of products from the top layer be maintained at floor level opposite the racks.

Throughout the financial analyses the cost of racking was excluded due to uncertainty and also because it was common to each alternative.

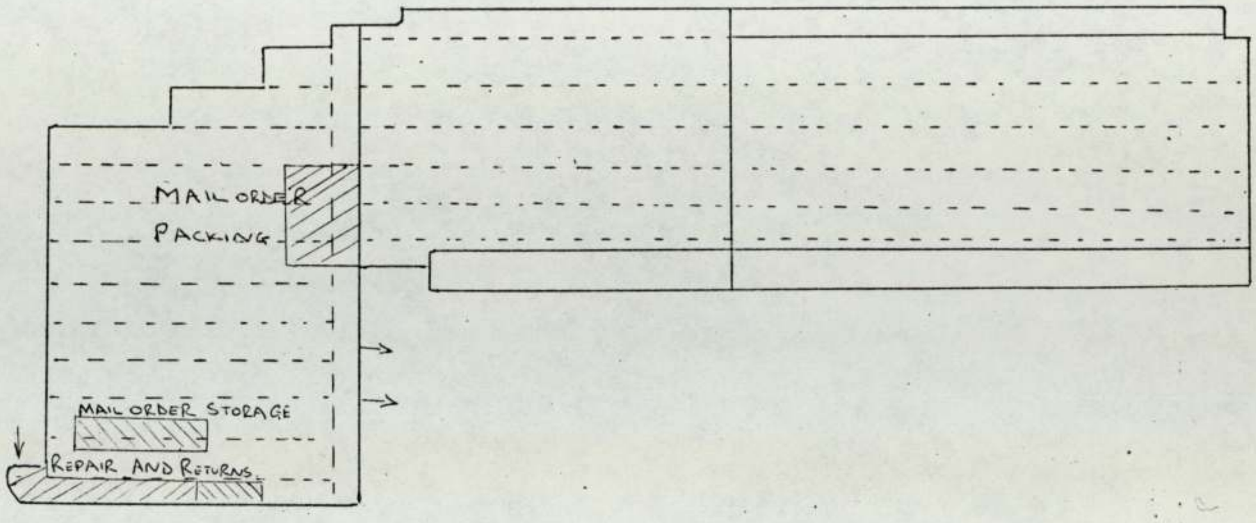


Diagram 7.1 Mail Order and Repair and Return Sections Locations, October 1970

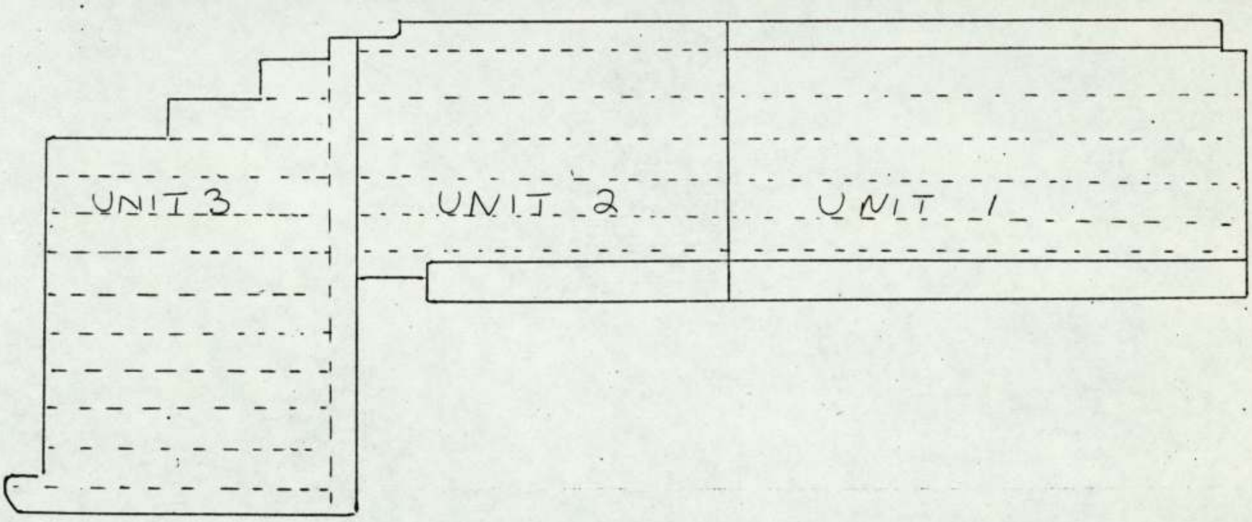


Diagram 7.2 Factory Site at Tipton

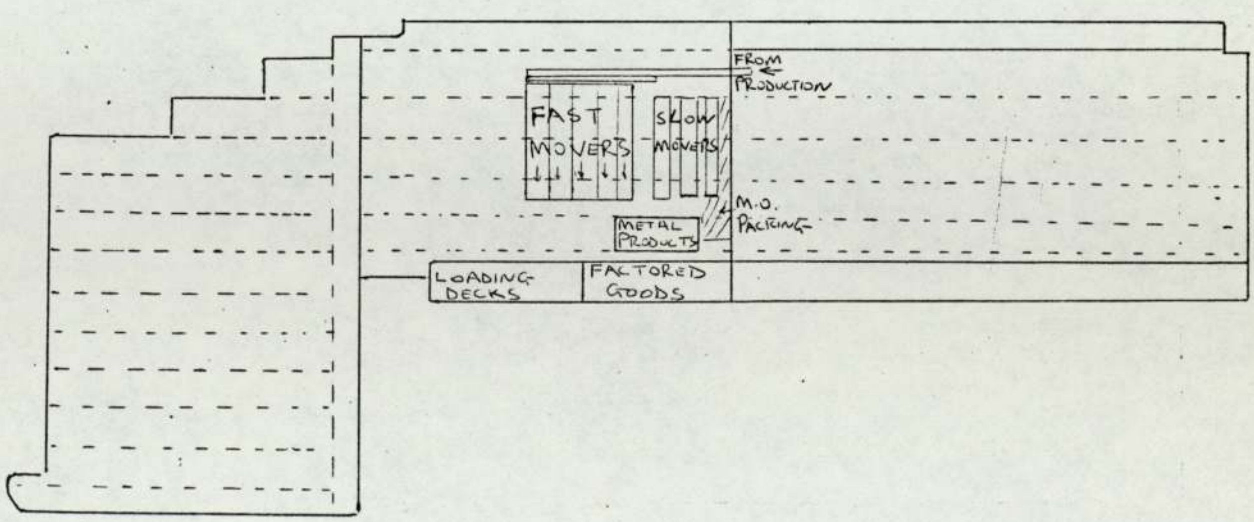


Diagram 7.3 Accepted Warehouse Layout

REVIEW

Diagram 7.1 illustrates one cause for congestion in the warehouse, mail order packing and storage areas were at different sides of the warehouse and the repair and return section was at the point farthest from the production area. The locations of mail order packing and the repair and return sections were reversed. Improvements to the rear of the warehouse to develop loading facilities for mail order products were not carried out despite the possibility of a 16% increase in loading productivity at a minimal cost of £4,000 per annum.

Location areas for products were not well defined and sales management had found items which had been recorded NA actually in store. Re-allocation of storage space proportional to each products turnover, with high visitation areas nearest the loading bays was accepted by the warehouse and distribution management. Full implementation was hampered by sales management's decision to put the following year's product range into the warehouse 6 weeks before it was launched.

Comparison of alternative sites and administration systems for the finished goods warehouse provided a further insight into the company. A decision was taken before the analysis was completed indicating the nature of pressures on management. Financial considerations were not the main ones although the researcher believed at the outset that they would be.

The situation was analysed assuming that funds to re-equip were limited and also that funds would be available

Although a system involving automatic tow lines for moving the products from production areas to the existing storage area would have been most efficient it was rejected by the board. Their decision was based on the desire not to have too rigid a system and on access problems to the production area in the centre of the factory. Also possible Government legislation concerning the storage of expanded polystyrene products in separate fireproof buildings would have meant that access problems to the central area would have been increased.

The final decision taken by the board was guided by the analysis and during February 1973 work will begin to modify the storage facilities as diagram 7.3.

As warehousing had not originally been considered as part of the research in October 1970 the inclusion indicated a change of thinking concerning the definition of physical distribution management.

8. STOCK INFORMATION SYSTEM PREVIEW

Upholstery products are generally produced to order and hence problems resulting from finished stock build-ups are load building and vehicle routing problems. However, bedding and some upholstery stocks, black Penthouse chairs and certain cheaper suites, need some form of control as storage space is limited.

Work had indicated, chapter 4, that finished stock recording was inaccurate and that no record of finished stock was maintained anywhere in the company.

The first step must be to analyse demand patterns for beds over the last year and to compare this with previous years. Any unusual demand peaks will be compared with sales policies as promotional activity could lead to atypical results.

8. STOCK INFORMATION SYSTEMS

8.1 Introduction

The majority of inventory control literature is concerned with single item inventories with known, and usually constant, demand and relatively long lead times. Possibly the most successful approaches to multi-product inventories have been Murdoch's Coverage Analysis (13) and the series of Lagrange Multiplier Models (14).

Coverage analysis divides items into about a dozen categories based on annual usage value and arranges that these categories have a perfect square midpoint value such that the number of replenishment per year can then be easily made proportional to the square root of the annual usage model. The total number of replenishment order per annum must remain constant and either the holding interest rate or the cost of replenishment or their ratio is the same for all items. This latter restriction is usually valid although the former could impose a false restriction.

Although the method does not claim to retain the same level of customer service operated by the company, it is claimed that this remains much the same after its introduction. The series of Lagrange Multiplier Models considers restrictions on capital invested, storage space, machine utilization and/or combinations of these factors. However, these models are only concerned with active stock and ignore buffer (or safety) stocks on which the level of customer service is determined.

These models introduce the concept of customer service levels and lead times. As mentioned earlier, chapter 6, the company interprets service level as meeting an order within a quoted delivery forecast. This forecast is an arbitrary figure based on what the company feels their competitors are providing. Although this is now 21 days some directors still talk of a 7 day service. Bedding manufacture (at Vono) is such that the only major difference between models is the cover, hence stocks of sewn covers are important. Production is therefore flexible, no loss of labour performance is observed when Orion manufacture changes to Autumn Leaf manufacture for example. Having long delivery dates going out of stock of finished products is unimportant with such a flexible production system.

As a result, conventional definitions of service levels involving the percentage of orders met without stockout, etc., are inappropriate to this situation. Lead times are similarly confusing. If production management decide, then one bed can give way to another and the new model be moving off the production line one hour later.

Certain products are produced on the flowline principle hence stock holding is again questionable. Spring units are continuously being made without inventory control procedures.

Cover material (tick) is bought against a 3 month sales forecast, and adapted by experience. With such a production system the production planning period is debatable, is it the hour to change the production line, or a day to form a complete production schedule, or the week involved collating demand date on the computer, or the week the directors hope for, or the 21 days the sales staff issue or ....?

The researcher has assumed that it must be defined as the 7 days set by the company and that the procedures must adapt to this target.

8.2 Present situation and demand patterns

The selling policy regarding special offers, promotions and customer discounts has been discussed in chapter 3 and chapter 6. Table 8.1 illustrates the pricing policy with reference to part of 1972 bedding range. Not included in this table are customer own-label beds but no data was available on the effect of such beds on demand for the standard range in the sales regions concerned. Table 8.2 illustrates one further problem in inventory control analysis, the range changes. With very few exceptions at Vono, for example the Diana bed, the range changes to suit fashions in colours, etc. During the last 2 years it has been unusual for the range, or the colour, price or specification of individual beds, to be constant for longer than 6 months.

An analysis indicated that for 1971 3 bed types accounted for 60% of home retail sales turnover. As with most of the analysis of bedding this figure must be regarded as an estimate based on the best available information. Average usage values were obtained by applying the product - size - tick mix formula developed in Appendix II to total sales figures. Table 8.3 compares this formula with that which the company were using. Diagram 8.1 illustrates weekly sales over 9 months during 1971 for the above bed types.

BED TYPE	CATALOGUE PRICE £	ACTUAL RETAIL PRICE £
Diana 4'6" SE set	41.10	33.20
Jupiter 4'6" SE set	45.05	40.55
Mercury 4'6" SE set	29.80	24.20
Orion 4'6" SE set	33.20	25.90
Saturn 4'6" SE set	38.85	34.97
Sovereign 4'6" SE set	39.40	39.40 (but offer of free Goblin Teasmade)

The prices are the purchase tax calculating prices. Discounts to individual accounts are over and above these. Other offers included a television set at a special price with an order of 12 Jupiter sets at the above reduced price.

Table 8.1 Comparison of catalogue and actual prices for some 1972 range beds

1968 (Spring)	1968 (Summer) (Price change)	1968 (Autumn)
DIANA S/E	DIANA S/E	DIANA S/E
DIANA F/E	DIANA F/E	DIANA F/E
A'LEAF F/E	A'LEAF F/E	A/LEAF F/E
APOLLO S/E	APOLLO S/E	APOLLO S/E
APOLLO F/E	APOLLO F/E	APOLLO F/E
METEOR F/E	METEOR F/E	METEOR F/E
ASTRA F/E	ASTRA F/E	ASTRA F/E
		JUPITER S/E
		ORION S/E

1969 (Spring)	1969 (Summer) (Price change)	1969 (Autumn) (*=Price Change)
DIANA S/E	DIANA S/E	DIANA S/E
DIANA F/E	DIANA F/E	DIANA F/E
APOLLO S/E	APOLLO S/E	APOLLO S/E
APOLLO F/E	APOLLO F/E	APOLLO F/E
METEOR S/E	METEOR S/E	METEOR S/E
METEOR F/E	METEOR S/E	METEOR F/E*
ASTRA F/E	ASTRA F/E	ASTRA F/E
JUPITER S/E	JUPITER S/E	JUPITER S/E
ORION S/E	ORION S/E	ORION S/E

Table 8.2 Vono Standard Bedding Range

1970 (FEB)	1970 (MAY)	1970 (AUGUST)
JUPITER S/E	JUPITER S/E	JUPITER S/E
DIANA S/E DIANA F/E	DIANA S/E DIANA F/E	DIANA S/E DIANA F/E
SOVEREIGN S/E SOVEREIGN F/E	SOVEREIGN S/E SOVEREIGN F/E	SUPPORTA F/E
ORION S/E ORION F/E	ORION S/E ORION F/E	SOVEREIGN S/E SOVEREIGN F/E
APOLLO S/E APOLLO F/E	APOLLO S/E APOLLO F/E	ORION S/E ORION F/E
METEOR S/E METEOR F/E	SATURN S/E SATURN F/E	APOLLO S/E APOLLO F/E
ASTRA F/E	METEOR S/E METEOR F/E	SATURN S/E SATURN F/E
	ASTRA F/E	METEOR S/E METEOR F/E
		ASTRA F/E

Table 8.2 continued

1971 (FEB)	1971 (AUG)	1971 (NOV) *= Price Changes)
JUPITER S/E	APOLLO S/E	APOLLO S/E *
DIANA S/E	APOLLO F/E	APOLLO F/E *
DIANA F/E	ARLINGTON S/E	ARLINGTON S/E
ARLINGTON S/E	ARRAN F/E	ARRAN F/E *
APOLLO S/E	A'LEAF S/E	A'LEAF S/E *
SATURN F/E	A'LEAF F/E	A'LEAF F/E *
CHARTWELL S/E	CHARTWELL S/E	CHARTWELL S/E
CHARTWELL F/E	CHARTWELL F/E	CHARTWELL F/E
A'LEAF S/E	CLEVEDON S/E	CLEVEDON S/E
METEOR F/E	CLEVEDON F/E	CLEVEDON F/E
CLEVEDON S/E	DIANA S/E	DIANA S/E *
CLEVEDON F/E	DIANA F/E	DIANA F/E *
OPTIMA F/E	JUPITER S/E	JUPITER S/E *
ARRAN D LUX F/E	METEOR S/E	METEOR S/E *
ARRAN F/E	METEOR F/E	METEOR F/E *
SUPPORTA F/E	OPTIMA F/E	OPTIMA F/E
	ORION S/E	ORION S/E *
	ORION F/E	ORION F/E *
	SATURN S/E	SATURN S/E *
	SATURN F/E	SATURN F/E *
	SUPPORTA F/E	SUPPORTA F/E

Table 8.2 continued

<u>1972 (FEB)</u>

APOLLO S/E
APOLLO F/E

ASTRA F/E

DIANA S/E
DIANA F/E

JUPITER S/E

MERCURY S/E
MERCURY F/E

METEOR S/E
METEOR F/E

ORTHO/METEOR S/E
ORTHO/METEOR F/E

ORION S/E
ORION F/E

SATURN S/E
SATURN F/E

SOVEREIGN S/E
SOVEREIGN F/E

VICTORIANA

<u>Table 8.2 continued</u>

Diagram 8.2 illustrates the sale of beds in the home retail and mail order markets for the years 1969, 1970 and 1971. (These sales are not by sub-type as such information is almost impossible to determine). Assuming a constant factor per week the graphs for the sub-types would be identical in shape to those for the total types. The apparent disagreement between diagrams 8.1 and 8.2 can be readily explained. The three best selling beds are based on contribution to turnover from an ABC analysis . Diagram 8.2 covers the sales of all beds by volume including mail order and special promotions to one account.

Sales forecasting deviations from achievements, illustrated in table 8.4 are another problem accentuated by the selling policy, range changes and fragmented markets. Sales forecasts for individual products were never issued although attempts are now being made to forecast for every stock item in the range.

The above problems cause difficulty in inventory policies and also in buying. Lead times on tick can be 3 months, orders are therefore placed from a 3 months sales order intake forecast and 'some knowledge of the bedding industry'.

Marketing department personnel at one time issued stock levels for bed types. These were meant to be maintained at all times to cover forecasting errors and were classed as a measure of safety stock. Had these levels been maintained then there would have been very little room in the warehouse for allocated orders and stocks of specials. Although the company were attempting to introduce inventory control it was for the wrong reason and without reference to the production and order processing systems.

Model developed by the author

Bed type			SIZE 5'	4'6	3'3	3'
Arran	Blue			25.8%	3.64%	43.21%
	Mushroom			8.82%	3.33%	15.2%
Optima	Blue		13.06%	25.98%	8.54%	26.9%
	Gold		3.25%	6.5%	4.16%	12.3%
Chartwell	Purple	F.E.	8.1%	6.75%	1.54%	1.74%
		S.E.	20.3%	11.4%	1.35%	1.93%
	Brown	F.E.	1.35%	1.35%	0.19%	1.74%
		S.E.	5.00%	5.00%	0	5.79%
	Gold	F.E.	3.09%	5.00%	0.77%	2.31%
		S.E.	5.78%	11.8%	2.31%	5.79%
Arlington	Red		13.00%	12.36%	0.65%	1.95%
	Brown		6.18%	6.18%	0.97%	0.65%
	Mushroom		35.01%	13.30%	5.2%	4.55%
Diana		F.E.		18.3%		2.41%
		S.E.		71 %		8.29%
Saturn		F.E.		55.6%		16.78%
		S.E.		15.18%		12.44%
Apollo		F.E.		5.67%		6.46%
		S.E.		72.4%		15.4%
Meteor		F.E.		13.18%		8.30%
		S.E.		60.22%		18.30%
Autumn Leaf	'D'	F.E.		20.88%		21.6%
		S.E.		4.54%		3.12%
	'L'	F.E.		19.5%		16.50%
		S.E.		12.06%		3.30%
Orion		F.E.		0.58%		0.38%
		S.E.		74.6%		24.6%
Clevedon	Cerise	F.E.	5.28%	14.88%	1.86%	6.11%
		S.E.	3.80%	5.62%	1.49%	2.14%
	Gold	F.E.	2.14%	7.44%	1.32%	9.58%
		S.E.	3.72%	5.58%	0.51%	3.14%
	Blue	F.E.	2.48%	4.28%	0.33%	2.31%
		S.E.	5.12%	6.76%	1.65%	3.47%

Table 8.3 Product/Size/Tick Mix

Existing company model

		%		%		%
Arran	AR1	70 (Blue)	AR2	30 (Mushroom)		
Optima	O1	90 (Blue)	O2	10 (Gold)		
Clevedon	CL1	50 (Cerise)	CL2	30 (Gold)	CL3	20 (Blue)
Arlington	A1	30 (Red)	A2	15 (Brown)	A3	55 (Beige)
Chartwell	C1	60 (Purple)	C2	10 (Brown)	C3	30 (Gold)
Autumn Leaf	408/5	35	408/2	65		

	Base	90	100	135	150
Arran	f.e.	60 %	10 %	30 %	- %
Optima	f.e.	40 %	20 %	30 %	10 %
Clevedon	f.e.)60% s.e.)40%	25 %	10 %	45 %	20 %
Supporta	f.e.	25 %	- %	75 %	- %
Chartwell	f.e.)40% s.e.)60%	5 %	15 %	60 %	20 %
Arlington	s.e.	5 %	20 %	40 %	35 %
Jupiter	s.e.	15 %	- %	85 %	- %
Diana	f.e.)15% s.e.)85%	15 %	- %	85 %	- %
Saturn	f.e.)55% s.e.)45%	25 %	- %	75 %	- %
Apollo	f.e.)20% s.e.)80%	20 %	- %	80 %	- %
Meteor	f.e.)30% s.e.)70%	25 %	- %	75 %	- %
Autumn Leaf	f.e.)70% s.e.)30%	45 %	- %	55 %	- %
Orion	f.e.)45% s.e.)55%	20 %	- %	80 %	- %

Table 8.3 Continued

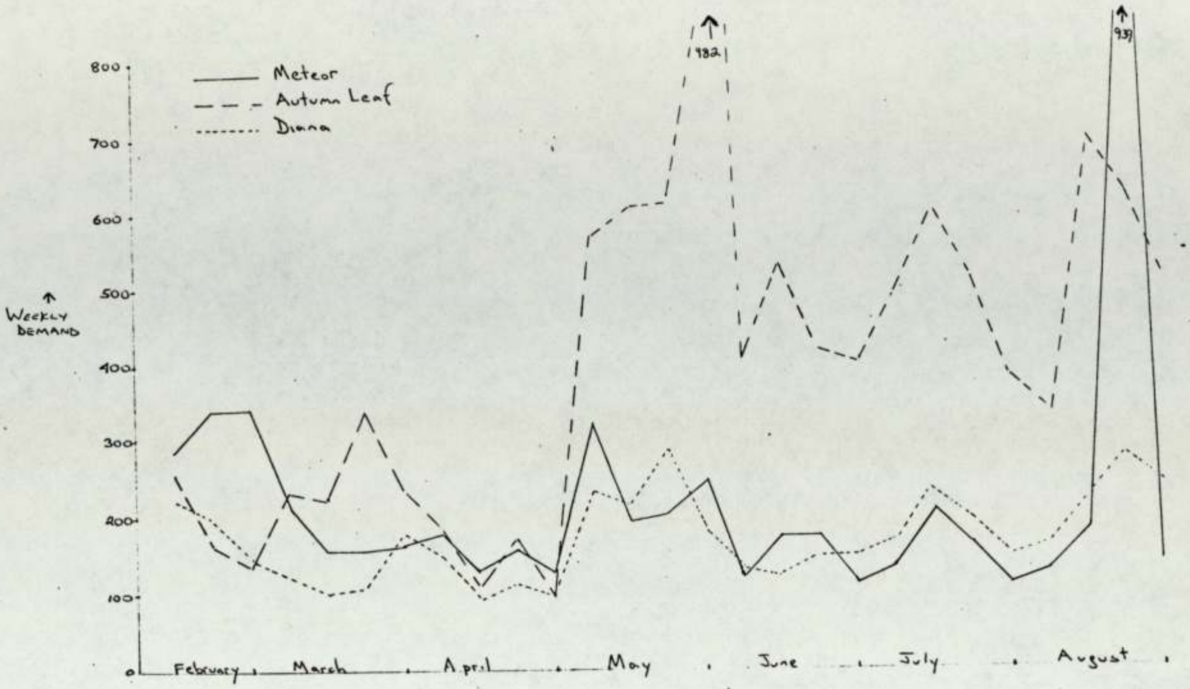


Diagram 8.1 Weekly demand for 3 Bed types during 1971

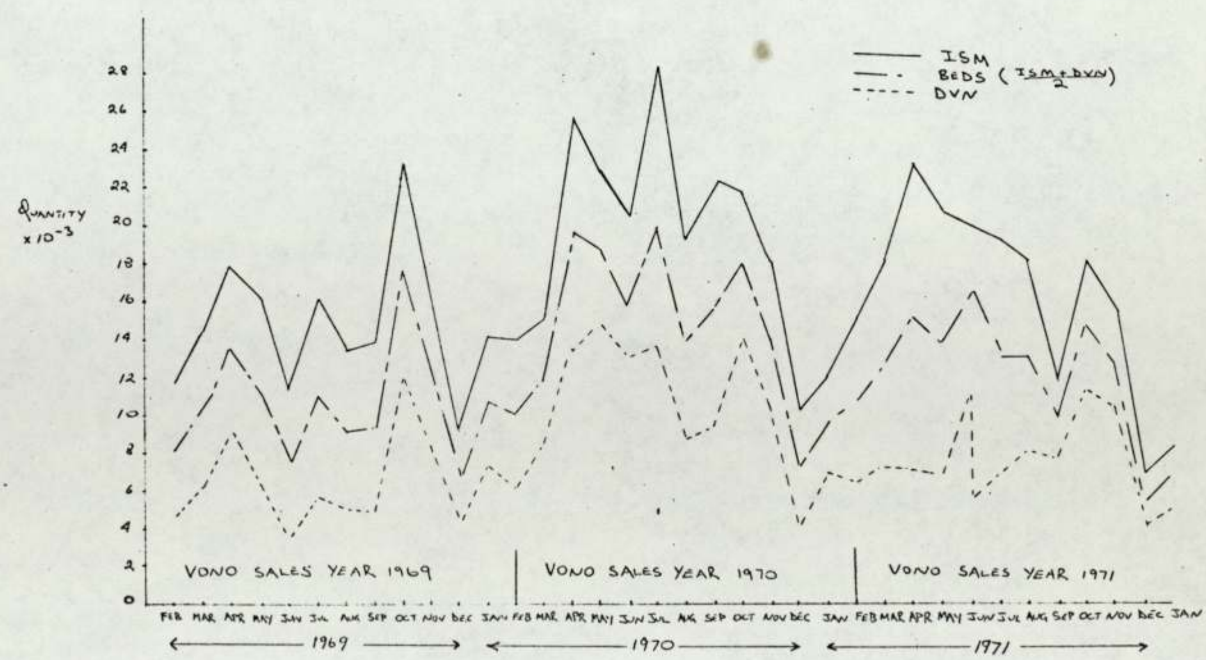


Diagram 8.2 Total monthly sales of Beds 1969, 1970, 1971

Attempts at modifying the demand data for the 3 best selling beds of 1971 were not successful. It was felt that by substituting for demand peaks caused by promotions or furniture exhibitions the average demand without them a more familiar pattern would emerge. Demand patterns by bed type were still unpredictable after careful examination of 3 years figures. Because of the lack of a standard background, alternatives to conventional inventory control policies were attempted.

8.3 Alternative Policies Considered

8.3.1 Pre-allocation

Table 8.5 provides one reason for high stock levels regardless of inventory control policies. This table illustrates the waiting time between the time the load could have been despatched and when it was actually loaded. The load building procedure involves holding the paperwork for orders in the distribution office until the orders for an area can be assembled to form a load. Constraints are closing days and there is a desire to reduce delivery costs.

Although receipts of paperwork by the department is preceded by receipt of the relevant product by the warehouse the implications were not appreciated by the company.

If the warehouse were stocked according to the principle put forward in Appendix VIII, then 2 weeks forecast sales of bedding could be stored. Upholstery orders are mainly to special order and hence finished stock levels are considered not essential by the company.

TABLE 8.5

Waiting Time Analysis for Loads Investigated

(Times are days from receipt of order by distribution to loading on van)

Load No.	Load Area	Loading Date (on green copies)	Waiting Time(Days Range			Average
4405	Coventry	8. 5.70	10		2	4.1
4450	Bovey (Depot)	8. 5.70	7		2	3.3
6403	Liverpool	22. 7.70	7		0	2.5
6422	Glamorgan	23. 7.70	7		1	2.0
6469	Liverpool	27. 7.70	10		4	6.7
7800	Bristol	21. 9.70	32	*	7	11.0
7803	Weymouth	21. 9.70	6		4	4.7
7808	Cambridge	21. 9.70	24	*	5	12.0
7809	Driffield	21. 9.70	10		4	6.6
7814	Salop	21. 9.70	24	*	4	8.25
7820	Skipton	21. 9.70	17	*	4	7.5
7822	Birmingham	21. 9.70	19	*	4	5.2
7838	Leeds	21. 9.70	17	*	0	6.6
7841	Manchester	21. 9.70	6		4	4.5
7867	Bovey (Depot	25. 9.70	8		4	6.8
7869	Lincoln	22. 9.70	14		4	7.0
7871	Pembroke	22. 9.70	14		1	6.5
7880	Spalding	23. 9.70	8		2	6.0
7891	Huddersfield	23. 9.70	9		2	5.5
7896	Preston	23. 9.70	19	*	2	7.0
7900	Stafford	23. 9.70	21	*	2	8.7
7907	Bristol	23. 9.70	8		2	5.25
7916	Oxford	23. 9.70	9		2	4.8
7928	Bristol	24. 9.70	13		2	5.0
7933	Manchester	24. 9.70	9		2	3.5
7948	Manchester	24. 9.70	8		0	4.1
7961	Burton-on-Trent	24. 9.70	9		0	2.6
7967	Sheffield	24. 9.70	20	*	0	5.0
7858	Bilston	25. 9.70	15	*	7	10.00
7980	Redditch	25. 9.70	10		1	5.0
7988	London	25. 9.70	21	*	0	5.1
8114	Glasgow (Depot)	1.10.70	7		2	4.2
8201	Nottingham	5.10.70	21	*	6	8.1
8215	Wilmslow	5.10.70	19	*	3	6.2
8234	Nuneaton	6.10.70	26	*	4	7.2
8238	Huddersfield	6.10.70	7		1	2.6
8255	Stoke-on-Trent	7.10.70	13		2	7.5
8262	Oldham	7.10.70	12		2	5.2
8275	Teesside	7.10.70	2		2	2.0
8283	Derby	8.10.70	12		2	4.9
8292	Poole	8.10.70	13		2	5.0
8298	Wokingham	8.10.70	14		2	6.4
8307	Wigan	8.10.70	8		2	4.5
8326	Oxford	8.10.70	22	*	2	4.4
8333	Coventry	9.10.70	37	*	2	5.25
8338	Brighouse	9.10.70	14		2	4.7
8342	Wolverhampton	9.10.70	4		1	2.7

Load No.	Load Area	Loading Date (on green copies)	Waiting Time (Days)			
			Range			Average
8379	Sheffield	12.10.70	14		5	8.0
8384	London	12.10.70	18	*	4	6.7
8387	Reading	12.10.70	11		4	6.0
8394	Chester	12.10.70	11		4	6.4
8405	Teesside	12.10.70	5		3	4.4
8411	Liverpool	12.10.70	7		3	4.2
8427	Leicester	13.10.70	15	*	4	7.5
8436	Northumberland	13.10.70	4		1	3.6
8445	Kidderminster	13.10.70	13		1	3.1
8452	Stafford	14.10.70	9		2	3.0
8484	Berkshire	15.10.70	17	*	2	7.3
8489	Manchester	15.10.70	9		2	4.2
8507	Wigan	15.10.70	10		1	3.8
8536	Warrington	16.10.70	7		1	3.1
8565	Barrow-in-Furness	19.10.70	19	*	4	9.9
8578	London	19.10.70	14		4	8.7
8600	Manchester	19.10.70	14		3	7.5
8622	Colchester	21.10.70	30	*	2	11.0
8623	Stoke-on-Trent	21.10.70	6		2	4.0
8671	Southampton	22.10.70	9		2	5.1
8700	Gloucester	23.10.70	4		2	3.1
8709	Halifax	23.10.70	7		2	2.9
8720	Birmingham	23.10.70	8		2	3.0
8752	Swansea	26.10.70	10		4	5.6
8763	Nottingham	26.10.70	14		4	7.7
8786	Brighton	26.10.70	15		4	5.5
8792	N. Wales	26.10.70	10		4	6.2
8798	Hull	26.10.70	13		4	5.7
9008	Salop	4.11.70	5		1	3.2
9048	Southampton	5.11.70	13		2	4.5

The waiting time analysis was performed on a further sample of orders and again an average waiting time of over 2 days was recorded.

If orders were allocated to products prior to production then there would, on average, be 2 days less stock in the warehouse. This approaches a 15% reduction stock or approximately £40,000 per year less tied up in stock and could be achieved without any high level inventory control procedures.

Distribution management felt that they would be able to plan more efficient deliveries by this system. No figure could be put on savings in this area although small percentage savings would be significant.

Comparison of production forecasts with actual production indicated reasons for lack of interest by production personnel. Production forecasts were issued weekly based on sales order intake and allocation clerks figures of stock levels. Over-production was as serious as under-production and no daily schedules were issued.

Production control was very slack, warehouse control almost totally lacking and the administration more concerned with micro-filming existing paperwork to do more than agree with the proposals. No attempts were made by the company to investigate the causes of the problems.

Simulation of pre-allocation was considered but would have involved knowledge of all orders at the date of receipt, accurate daily production schedules in advance and constant information on the load building situation. A proposal for a full reporting and information system was presented to the company in December 1971 and work continued in other areas.

8.3.2 Stock Information System Simulation (SISSIM)

This simulation program is only concerned with the standard bedding range and is an attempt to provide daily information on allocated orders, production schedules, spare production capacity and finished stock variations. Diagram 8.4 is the flow diagram for the program.

Basically the steps involved are as below.

(a) produce a ranking of bed types from an ABC analysis

(b) obtain the proportion of sales turnover accounted for by each bed type (Factor 1)

(c) obtain the proportion of a bed's turnover accounted for by each sub-type (Factor 2)

These steps are not performed by the programme but the factors and the ranking are essential to the operation

(d) obtain a maximum stock level for each sub-type and set minimum stock levels.

(e) obtain the requirements for export mail order and specials to give the ISM and DVN production capacities to be allocated to home retail and standard bedding.

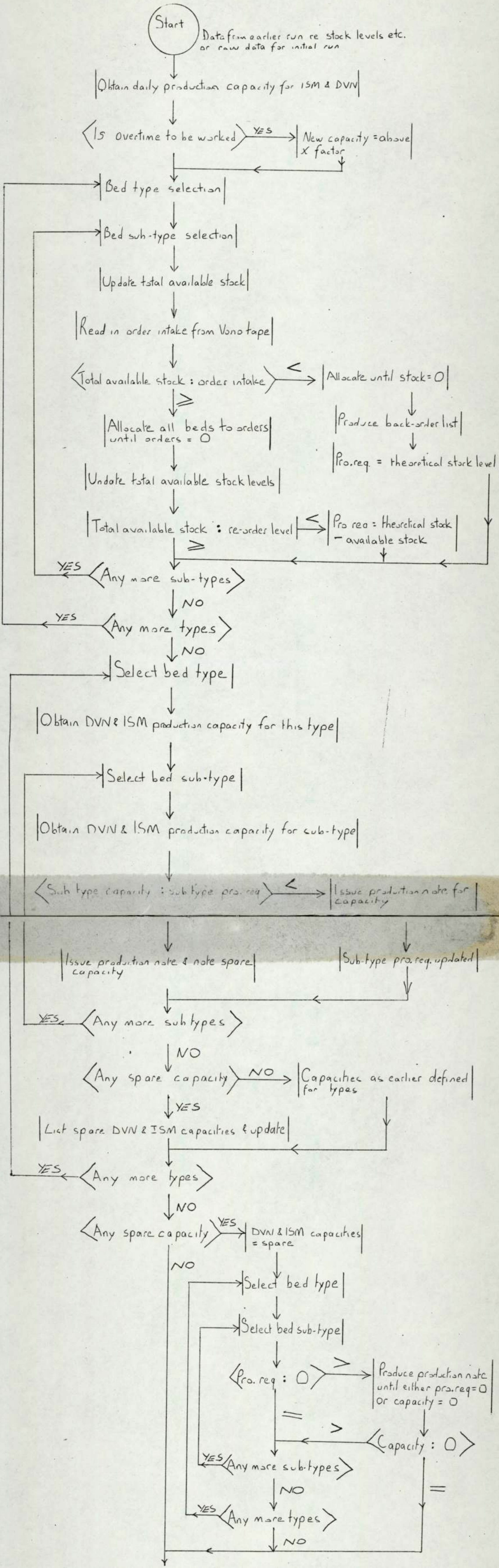
(f) compare the order intake for type 1 sub-type 1 with stocks compares remainder with minimum stocks and issued production requirements and notes orders not met.

(g) after type 1 is finished checks to see if any of its allocated production capacity is left, if so goes through 1.1 etc., allocating capacity until requirements or capacity is zero.

(h) steps (f) and (g) are repeated until all beds have been checked.

(j) if any spare capacity the programme works through 1.1 etc., allocating capacity until either requirements or capacity is zero.

(k) output is total stock, prediction requirements, back order list and theoretical stock levels for each sub-type. Total value of stocks and value of allocated stocks are output per day.


Start
Data from earlier run re stock levels etc. or raw data for initial run
Obtain daily production capacity for ISM & DVN
Is overtime to be worked
YES
New capacity = above X factor
Bed type selection
Bed sub-type selection
Update total available stock
Read in order intake from Vono tape
Total available stock : order intake
<
Allocate until stock = 0
Produce back-order list
Pro.req. = theoretical stock level
≥
Allocate all beds to orders until orders = 0
Update total available stock levels
Total available stock : re-order level
<
Pro req = theoretical stock - available stock
≥
YES
Any more sub-types
NO
YES
Any more types
NO
Select bed type
Obtain DVN & ISM production capacity for this type
Select bed sub-type
Obtain DVN & ISM production capacity for sub-type
Sub type capacity : sub type pro. req
<
Issue production note for capacity
Issue production note & note spare capacity
Sub-type pro.req. updated
YES
Any more sub types
NO
Any spare capacity
NO
Capacities as earlier defined for types
YES
List spare DVN & ISM capacities & update
YES
Any more types
NO
Any spare capacity
YES
DVN & ISM capacities = spare
NO
Select bed type
Select bed sub-type
Pro. req : 0
>
Produce production note until either pro.req = 0 or capacity = 0
=
>
Capacity : 0
YES
Any more sub-types
=
NO
YES
Any more types
NO

Minimum stock levels have been set at one day's demand averaged over a month (February 1972). Where there was no demand minimum levels of 1 or 2 have been used. Maximum levels were originally set at a given figure but are now a function of the last n days demand. For illustration 40% of the last 5 days orders was used although the function and n can be controlled by the company.

The system is basically on sS policy with varying S levels. This was felt to give greater flexibility in the light of the company's selling policy and uncertain demand patterns.

By performing the system on the computer a constant review policy can be followed without daily manual checks. The company is using the computer to collate orders and sort them for production purposes, and hence part of the proposed procedure would be performed for this purpose. By using this information to update stocks, allocate orders, perform stock valuations and load the manufacturing section, better use of computer time and company personnel can be obtained.

Although the system uses no EOQ formula it attempts to provide a logical apportioning of resources for the given situation.

Bedding production is unusual in that set up cost are zero, in that there is no loss of production on a bed change. Production personnel are supplied with the springs; padding and sewn covers are provided ready cut for a particular bed, and hence production is equivalent to wrapping a unit in different coloured cloths.

The annual forecast demand of any one stock item, e.g. 3' Diana FE divan in white is not known with any degree of certainty. Table 8.4 indicates that forecasting one month ahead for all Diana sub-types as a whole was not very successful.

For budgetary purposes the company forecasts its expected sales by value, but value figures can be met in a number of ways including special promotions.

Standard works prime costs for all beds are known although work was progressing within the company to arrive at accurate production capacity figures which could modify production costs. The prime cost of a mattress and its divan are different and consequently differing order quantities would be required.

The EOQ formula would place greater emphasis on the smaller cheaper products which were not the best sellers.

If monthly EOQ levels were set for each product, forecasting errors could lead to overstocking or shortage situations. The company were conscious of damage caused through overstocking, the bottom mattress or divan of a stack of 7 was known to never fully recover its depth after being compressed for 2 months or longer.

Because of the problems in substituting figures into the EOQ formula the logical apportionment of resources proportional to sales turnover is offered as an alternative.

By modifying the factors to suit particular promotions it offers the company the advantage of ensuring that production facilities are utilised in unison with sales effort.

Whether such a system is the best for the particular circumstances facing this bedding company is open to discussion and research but it has none of the drawbacks of EOQ and standard systems.

The program has been run on the University of Aston's computer taking 145 seconds to analyse one month's data. Unlike production control packages offered by computer companies the programme uses few sophisticated procedures and only produces a set of requirements at a gross level. Duport Computer Services Ltd. are investigating the use of I.C.L.'s package, Prompt, but to run daily would lead to approximately £100 per week running costs. By October 1972 these investigations were indicating that Prompt was inappropriate to bedding productions because of the short lead times offered to customers in relation to the lead times on raw materials.

The priorities of production, that is according to ABC classification would be difficult to modify but by modifying the stock update procedure different priorities other than order date could be used.

By obtaining the average daily or weekly spread of orders then the procedure could be used with sales forecasts to plan production for the next month. As forecasts were inaccurate this was not attempted.

8.4 Sewn Cover Stocks

During the research into stock holding policies it became apparent that holding stocks of finished beds was probably the wrong approach.

For any given size of bed, e.g. 3' wide 6'3" long, there were only three types of spring unit used. One was firm and sold very little, one was in the most expensive type of bed, and all other beds had the third type. The quality of filling differed between beds as did the tick (cover material). Filling and tick are supplied ready cut and sewn and mated with the springs on the production line. Spring units were made with regard only to sizes, and being the slowest process in bed making at Tipton inventory control was minimal. A large stock was maintained which, unlike the finished product, was stacked high and close. Having no cover to damage the same degree of care was not exercised.

Covers were cut and sewn approximately 2 days before they were required by the assemblers.

The author's views on stock control turned to controlling the stocks of finished (i.e. cut and sewn covers) rather than controlling stock levels of the finished beds.

Detailed costs of one bed, a 3' Firm edge Sovereign divan set indicate the possible savings.

Total raw material content	slightly over £10
Value of tick	approximately £ 4
Total labour content	approximately £ 2
Labour cost of sewing cover	approximately £ 0.18
overhead recovery on total bed	approximately 260% labour
overhead recovery on tick	approximately 180% labour

If forecasting over the year were too high and excess stocks remain unsold the company would be faced with disposing of out of range products. Discounts of over 20% of the trade price have been known to dispose of such products.

If, however, the sewn cover stocks only were maintained and beds produced effectively to order the loss to the company would be considerably less. When these ideas were discussed with the board of directors their view was that the savings to the company were likely to be considerably greater.

Materials for covers must be held in stock because of the 3 months lead time. Consequently the loss due to overstocking sewn covers would be the labour content of the production.

An analysis was presented to the board detailing suggested stock levels, reorder points and reorder quantities based on projections from the previous year's sales and sales managers' opinions.

This work was performed too late for inclusion in the thesis in detail.

REVIEW

Demand patterns for total bed sales were shown to be of a seasonal nature but the peak in sales had occurred at different times in each of the last three years. The timing of the peaks for divans and mattresses was also noted to be out of phase, a fact the company could not explain.

Figures for the three bed types accounting for 60% of turnover indicated for 1971 that the promotional selling of one bed could have caused the shift in the timing of the peak demands.

Forecasting errors, lack of knowledge of ordering costs together with the need to maintain equal stocks of divans and mattresses led to an alternative to EOQ formulations for determining production requirements.

The alternative was based on a minimum/maximum stock level policy with the maximum varying according to demand. This variance, which was set at 40% of the last week's order intake, reflects the popularity of each bed and should ensure that overstocking with subsequent damage to products does not occur. Although the programme, SISSIM (Stock Information System Simulation) was successfully run on test data, data collection problems within the company held up parallel running with the manual production control system.

The programme was accepted as valuable in principle to the company, by the financial and production directors. Major changes in the order processing system would be required to implement this, or any production control system and discussions are in progress with senior systems analysts of Duport Computer Services Ltd. regarding theproblem.

9. LOAD BUILDING PREVIEW

The load building model had been shown to be unnecessarily complicated and also inaccurate (chapter 4).

Following the general concept of physical distribution management it is necessary to be able to efficiently load a vehicle, consequently it is necessary to have a workable model. Also any work which follows the two year research programme concerned with vehicle scheduling packages will require a unified load building model.

Consequently, to improve efficiency and smooth the way for other work attempts will be made at providing a unified load building model.

9. LOAD BUILDING

The load building procedure, described in detail in chapter 4, is to pick orders from a broad delivery area file until a van load is obtained and then to route the deliveries.

Unlike vehicle scheduling packages the orders are not filed in any way dependent upon size, but solely upon date of receipt by the department. Ranking by size would be difficult with the existing model.

The load building model was developed in the days of flock mattresses, a 4'6" mattress when rolled was equivalent to 1 unit. As interior sprung mattresses were developed the model was simply re-applied.

Slumberland Ltd, use the same model except that, having smaller vehicles, their van load figure is less. As the companies merged only in 1970 there was no possibility of joint development of load building models.

With the production of upholstery at Tipton a new unit, uph unit, was produced.

The builders of the theoretical loads have no contact with the loading bay and hence there is little feedback on the validity of the model. The feed-back system is such that the load building clerks know of problems only after the vehicle has been loaded and checked out at the traffic office.

Van Full (VF) situations arise when the model breaks down because either the van is smaller than standard or the products are bigger, but little action was taken to investigate the situation.

Observations of physical load building indicated that space was unused in vehicles. This, combined with the apparent inflexibility of the model and the different sizes of vehicles, prompted investigation into load building.

Had a suitable model been applicable the economic van load and vehicle monitoring considerations could have been started much sooner.

9.1 Economic considerations

An accurate load building model affects transport costs because fewer items per load means more loads. Product costing at Vono Ltd. includes an allowance for carriage, being 6.6% of the trade price (by comparison direct labour costs are budgeted as 6% of trade price). Because of the company's sales policy the invoiced price can be less than the quoted trade price and carriage allowances would therefore appear to represent more than 6.6% of actual trade price.

The cost accountants have a model for carriage charge as below:-

> Assume a 1750 cu.ft. van can take x of product A, if 90% full on average, then 0.9x products constitute a van load.
>
> Average miles/load = Y at p pence per mile but 22½% of all products go through depots with an overall average extra mileage Z at p pence per mile
>
> $\therefore$ carriage allowance/product = $p \dfrac{(Y + 0.225Z)}{0.9x}$

It should be noted that the cost of delivering to depots is not included as depots deliveries are not recorded as mileage journeys. Every year cost p has been raised by 10% except for 1972 when the increase was 25% (it had been shown by earlier work that the company was grossly under-recovering, raising the allowance was easier than co-operating in investigating the situation in detail).

Having a carriage allowance per product and a cost per mile an economic van load can be defined as that load whose total carriage allowance is equal to, or greater than, the mileage charge expected. This is one of three alternative definitions which were put to the Vono board.

9.2 Model investigation

Table 9.1 indicates the volumes of products and the load building units, it being apparent that cubic feet per unit varies considerably. As depot loads are single delivery loads no space should be wasted because of reverse delivery order stacking. Table 9.2 indicates the theoretical volume used on such loads. The figures in brackets refer to the volume which would have been used had products not been left off as VF. Had the volume of stacked chairs been taken as the volume of one chair fitted inside another rather than two separate chairs then space would have been less.

The problem was considered to be a space minimization problem and a linear program was formulated. However, it was not possible to utilize all the space although the programme fitted volume into the space regardless of length, breadth, and height, and this approach was abandoned.

Multiple correlation and regression analyses were thought to be useful means of obtaining average load building units per product based on the hypothesis that space used was proportional to products loaded. Assessment of space used was performed by the loading bay senior foreman. This man based his assessment on the space used and whether any product could have been fitted in the space left.

In the I.C.L. 1900 Statistical Analysis Package the dependent variable was van capacity used and the other independent variables the number of products. As the Durbin-Watson statistic indicated ordering between observations the number of deliveries and dummy variables to indicate loading gangs were included.

The residual error

$$r = \sqrt{\frac{E.S.S.}{\text{degrees of freedom}}} \;\hat{=}\; \text{standard deviation } \sigma$$

Therefore all loads with an error of $\pm 3\sigma$ and unusual loads, e.g. load with 99 headboards, were removed.

Running the programme at 99%, 50%, 25%, 10%, 5% and 1% significance levels, provided no evidence to support the hypothesis. Table 9.3 illustrates the theoretical volume, determined as earlier, the load building units and assessment of used space for 25 of the 50 loads analysed.

A simulative approach based on a vehicle with dimensions

24 ft. long
7½ ft. wide
8½ ft. high

and a Luton box with dimensions

7 ft. long
7½ ft. wide
4 ft. high

giving a capacity of approximately 1,750 cu. ft. was attempted.

Product	cu.ft.	load building units	cu.ft./load building unit
Penthouse type chair	33	1	33
Pentagon type chair	25	1	25
Conventional easy chair	12	1	12
Comfor type chair	23	1	23
Small studio couch	34½	1½	23
Bromley sofa	56	2	28
Waldorf sofa	39	2	19½
Wilton sofa	48	2	24
Madeley sofa	54	2	27
Dandy frame	5	½	10
Headboards	½	0	0
135 cm stowaway pallet	2½	1	2½
Stowaway	5	½	10
90 cm SE dvn	15½	½	30
90 cm FE dvn	8	½	16
135 cm SE dvn	28	1	28
135 cm FE dvn	18	1	18
90 cm 15m	12½	½	25
135 cm 15m	19	1	19
Bunk beds	21	2½	8½
Rolloway	12	½	24

Table 9.1 Volumes of Products and Existing Load Building Units

Load No.	Vehicle capacity cu.ft.	Capacity Used cu.ft.	% Total Available
5553	1750	1069	61
5774	2000	1203 (1753)	60
4479	1600	1189	74
4801	1750	1247 (1484)	71
6107	1750	1489	85
4926	2000	1023	51
6179	2000	1372	69
6474	2000	1764 (1848)	88
6554	2000	1128	56
6079	1750	1065 (1398)	61
6430	1600	1233 (1341)	77
6335	1750	1150	66
6178	1750	1237	70

Sample

Table 9.2 Theoretical Volumes used on Depot Loads Using Existing Model

Load No. (Stats input)	Load Building units	Vehicle Capacity cu ft.	Assessment of Capacity Used cu ft.	Theoretical Capacity used cu ft
1	80	1850	1570	1535
2	57	1750	1575	728
3	40	1250	1120	538
4	65	1850	1400	1096
5	27	1750	1750	579
6	31	1750	1575	1171
7	65	1500	1500	1564
8	50	1750	1575	1164
9	53	1750	1750	1313
10	66	1750	1750	1569
11	60	1750	1750	1100
12	57	1750	1660	1145
13	45	1500	1500	960
14	43	1750	1400	861
15	43	1750	1750	709
16	80	1850	1850	1271
17	95	1850	1850	1013
18	47	1750	1575	1247
19	63	1500	1750	887
20	54	1750	1575	1128
21	41	1750	1750	924
22	49	1750	1575	1168
23	57	1750	1750	1479
24	40	1500	1350	923
25	38	1500	1500	971

Table 9.3 Theoretical Volume Used on Loads Statistically Analysed

Products were separated into

sprung edge beds
firm edge beds
upholstery

Table 9.4 illustrates the results for bedding

Product	Maximum Number	Unit Volume cu.ft.	Total Volume cu.ft.	Unused Volume cu.ft.
135 cm SE set	29	43	1247	503
135 cm FE set	37	33	1221	539
90 cm FE set	62	22	1364	386
Penthouse chair	40	33	1320	380
Seftonsuite	11	118	1360	350

Table 9.4 Unused Space in Vehicles

Upholstery storage will differ for every piece of upholstery but for the Sefton suite approximately 400 cu. ft. was not used.

Based on the size and stacking potentials of all products it was concluded that heights above 8 feet 3 inches were unnecessary. Unfortunately distribution management ignored the findings and insisted on 8 feet 10 inches high vehicles in order to obtain 1,750 cu.ft. capacity with the new demountable vehicles. As product mix per vehicle isfar from constant and statistical analysis had not clarified the situation an elementary model was considered. For each product the maximum number per van load was obtained by iconic modelling, each product then being allocated a percentage figure of a van load e.g. 40 chairs to a van, therefore 1 chair = 2.5 units

100 beds to a van, therefore 1 bed = 1 unit

It was found necessary to combine upholstery products into groups similar to those proposed in chapter 3.

Advantages offered by this model are that all products have equivalent base units and therefore the company can set meaningful minimum van load capacities, and also a differential exists between firm edge and sprung edge divans, also load building would rely less on intuitive thought processes of clerks. The model caters for mixed loads as unused space is included in the calculations. Table 9.5 compares this new model with the existing model.

Product	Existing Load Building Units	Proposed Load Building Units
135 cm SE set	2	3.5
135 cm FE set	2	3.0
90 cm SE set	1	2.0
90 cm FE set	1	1.5
Bunk beds	2.5	2.0
Sefton or conventional suite	4 uph	9
Sefton or Conventional sofa	2 uph	5
Sefton or Conventional Chair	1 uph	2.5
Penthouse type sofa	2 uph	5.0
Madeley & Linear type suite	4	6
Madeley & Linear type sofa	2	3
Madeley & Linear type chair	1	1.5
Full Load for 1,750 cu.ft. Van	60 or 40 uph	100

Table 9.5 Proposed & Existing Load Building Models

Attempts at application have indicated its potential. Table 9.6 indicating load number, old units, new units, product additions and comments. The model has also been offered to the accounts department as an easier and more accurate carriage allowance calculator.

For example if the average mileage/load = 350 miles

then the average cost/load = 350 x A

then the average cost/unit = 3.5 x A

where A = mileage rate charged by Vehofreight.

This system can be built into the ideal system discussed in chapter 11. By law a carriage charge must be indicated in the purchase tax calculating price, although this can be as low as 2½% where it is difficult to determine carriage costs. Work on vehicle monitoring had indicated that Vono was under-recovering on transport costs, consequently all carriage allowances were raised by 25%.

The proposed model enables the carriage allowance per unit to be obtained based on the same mileage assumptions per load as the existing model.

Table 9.7 compares carriage charges for a range of products by the proposed load building model with the existing carriage allowances.

Load No.	Existing Units	Proposed Units	Comments
3049	68	92	reasonable load
3050	38 uph	85	Two Madeley suites added, extended load loaded, 97 units
3106	56	94	
3120	50	81	Space available but nothing could be added, no orders in file
3126	58	103	Problem with suites
3125	40	83.5	Nothing could be added, no orders in file
3052	38 uph	80	One suite added to give 89

Table 9.6 Preliminary Test of Proposed Model

Product	Existing Carriage Allowance (£)	Proposed Carriage Allowance (£)
135 cm SE set	2.10	2.24
135 cm FE set	2.10	1.89
90 cm SE set	1.20	1.26
90 cm FE set	1.20	0.945
Bunk bed	2.20	1.58
Stowaway	0.314	0.314
Rollaway	0.472	0.472
Sefton or Conventional suite	11.65	5.67
Sefton or Conventional sofa	6.99	3.16
Sefton or Conventional chair	2.33	1.26
Madeley type suite	5.73	3.78
Madeley type sofa	3.41	1.89
Madeley type chair	1.16	0.945
Penthouse type chair	2.33	1.58
Penthouse type sofa	4.65	3.16

It has been suggested that upholstery allowances be increased by varying amounts to obtain break-even.

Table 9.7 Existing and Proposed Carriage Charges

REVIEW

No significant relationship was found between products loaded, space utilised and the load building units derived from the existing load building model. Anomalies were also found between the theoretical volumes loaded, defined as the volume of a cuboid with the overall dimensions of the product, and the size of vehicles.

A model has been proposed based on the % of a large van load for each product, or product group. The model was develope after attempts at three dimensional space minimization were abandoned.

The model has the main advantage that all products are based on a common unit and consequently load building with different product groups becomes simpler. It is also possible to specify minimum van loads capacity figures and to readily check that these are being observed. Smaller vans, e.g. 1,500 cu.ft., would pose no problem as the maximum value would be reduced proportionally. Trials with this model indicated that it was possible to load more products into apparently full loads obtained by the existing model. From limited trials one to two suites of furniture, approximately 10% extra, was added to loads.

Carriage charge allowances, built into the selling price of all products, were recalculated based on this new model. Extensive trials of these charges by the company's accountants resulted in a very favourable recovery performance compared with the existing charges. Averaged over 250 loads the transport cost recovered in the selling price was much closer to the actual transport bill than the existing charges.

The most noticeable effect of the new charges was that contributions to general overheads of one of the best selling suites was increased by over £5 per suite. This aspect of the new carriage charges should assist the sales staff in their promotional effort.

From February 1973 the proposed carriage charges outlined in Table 9.7 will be built into the company's pricing procedure.

Because of the ease of applying the new load building model a procedure for obtaining the marginal cost of urgent or wrongly delivered orders was developed in May 1972. To date (October 1972) this has not been implemented by Vehofreight personnel, details are included in Appendix IX.

10. MANAGEMENT INFORMATION SYSTEMS ESTABLISHED PREVIEW

During the period of the research it became apparent that potentially useful information regarding the transport operations and sales analysis by town was not being used. Associated with the transport operations information is information on total finished stocks, free stocks, allocated stocks and stocks in transit.

Attempts will be made to collect relevant information to analyse it and to present it to senior management in a viable form.

Although the systems are presented towards the end of the thesis this does not imply that they are to be considered the last things to put right. Conversely it is believed that the establishment of efficient management information flows is th most critical factor in attempting to control a company.

10.1 Vehicle Monitoring

There were two aspects of vehicle monitoring considered by the author to be necessary for Vono Ltd.,

i) monitoring of each vehicle and contractor with respect to earnings and other statistics

ii) monitoring the ratio of budgeted carriage charges to actual transport costs

This form of analysis had not been available within the company prior to publication of the February 1972 figures by the author. Negotiations on mileage rates with contractors had been based on average figures published by the Road Hauliers Association and little evidence of actual expenses for Vono delivery operations.

10.1.1 Systems and Objectives

(i) Vehicle and Contractor Monitoring

Data collection involved, initially, completion of a form by traffic office personnel for every vehicle delivering Vono products.

The forms were to be completed when the drivers returned their green way bills, the mileage paid by Vehofreight (thereby claimed from Vono) would be obtained when the traffic office personnel checked the white way bills (invoices) before passing them to the accounts department.

Every month the data would be analysed to provide details of every vehicle and also the average order size and a measure of vehicle utilisation fleetwise. Table 10.1 illustrates one month's analysis.

The main objective of the system was to provide Vono senior management with information on the cost and efficiency of distribution of their products to assist in negotiation of haulage rates with Vehofreight. Also by comparing data on rigid chassis vehicles with data on demountable body vehicles could alternative distribution policies be examined.

(ii) Carriage Allowance Program

This system involved comparing the total budgeted carriage allowance per load with the actual carriage charges, noting the load number and invoice value of products comprising the load. Vehofreight invoices were matched against invoiced loads, using Vono's cost master file to generate sales values and carriage allowances. The objective was again to provide senior management with information hitherto only contained in the operating statement issued by the management accountant. It would also be possible to check instantly loads which appeared to be under-recovering transport costs. Alternatively by having load numbers from deliveries in a given area it would be possible to check on the cost of supplying that area. It would also be possible to observe the effect of changes in policies regarding "van full capacities".

10.1.2 Results and Discussion

(i) Vehicle and Contractor Monitoring

Problems arose with the style of form when the system was being discussed. Vehofreight personnel considered that knowledge of miles claimed by drivers was information to which Vono were not entitled.

It was the author's intention to use this information to test the hypothesis that drivers with low utilisation ratings would attempt to claim excess mileage to boost their earnings. The author having determined from the contractors that drivers were paid a bonus for every mile over approximately 700 miles per week.

The hypothesis was disproved but the results brought to light certain misunderstandings concerning the rate per mile payable by Vono to Vehofreight. An extra mileage claim was observed on the way bills which gave say £y per load. Vehofreight were permitted by their contract with Vono to charge £y per load extra for hourly rated journeys as their hourly payments to the contractors were equal to their hourly payments from Vono.

This anomaly in the contract was brought to the attention of the financial director who, with the managing director, successfully re-negotiated the relevant clause and recovered the excess charges. In itself the figure was small, only £6,000, but vehicle monitoring had firmly established itself as a useful management information system.

It became difficult to obtain the full co-operation of Vehofreight personnel following the above as the author had no position nor authority to demand information or co-operation from anyone in Vono. Vehofreight were concerned at apparent investigations into their earnings by persons not employed by either themselves or Vono. To overcome this, it was decided to experiment by using the green way bills used by Vehofreight as their reference copy. Analysis of these took over 3 days per month whereas a full analysis of the earlier forms could be performed in less than ½ day.

Not only was the time factor unacceptable but the data was such that accurate results were impossible. The green way bill is the bottom of a self-carbonning set of six copies and consequently it was sometimes impossible to read the contractor's name and/or the vehicle registration number.

This caused inaccurate information regarding the numbers of vehicle per contractor, the vehicles operating all the period, loads/vehicles/week and earnings per vehicle and consequently return on investment by the contractors. Monitoring of demountables will also be confused although no information, accurate, readable or otherwise has been obtained since 1st June, 1972. Action by the financial director was required to obtain information for April and May 1972.

Where information was legible it was impossible to determine the following based on four month's figures:

1) No contractor operated the same number of vehicles every week in any month.

2) Excluding Quedgley, depots and similar one drop loads, the average drops per load was approximately 12.5 (in September 1970 it was 13.7).

3) Average loads/vehicle/week was 2.15 across the fleet as a whole (in September 1970 it was 2.1)

4) No information was available from Vehofreight regarding registration numbers of vehicles on contract.

5) Earnings per vehicle assuming vehicles were operating all the period were below the accepted figure of approximately £90/week, hence the contractors were losing money or working elsewhere or unaware of the position, or having fully depreciated their fleet were not re-investing.

Since February 1972 Vono staff have been checking each load for mileage and regularly referring excess claims back to Vehofreight.

In conclusion, the system is not generating the anticipated results through lack of total co-operation by all concerned.

To provide Vono with usable information I would suggest a return to the forms used originally and a note of all vehicles meant to operate from Vono.

(ii) Carriage Allowance Program

The initial program VT01 printed carriage charge and load value only. A further program was developed by the author (VT05) to make more detailed comparisons.

This relied on matching invoices from Vehofreight with data on loads obtained from Vono's cost tape file. Results indicated gross under-recovery of transport costs on every load. Re-checking of the program resulted in the same answer, except that a list of products unmatched with the master cost tape (and the load numbers from which they come) indicated faults with Vono's systems.

The master cost tape contained products in home retail with no carriage and/or labour charges. Matching this with the unmatched products from VT05 indicated that products on the unmatched lists were not on the master cost tape, although a product selling price for the products was printed out.

Problems also arose with receipt of Vehofreight invoices over a 3 month period. There were loads from May which were unmatched in August. There were also loads for which no details of products were available, it was assumed by the author that these must be amendments to previous way bills where Vehofreight had underpaid the contractors.

Depot loads showed up badly as stock items are not invoiced, consequently a gross under-recovery was indicated.

It was decided with the financial director in July 1972 to run the program on a 3 monthly basis because of the haphazard invoicing procedure being followed by Vehofreight Ltd. This would also enable the accounts department to analyse the unmatched tape printout and amend the cost master tape.

10.2 Conurbation Analysis

Sales analyses performed by the marketing department staff were used mainly to assess sales representatives' performances against targets. Consequently the figures were total numbers of each product demanded by sales areas per month. The figures took no account of the type of tick or the size of beds or the type and colour of material on upholstery products. Being manually collated, from computer analyses, for tabulation meant that there was at least one week's delay in publication.

Information presented in chapter 3 was not available within the company prior to its publication.

Monthly sales values, by date of invoice, were also available from computer analyses. Representatives were controlled mainly by sales value targets although targets on volume were also issued. These figures would not agree with the above because of the long lead times on upholstery products.

Information was also available for each account detailing cumulative sales by month. As there were between 6,000 and 9,000 accounts analysis of this would have been difficult.

No information was available of major conurbations which the company might consider as test areas.

10.2.1 System and Objectives

Monthly analyses referred to above were performed by accumulating weekly data on tape in the computer department. To provide weekly analyses this weekly tape was used.

Customers are coded such that the first two digits of the code number specify a standard Geographia marketing region.

Using I.C.L. Sort Programs it is possible, by specifying these numbers as the search parameter, to obtain all orders coming from selected Geographia marketing regions, or, as referred to here conurbations.

Orders placed directly on the Tipton factory are identified by the letter T (hence T No. orders), while orders placed on a depot bear different letter prefixes. Therefore by sorting conurbation orders into T prefixes and others the percentage of orders from a town within a depot area placed directly on Tipton can be determined.

The main objective was to enable promotions and other marketing policies to be studied in selected major conurbations. For trial purposes conurbations were selected by the author from data collected during the formation of table 3.2 in chapter 3.

10.2.2 Results and Discussions

The main objective of studying marketing strategies was not followed up by the company. This was partly because data concerning the timing and type of promotions was not collated. People had an idea that such and such a promotion had occurred but details were very hard to determine.

Live running of the program indicated that towns within depot areas preferred to order directly from Tipton rather than from the depot. The company considered this to be a major finding, although this fact had been reported throughout the research programme. Another use the sales management saw was to check representatives' performances in different conurbations within sales areas.

To this end the sales management suggested modifications to enable search parameters for conurbations to be changed by them weekly.

Shortly after the development of the programme the marketing department was made redundant. Consequently data concerning sales per region were not published until sales clerks were allocated to the function two to three months later. Longer delays were experienced before publication of data.

Attempts at comparing sales values from the programme with sales values per sales area were unsuccessful. The only sales values available up to October 1972 were three monthly totals used for sales representatives' bonus payment calculations.

Consequently the system was handed over to the sales management to use as they wished as the objectives behind its development could not be met.

Table 10.1: One Months Vehicle Monitoring Analysis

February	Contractor Reference												
	A	B	C	D	E	F	G	H	I	J	K	L	M
Vehicles Total	2	2	9	2	12	4	11	4	13	4	2	11	5
Op. All Period	2	1	1	2	9	1	5	3	7	2	0	5	2
Total Loads in month	18	16	39	14	83	19	65	34	62	22	4	55	29
Av. loads/week per vehicle	2.25	2.25	1.8	1.75	2	1.75	2	2.33	1.3	1.5	2	1.8	2
Range of loads/week	2.25	$2^1/_3$-$2\frac{1}{4}$	1-$2\frac{1}{4}$	1.75	$1\frac{1}{2}$-$2\frac{1}{2}$	$1^1/_3$-$2\frac{1}{4}$	1-$2\frac{1}{2}$	2-3	1-$2\frac{1}{4}$	$1^2/_5$-$1\frac{3}{4}$	2	$1^2/_3$-$2\frac{1}{4}$	2
Av. drops/load incl Depots	9.2	9.9	10.3	9	7.5	9.15	7.7	5.3	7.85	9.5	7.25	11	10.5
Av. drops/load excl. Depots	15.3	13	12.9	13.5	11	12	11.7	6.15	11.4	13.5	9.3	15.2	13.6
Depot loads (+ single drops)	7	4	11	5	26	5	25	5	21	7	1	14	8
Vehofreight Payments 1) Total £	872	775	1786	910	3907	1035	3144	1743	2789	1114	162	4148	1223
2) £/veh/week (if assume all vehicles all time)	109	97	47	114	81	64	71	105	55	140	20	93	62

REVIEW

It was possible to utilise existing information to provide a more detailed analysis of the distribution function than had been available prior to the research programme. Vehicle and contractor monitoring, carriage allowance recovery analysis and conurbation order intake analysis systems were implemented with minimal disruption to the normal office work.

The original results highlighted problems with, interpretation of the contract between Vono and Vehofreight concerning payments, the updating of the cost master tape and sales demand data availability within the company.

However, the first two systems are now, October, 1972, fully operational and generating information considered by the company as necessary to efficiently control the distribution function. The conurbation analysis is under investigation by the sales management but not as a marketing strategy analysis tool.

Implementation of these systems demonstrated to the company the problems of relying on data processing staff to update programs without a formal review procedure.

11. TRANSPORT COST MODEL AND A PROPOSED ORDER HANDLING SYSTEM PREVIEW

Vono Ltd. does not budget for transport costs to vary with output to different sales areas. The mileage rate payable is assumed to rise by 10% per annum, which is the average increase in road haulage rates forecast by the Road Haulage Association.

As Vono only pays for miles travelled it should be possible to model the situation, however roughly, to provide a broad guide to expected transport costs.

Throughout the earlier chapters comments have been made regarding the unsuitability of various computerised techniques to the Vono situation. These were not meant to refute the usefulness of the computer itself but rather to indicate the drawbacks of the various techniques.

Assuming SISSIM can be developed to the stage of live running the reorganisation of existing data or files should open new fields of computer applications. One field is a totally integrated order handling, stock update, production scheduling and vehicle routing system. Although ideas on this field have not been worked through modules of it will be discussed and future work suggested.

11. TRANSPORT COST MODEL AND A PROPOSED ORDER HANDLING SYSTEM

11.1 Transport Cost Model

Except for depot deliveries Vono pays for the delivery of home retail products according to miles travelled. There are no additions for waiting time at Tipton,waiting to be loaded or for overnight lodgings expenses incurred by drivers. Consequently a model to determine the theoretical transport costs would only need to consider the total mileage to be travelled.

One approach would have been to determine the number of loads going to each account, and therefore the total mileage. However, there were over 9,000 accounts operating at the time and individual accounts did not order van loads at a time.

The load building model in use by the company differentiated between bedding and upholstery products and therefore separate loads of each would have to be assumed. Complicating this matter was the fact that there was no policy regarding what constituted a van load.

It was decided by the author to base the model on loads to sales areas, delivery points being towns. The total number of bedding and upholstery products delivered to each area for 1971 was determined from sales office records. By dividing by relevant factors for upholstery and bedding the number of van loads to each area was obtained.

The number of loads to each town was assumed to be proportional to the ratio of that town's turnover to the sales area's turnover for 1970 (the last year for which data was available). This apportionment was repeated until no complete loads were possible. The remaining loads to the area were then given an average distance from Tipton for that area unless more than half the remaining towns were greater that this average distance from Tipton. In these cases the mileage allowed was greater than the average.

Vehicle monitoring, chapter 10, had indicated that there were approximately 12 deliveries per load. Under the old Vono contract with vehicle owners an allowance of 2 miles for every delivery over one in each town was allowed. Therefore 25 miles were added to the mileage for each load.

The cost of delivering to depot areas was simply the unit cost of each van delivery multiplied by the number of loads. However, London depot only handles bedding products. Also Attleborough and Ynysybwl depots were closed in September 1971 and Belfast depot was closed in October 1971.

11.1.1 <u>Results</u>

Table 11.1 compares the theoretical loads in total and to each depot with the actual number recorded by the distribution department.

	Theoretical	Actual
Total loads	1,376	1,703
London depot loads	91	143
M31 loads (Attleborough)	35	27
M34 loads (Ynysybwl)	34	25
N47 (Stanley)	54	57
Scottish loads	178	91
Irish loads	73	26
S21 (Bovey Tracey)	42	52
Cost for 3 months	£62,631	£96,375

<u>Table 11.1 Theoretical and Actual Loads</u>

11.1.2 Discussion

The records held by the company related to the total number of beds delivered, size not being recorded. Although 60 units of bedding were equivalent to a van load different sized beds had different units. Earlier work, Appendix II, had indicated that the national bed size mix was 70% 4'6" and 30% 3' giving a loading unit of 0.85 per ISM or DVN. As a result of this the total number of ISM + DVN was divided by 70.

Scottish and Irish loads are complicated by the use of ordinary vehicles and different sized containers.

London depot is complicated because of its area and the assumption that only bedding orders are handled. Some upholstery is handled by the depot but it is impossible to give this as a % of the total upholstery for the area. Bovey Tracey (S21) follows the pattern for total loads, i.e. actual is 25% above theoretical. In this case it could be that the volume of orders was not sufficient to send full vehicles. N47 results agree very well, which could be due to the fact all products went on standard vehicles only.

A discussion of the assumptions used should indicate why the model under-estimated the actual transport costs.

Assumption 1) Sales areas are equivalent to delivery areas.

It has already been indicated that sales and delivery areas bear only limited relationship to each other, except for M31, M34, S54 (until closures), S21, N47 and Scotland, i.e. depot areas.

Delivery areas are very vague as van loads are built in relation to early closing days rather than sales areas.

Unfortunately sales areas were the only entities for which demand data was available unless every account was to be analysed.

Assumption 2) Delivery points within sales regions can be nominated. Following from above it was necessary to know where products were to be delivered.

1970 sales figures, chapter 3, were used, towns being allocated loads proportional to their % of the area's turnover. In itself this assumed that 1970 sales figures gave accurate splits for 1971. It must be assumed that sales increases per town were proportional (i.e. the league table is unaltered) per year. As newer data were not available this could not accurately be checked.

For every mile wrong in locating the drop area an error of $\pm$ 2 x n x A pence is obtained (n being the number of loads to a drop area, A being the mileage charge).

This assumption places greater emphasis on the large accounts whereas the small account requiring few visits will cause routing difficulties. If deliveries to a large account can only be made by going Z miles to a small account (because of van load considerations) the small account will have a much higher visitation record.

Assumption 3) A relationship exists between load building units and van loads.

Early work on load building, chapter 9, indicated that this assumption was invalid. No relationship could be found between load building units and space utilized on vehicles. For example, loads with 70 units were found to be only 70% theoretically full whereas 60 units constituted a full load. Different sizes of vehicles and special deliveries also complicated the issue. An associated assumption is that upholstery and bedding are delivered separately. This was necessary because no unified load building model was in use at the time and the calculation of mixed loads was based on experience. There were occasions when separate loads were sent but to determine the % of the whole involves analysing every load. It was found that London and Glasgow loads could be separated and this was attempted.

<u>Assumption 4)</u> National bedding size mix holds for every area.

Data on demand/area relates to beds by name only, e.g. Arran no indication of sizes being available. The product/size/tick/mix formulated in Appendix II was used to provide an idea of bedding units to obtain van loads. It is obvious that if smaller beds, e.g. firm edge or 3' etc. predominate then fewer actual loads will be sent while if larger sizes of sprung edge predominate then more actual loads will be sent. The sales analysis by product group (chapter 3) indicated that such a situation existed, i.e. Scotland demanded smaller firm edge beds and cheaper, less bulky upholstery whereas London demanded sprung edge beds and expensive, bulky upholstery. This explanation is offered for the differences between actual and theoretical loads for Scotland and London.

<u>Assumption 5)</u> Average hourly journey is 9 hours.

This was based on analysis of local deliveries and was found to hold.

Assumption 6) No collection loads.

Damaged products are collected from customers either on special collection loads or by vehicles returning from delivering a load. During the period investigated collection loads would have been nowhere near the 300 difference between actual and theoretical loads. It was assumed by distribution management that separate collection loads would account for 5% of total costs but no attempt at stating the excess mileage on delivery loads would be made. No records were available to provide the information other than detailed analysis of all waybills.

The theoretical number of loads was 25% less than the actual indicating problems with assuming a mileage for multiple drop deliveries. It may also be that the transport bill for the 3 month period included excess mileage claims. Vono's distribution office manager is regularly referring mileage claims back to Vehofreight although such a check was not in operation in 1971.

If all loads had been approximately 65% full the modifications to the model would have produced a figure approximating to the actual. Analysis of 25 loads despatched during the period indicated however that the average was about 87% full, using the new load building model. This still caused a large amount of costs to be covered by the simplifying assumptions.

The unified load building model has been shown to produce more realistic carriage allowances and enabled more products to be loaded on a few loads. As each product has effectively a different loading unit and the existing model was in use at the time the new model was not used. One of the advantages claimed for the new model, that of determining % full of each load would be useful in any future theoretical derivation of transport costs.

Had the transport cost model been more accurate, i.e. ± 10%, then it was to have been used for depot siting investigations. The cost of installing a depot in, say, the Manchester area, would be compared with the cost of delivering to the sales areas covered by the depot.

A preliminary analysis was performed on resiting a depot in the Manchester area. Boundary areas were arbitrarily drawn, the Pennines and the Scottish border and the line from Manchester to Chester. Manchester was chosen because Conurbation Analysis results (chapter 10) indicated that Manchester and Liverpool had high weekly sales figures.

Removing the cost of delivery to this depot area reduced the transport bill by £8,000 to £9,000, the higher figure assuming the accurate total figure. Using demountable body vehicles the journey to Manchester and back could easily be completed in one day, a further reason for not moving the depot into central Lancashire. Vehicles owners and Vehofreight considered £25 to be a fair price for the journey giving approximately £5,500 for delivery to the hypothetical depot.

Based on Scotland's depot the running expenses for the depot were assumed to be for 3 months.

Work on Ynysybwl and North East depots indicated that determining the service provided to customers was impossible because of the lack of data. At Ynysybwl it was determined that delivery loads from the depot were no more than 60% full.

It was decided to abandon depot siting considerations at this stage of the project as indications were that even from the limited data available it was clear that depots would be more expensive than direct delivery. The company's view, expressed after the Ynysybwl investigation that "depots are a symptom of poor distribution management" indicated that any depot siting exercise would be received sceptically especially if the transport cost model underlying it was only of limited accuracy.

Alternative forms of transport to the depot, e.g. demountable body vehicles with drawbar trailers, could be used but because the size (and therefore rent, etc.) and siting of a depot would have to be assumed, depot management does not come under the control of distribution management, the lack of detail in demand data and difficulties in determining the service provided such evaluations were not performed.

11.2 Proposals for a Computerised Order Handling and Distribution System

Efficient handling of data within the company does not necessarily mean that a computerised system is ideal. However most of the data necessary for a fully computerised system are available in the data files in use by the company.

If SISSIM, chapter 8, were developed to provide accurate information concerning allocated orders then no allocated file would have to be input.

Briefly the proposed system is

i) receive order and prepare daily order intake tape

ii) sort tape into product types with totals (sort within product tape on delivery forecast date)

iii) read totals into SISSIM type programme to produce stock information and production schedules.

iv) allocate from the order file the number of products of each type for which stock is available.

v) sort this allocated file by town (code built into customer account number).

vi) select the first town with highest priority (i.e. lowest value of delivery forecast minus loading date) and sum all the loading values of products for this town.

vii) from distance matrix file scan all towns within 1 mile, 10 miles, etc., of this town, whichever search square size is sought.

viii) check if any of these towns have orders allocated, if so check whether they will fit into a van.

ix) check van load against minimum criterion in use at the time.

x) erase all orders loaded from the allocated order file.

xi) begin search again at i) if less than Z loads used. Z must be the number of loads the loading bay can load per working day.

Priorities of special customers can be modified to always be zero after allocation. The allocated file would have to be updated if more orders were available than is possible to load.

Areas of study needed at the theoretical level are concerned mainly with the formation of routes. The search envisaged would hopefully form concentrated routes similar to the Sussams maximum drop density theory. Starting points of routes could be anywhere rather than near or far.

It was felt that this procedure most closely parallels the Vono type ideal requirement. Assume 40 loads per day with

12.5 drops per load and 3 products per drop there would be 1,500 products at each search stage.

The company's administration system would need modifying in that load building units would have to be included in the product file (from which the order tape derives its information. Early closing days could probably be catered for by scheduling no deliveries to affected towns on those days.

Boundaries, e.g. River Mersey, could be included at the distance matrix computation stage. The procedure proposed would seek to maximise space used on vehicles (using the load building model developed during the research) and would also seek to form tight clusters of deliveries thereby minimizing the driving time between deliveries on the delivery part of the journey. The delivery part of the journey is defined as the time between arrival at the first customer and departure from the last.

The procedure is simple in that criteria for overnight deliveries are not included, no maximum mileage (or hours) per day, etc., because for the situation under investigation mileage travelled in total is important. Travelling salesmen type formulations should really be performed for every route to minimize the mileage. From the literature review it became apparent that particular formulations were felt by various authors to be better than others.

If an experienced router were presented with a list of delivery points for a single journey it is believed that he would be able to route them efficiently using a map.

One problem to be overcome would be running costs because at present allocation, routing, and traffic clerk duties employ 9 people (excluding Vehofreight personnel) with approximately 3 to 5 in production control. Assuming 12 people gives a cost of approximately £24,000 per year. Approximately 3 people would have to be retained for routing and traffic clerk duties, and production control would insist on 2 at least hence the savings possible assuming that no mileage is saved would be £10,000 less running costs.

Because of the apparent inflexibility of the theoretical system it was felt that the company would not sanction development. A similar routing procedure based on J. Lyons & Co.'s approach is therefore offered.

11.3 Proposed Manual Routing Procedure

At present routers maintain a batch of orders for broad delivery areas filed according to receipt date. This receipt date is the date the order was received by them, not by the company. Only by checking the files can the router assess the feasibility of loads to a given area. There is a move towards separating the routing and load building functions, the argument being, that if one man routes all the loads then mileage problems with Vehofreight can be resolved easily.

A proposal was made in April 1971 to provide for a pictorial representation of the availability of orders for loading. The proposal would have removed much of the mystique surrounding load building and routing but was complicated by the load building model in use at the time.

This complication had been overcome by the development of a new load building model (chapter 9).

A large scale map, 10 ft. by 6 ft., of England and Wales would be essential equipment. It was originally suggested that a Geographia Marketing Map be used as this would not confuse anyone with detail. Adopting a colour scheme according to the early closing day of the major town would enable marketing areas to be simply classified. If pre-allocation were not implemented then coloured pins could be used to indicate the number of available load building units in each area. Routes would thus build up continuously and be seen all the time. Visual checking of all loads would, I believe, lead to greater efficiency. Detailed routing could be performed with reference to maps by routers or by Vehofreight personnel.

If pre-allocation were accepted then the only difference would be that the routers would plan routes for the day after next, etc., rather than today.

Filing of orders by the routers would have to compromise between the present system and alphabetical by town.

Although a schedule of deliveries is published it is very general. By having a map shaded according to early closing days then alternative schedules may be indicated.

The company were receptive to the idea in April 1971, but Vehofreight personnel were not co-operative. Recent suggestions to the distribution office manager resulted in a lack of interest.

REVIEW

A transport cost model based on deliveries to towns within sales areas rather than to individual retail outlets was developed. Over a three month period the model gave transport costs as £62,631 as opposed to £96,375 actual. Allowing for 60% full loads would have led to an accurate model, however analysis indicated that loads during the three months investigated were nearly 90% full.

The model was not accepted by the company as accurate enough for use.

A theoretical order handling system has been discussed based on using SISSIM (chapter 8) and the present order-tape preparation system. The company did not sanction development of the system although interest was expressed in a proposed manual routing procedure.

This procedure used a 10 ft. by 6 ft. map with colour coding for early closing days. The advantages of this routing procedure over the existing manual one is that all routes can be studied during build-up of orders.

12. DISCUSSION

12.1 IN RETROSPECT

Physical distribution management within Vono Limited was an ill-defined function in October 1970. There was also little co-operation between the distribution manager and the transport manager.

Although there were no finished stock control policies the distribution manager had responsibility for the warehouse. It became obvious that the ideas this man had on implementing a stock control policy had not been analysed by him in detail. The layout and manning of the warehouse and the associated order processing systems were accepted without question by all.

The transport manager dealt with the individual vehicle owners on matters of contract and queries on mileage claims. This function arose after a strike by Vono drivers in the mid 60's when Vono decided that they could have a more peaceful distribution function by hiring vehicles on long term contracts. The majority of the drivers are non-union men and the factory has none of the restrictive elements noticeable at Slumberland where the vehicles are company owned and the drivers are company employees and union members.

Routine settlement of mileage claims was performed by a traffic office clerk.

It was against this background that the project was conceived, as improving the distribution function by computerised vehicle scheduling.

Initial investigations into the size of fleet leased by Vono indicated even more the lack of definition and appreciation of physical distribution management which had evolved in the company. Although the information was available it was not reaching the new board of directors who consequently criticised the number of vehicles the author reported Vono itself was operating. The board also had little confidence in the procedure for settling mileage claims especially as the methods laid down in the contract were being abused. Odometer readings were meant to be taken to record mileages for journeys or if broken then the road mileage taken from a map.

If the odometers were working, checks were often not made of the actual reading reported by the driver or whether the reported figure was reasonable for the journey.

The information supplied to the board by the author, Appendix V, was used to brief a firm of consultants D.W.Wilson, (International Distributors) Limited, who took over the distribution management function on 1st November, 1970. This firm had experience of distribution as a forwarding company, i.e. persons requiring goods to be moved would contact them and they would in turn contact hauliers. Their profits came from the difference in haulage rates charged to, and by them. Under the terms of the agreement between Vono Limited and D.W. Wilson Limited, the role of consultant would change to that of an agent for Vono after one month.

D.W. Wilson Limited changed its senior management and its name in February, 1972. To avoid confusion their present name, Vehofreight Limited, will be used throughout this discussion.

The board of directors of Vono Ltd. decided to employ agents to handle their transport operations to ensure a period of stability while they concentrated on the production and selling aspects of the business. By agreeing a mileage charge annually time would not be wasted in arguing with twelve separate companies at more frequent intervals

Vehofreight own no vehicles, do not route loads nor interact with the load building/vehicle routing procedures, do not allocate products to orders and do not employ any drivers.

They derive their profit in exactly the same way as a forwarding company, charging slightly more for their services than they are charged. This could be construed as a fee per mile travelled, although this is denied by Vono and Vehofreight. Vono negotiates a rate per mile with Vehofreight annually and reserves the right not to raise the freightage figure if they consider the operation unsatisfactory.

Appendix VI compared Vehofreight charges with what Vono could have expected to pay over a 4 month period in 1971. The board of directors have agreed that the £36,000 calculated as the minimum gross annual earnings of Vehofreight is the savings possible if Vono operated the distribution function efficiently. However, they consider that this is their cost of ensuring that they have trouble-free transport relations until their production and selling problems have been solved. The analysis enabled Vono management to put a value on procrastination in the distribution area and also to set a reasonable target for their own management when the reorganisation period ends. This period was stated as two to three years of October, 1970.

One measure of distribution efficiency advanced by Vono is the transport bill to sales value ratio. This has fallen during the two years to September, 1972, but it is maintained by the author that this does not reflect distribution efficiency. Not only have product selling prices increased more than transport costs, but more expensive products have been introduced. The ratio used by the company includes all sales although only Home Retail are carried on transport under contract to Vehofreight. However, Export carriage charges were reduced substantially by Vehofreight by using selected contractors.

A better measure of distribution efficiency has been suggested (Chapter 10), vehicle monitoring. This would indicate the operating level of the fleet and also the level of earnings per vehicle. Only from such detailed work can realistic mileage rates be determined. Unfortunately, implementing the monitoring system caused problems to be highlighted which indicated that the services of Vehofreight were costing in excess of the £36,000 mentioned earlier.

Discussions with Vehofreight directors in August, 1972 revealed that accurate earnings and operating statistics of all vehicles were not maintained by them even though they were entrusted with negotiating mileage rates on Vono's behalf. It could be that the Vehofreight management in charge of the operation felt that Road Haulage Association statistics were sufficient to agree rates. Results of vehicle monitoring indicated that Vono must monitor the operation of the agents and subsequently, all mileage claims were thoroughly checked.

The situation is now being reached where Vono controls all aspects of transport except the booking in and out of vehicles and discussions with contractors. It is to be hoped that this is part of a gradual phasing out of Vehofreight as agents. Results of this research have indicated areas of concern in distribution management and these have been accepted by the company.

The return on this investment in Vehofreight cannot be detailed although it appears a high premium to pay for trouble-free distribution. Payment of this figure only highlights the difference between academic research and business decision making under conditions of change where negligible information is available.

It is not possible to comment on the various alternatives considered by the company before selecting Vehofreight but it is possible to state certain constraints imposed on them by Head Office. As far as possible the livelihood of the existing contractors had to be maintained, i.e. their contracts could not be severed as the majority have over 4 years to run.

This ruled out British Carriers type operations where the company would lease vehicles from the company responsible for delivering.

Introducing agents to handle any function inside a company must cause organisational problems. As defined in Chapter 1, physical distribution management is an integral part of a company's operation and does not mean just routing loads and agreeing mileage rates.

At meeting to introduce Vehofreight to the contractors problems of trust arose which took over one year to settle. The Vono distribution staff were themselves sceptical partly from the lack of management information on the change and partly because incentives to reduce mileage were not clear.

Alternative forms of payment to Vehofreight based on a straight fee increasing as the transport bill decreased, depending on business activity, might have provided a sounder basis for arriving at an efficient distribution system.

Because of the nature of the order processing system problems would have arisen with any change of distribution management involving an outside company. Control of allocation, load building, vehicle routing and scheduling hold the key to success in distribution but these functions are deeply built into the Vono management system. Until the research project was into the second year questioning the whole procedure, other than computerising vehicle routing, was not being done. The inter-action of the factors with inventory levels and production schedules was not appreciated but evidence is that now the departmental barriers are being peered over with a view to dismantling them eventually.

This inter-departmental approach became more evident after the appointment of the new production director (appointed 1st August 1972, appointed a director 21st November 1972).

On his appointment he was given, by other members of the board, copies of the author's work relating to warehousing. His reaction was immediately favourable and he commented to the IHD supervisors that it was gratifying to be appointed to a position and be given detailed analysis of one major area complete with recommendations.

This reaction was even more gratifying to the author who had spent time visiting automatic warehouse installations and discussing alternative systems with suppliers, with very little positive reaction from the company. Through the periods of depression resulting from no reaction the driving force behind the work was the belief that change was inevitable and when it came, and objective analysis of the situation would be valuable.

Throughout the research all proposals made by the author had been discussed with the company but because the decisions on each were taken by different people there was a ragged appearance to the work.

Acceptance of the warehouse analysis by a man experienced in warehouse and production control provided a much needed injection.

In effect this acceptance confirmed the belief that distribution management within the company was to be more than vehicle routing. Efficient use of the warehouse depended on the storage rack design and inventory policy principles,
rather than finished product stock, manning operations, vehicle turnround times and the type of vehicles to be used.

Although decisions regarding the above, and many other items, had already been taken this was the first time that the author's views regarding the whole problem had been accepted as a whole.

One man was appointed responsible for production scheduling and control, and warehouse layout and control and another responsible for allocation, load building, vehicle routing and vehicle scheduling. Both men were to report directly to the production director. Although it had been recommended that one man should be responsible to the board for physical distribution management, not to include production control, the production director obviously decided to make the best use of available talent.

Behind these appointments lies the realisation that physical distribution management is a definable management function knowing few of the conventional management boundaries. How far this uniting of functions and removal of barriers goes is open to conjecture but it is known that the research programme has laid the foundations on which to build an important management function capable of controlling a once little discussed problem.

12.2 COMMENTS ON FUTURE DEVELOPMENTS.

Whether the role of physical distribution management becomes a line of staff function is a question only the company can settle. A staff role would be easier to install and could be the first step to an entirely separate function. As staff roles are usually planning roles they could lead to problems with managers responsible for particular functions.

On the other hand, a line role would involve controlling the efforts of personnel doing the jobs. Problems could arise with managers of established functions who see their authority and responsibility decline rapidly.

Whichever the company decides will lead to a complete rethinking of the management structure within the company. The approach of the production director to slowly build up different aspects may in time lead to a painless transformation.

A knowledge of demand by location and also time would assist the planning of distribution. Vono Ltd, has no market research department probably because the bulk of its turnover comes from multiple stores employing central buyers.

. Regardless of this, analysis of sales on a regular basis would assist the salesmen selling to stores. Promotional offers could also be directed to the right products for each region. Analysis of demand by sales area indicated definite regional tastes but also underlined a basic weakness.

Approximately 50% of all shell upholstery produced in 1971 was demanded by the Southern region. As shells accounted for almost 50% of all upholstery demand in England there was a strong dependance on one market for one product.

The shell furniture being produced in 1971 was showing a definite decline in demand indicating the fashion trend in this type of upholstery. Unfortunately, the company have not commented on the analysis either from a market intelligence viewpoint or as a factor in distribution. Shell upholstery is very light yet bulky and is easily damaged, hence because of its high price poses distribution problems.

Furniture developments along the shell upholstery theme are progressing in the company. It is easy to produce, unskilled labour is required to produce the frame but long runs have to be guaranteed to recover the cost of the dies. It is apparent therefore, that the trend in upholstery from this companyis likely to be modifications to shell suites, for example, swivel bases on originally static chairs, with shape changes approximately every two years. Conventional upholstery will be gradually uprated until all turnover will come from the fairly luxurious end of the market, selling in the shops for between £190 and £499.

Such developments I feel require deeper understanding of the factors influencing the consumer to choose a certain product.

Company reports of upholstery and bedding manufacturers have indicated a buoyant market over the last 18 months and it is assumed that these companies have participated in the consumer spending boom. Margins have improved due to greater production runs in mass production units like Vono which improves their position under phase II and phase III of the anti-inflation procedures. It is difficult to determine the volume increase in upholstery although the value index based on 1966 = 100 has risen from 109 for 1970 to 138 for 1972.

Without deep analysis of the market forces affecting the purchasing of upholstery the company has formulated a marketing policy. Basically the company are speculating on the belief that people want expensive furniture. Furniture has ceased to be a 'need' and has become a fashion item effectively, and satisfying this 'want' with high price, high margin products is where the company sees its future. Although such speculation on fundamental market changes may hold in the short turn without full analysis of the company's strengths and weaknesses and the underlying factors affecting demand the longer term could involve costly policy changes.

The sales area comparisons, chapter 3, provide an indication of performance and if performed regularly would indicate any changes.

Although upholstery manufacturers have enjoyed a boom situation over the last 18 months the bedding market has been relatively quiet although indications are that the wholesale price index for 1972 will be approximately 156 (based on 1963 = 100) compared with 146.1 and 130.2 in 1971 and 1970 respectively. The bedding market, by volume, is essentially static, the average Briton buying three beds in a lifetime.

The regional analysis on Vono bed names indicated regional tastes which, associated with the sales area comparisons for Vono and Slumberland should have generated more interest. These two companies control over 30% of the U.K. bedding sales and any edge over competitors would further strengthen their position.

To maintain their market share in the face of fierce competition deeper analysis will eventually be required. One competitor aiming to topple Slumberland from the market leader position is Silentnight. This company has been very active buying bedding companies operating in each market below the lea leader to give a stated 17.5% share of the U.K. market Associated with low fixed costs (old converted mills bought very cheaply) this market share makes them a force to consider. The leader in the foam mattress field, Dunlopillo, have a very sophisticated approach to marketing although they have only a small share of the total market.

These factors may help convince Vono that market research is more than a tabulation of beds sold.

There was one aspect of Vono's selling policy which was difficult to understand, the apparent competition between beds once the prices were discounted. However this is a definite company policy to keep their products on the shop floor.

Retailers have a product to offer at discount and thereby cause greater interest in their shop and also, the company maintains the consumers induced to purchase. Properly managed the procedure could be used to even the cyclical effects in the bedding trade but much more research into consumers and competitors' attitudes is needed on this topic.

The developments foreseen in the bedding and upholstery markets will do little to assist distribution planning unless greater co-ordination between sales policies, market research and distribution policies is achieved.

Associated with sales policies is the functioning of depots. Although only a brief analysis was performed it confirmed the lack of understanding regarding distribution. No one at Tipton controlled the depots, stock level records were maintained though not checked and the depots were not operating as sales points as the company believed. During the weeks of analysis of depots the academic supervisors went on record as criticising the inaction of the marketing director. Unfortunately, this failed to produce any effect other than to destroy most of the goodwill built up by the author during the first year.

If further proof were needed of the lack of distribution information it was provided when the services provided by the company was analysed. Although sales management believed that 80% of orders for standard beds were met on time, the results indicated a level of approximately 50%. During the research period the delivery forecast for standard beds has gone from 7 to 21 days but with a slight decline in service performance.

Lack of analysis within the company fostered the feeling of contentment and it was firmly believed that a guaranteed 7 day delivery service on beds would produce 1% per annum market increase, approximately 16% increase in business. Analysis of 1972 data indicating that less than 15% of standard beds were, from the sample taken, delivered within 7 days did not quell the enthusiasm.

Suggestions by the university to supervise a market research project to determine what the market required and where Vono stood in relation to competitors were rejected.

It seems difficult to substantiate claims if one's own position and also the market requirements are unknown.

The aim to provide 7 day delivery on beds,raised by the sales director when the new production director was appointed in August 1972. Rather than take an audit of the present position, plans for reorganising production were laid. Modification of the objective to delivery within 7 days of receipt by the manufacturing unit has ignored all order processing problems which can take up to 4 days. This approach to the solution of problems has been criticised throughout the research programme. I firmly believe that until the company stops over reacting to emotional comments on how good they could be and begin analysing facts to see how good they are, then they are unlikely to ever realise their full potential.

Modifications to production scheduling and warehousing procedures enabled contact to be established with the production director within his first week with the company. Work has been proceeding along the theme of a totally integrated management function and the warehousing aspect was of immediate interest to him.

Warehousing problems were not helped by the fact that 12% of the catalogue beds produced 54% of sales volume and 47% produced only 5% sales volume. Maintaining a standard delivery service across this range led to small batches of cutting for the covers and inefficient use of a warehousing space. There are policy matters to be settled regarding range sizes. Why for example does the company carry the 47% of beds giving only 5% of sales volume. Material is one of the most expensive single items on a bed and hence a drastic reduction would improve the financial position and allow the sales force to concentrate on fewer lines.

One attempt at illustrating the interaction between production scheduling rules, inventory policies and order intake resulted in the development of SISSIM. SISSIM was developed by the author primarily to be used to demonstrate different production and stock holding rules. Behind the development was the hope that using it as a game would further improve the understanding of physical distribution management and the interaction possible between departments.

Evidence gained during visits and attendance at seminars indicated that the lack of appreciation of the part to be played by management games was not by any means unique to Vono.

Upholstery production simulation was not attempted as the company maintains a bespoke service because of the range of cloths offered and the value of the products.

Throughout the research programme the difficulty of applying classical solutions to the problems encountered has been noted. An area where these problems were particularly difficult was the finished stock control area. Demand for the products by stock item was erratic although slight seasonal effects could be observed.

However, very frequent changes, at least once per year for bedding, provided data of questionable value. A selling policy depending upon promotional offers to differing people of differing amounts for varying periods also helped to confuse the data. Bulk buying of a limited amount of cheap tick to sell a special bed again confused the issue. All these factors meant that forecasting demand was hazardous and hence bedding sales management required heavy buffer stocks on all products. Storage space was limited and the design of storage racks was an inhibiting factor.

Storage space was a major problem on upholstery where for the best selling lines inventory control policies could have been established.

Bedding production was considered by the author to be unsuitable for EOQ formulations because demand quantities per stock item were not known with any degree of accuracy and there was very little production cost difference between producing bed A or bed B. The stock information system simulation program (SISSIM) was developed to indicate relationship between production and inventory policies. The ICL production control package, PROMPT, was investigated for upholstery production by Duport Computer Services Ltd. and found to be acceptable.

Their investigations into using PROMPT for bedding production were frustrated because the companies product code did not include colour. Bedding lead times were so short that at least 3 runs per week would have been required, according to senior computer personnel.

Although SISSIM is less costly to run than PROMPT it is nowhere near as flexible. All SISSIM does is to produce a list of beds to be made and finished stock levels and allocated stocks. There is no statement of the order of production or the yardage of tick or reels of cotton etc. that are possible with PROMPT. Because it produces only a gross picture its value was seen by the author as a teaching, rather than on-line system.

The reliance on computer packages for all aspects of business is not to be commended and reflects some of the problems of having a computer company as a profit centre. With packages, expertise is available from the computer manufacturers if problems arise and results will ensue at a cost. Development of one-off programs is not a guaranteed process and in any case necessitates a different type of analyst. However evidence within the companies indicated that a low level analyst capable of implementing a payroll type system had been employed. The computer company went against individual programs because of the problems of updating when the original analyst left. Although the author believes this to be a poor defence by the computer company it must be respected.

During work on inventory control it became apparent that controlling levels of finished goods was the wrong approach and hence the idea of controlling the stocks of sewn covers was proposed.

There is however one area, apart from PROMPT to control bedding production, where computer packages are not so straight forward to appky. This is the area of vehicle scheduling and routing, the original problem area accepted by the university in October 1970.

As indicated in Appendix I the use of such packages is not as widespread as one would expect from the statements of computer salesmen. Vono's delivery problems must be typical of any manufacturer or supplier delivering a mixed product range to a multitude of customers. The extent of Vono's product mix in 1970 - 192 bedding items, 18 headboards, 250 + upholstery items, is probably not large compared with say a motor industry supplier, but its requests are usually 2 or 3 pieces per order from one of 6,000 customers.

Forming a savings matrix (for the 6,000 delivery points), would have been an expensive procedure every time new customers were obtained. A savings matrix of 125 delivery points and a run of ICL's MK II vehicle scheduling package took 45 minutes on the University of Aston's computer.

Alternatives suggested by other package salesmen were, as discussed in Appendix I, also impracticable.

Delivering to shops means that early-closing day considerations are important. Although early-closing days for each delivery point (either zone or shop) can be specified this facility has not been described in computer company manuals nor in discussions with representatives. Specifying a closing day implies that the computer knows for which day it is being run but evidence gained during the research is that this is not input.

Especially important to multiple deliveries to customers is the hours of opening. All packages use the time factor to determine working day restrictions for drivers. However, all the vehicles are assumed to leave at time zero, the printout giving elapsed time from leaving the factory. This unwittingly can cause two day journeys if the traffic clerk issuing the work miscalculates the times. When this happens the complex cost parameters etc. which are set up to justify two day deliveries become unnecessary. Any control being exercised over distribution costs by computerised routing and scheduling would begin to fail. One way over the dilemma would be to load all vehicles today for delivery tomorrow in order that early starts would be possible. As most companies use rigid chassis vehicles this entails tying up a vehicle and driver.

I believe that the companies who use the packages to produce standard routes for seasons of reasonably stable demand derive as much benefit as computer company representatives state are possible with full running. If one's transport fleet were articulated vehicles or demountable body vehicles a certain flexibility in planning would be possible which may increase the benefits.

One aspect of delivering which is almost impossible to computerise effectively is that of collections of damaged or faulty products. Where delivery order is important, e.g. Tono, the transport manager fits collections into the load such that the unloading of products will not be unduly hindered. This requires a knowledge of the shape and weight of products. Collections will be picked up as a continuation of a delivery run. Vehicles can therefore be delivering one day and collecting the next, thereby creating problems for cost parameter justification of two day deliveries.

Computer companies, and bureaux, offering vehicle scheduling, packages have made advances in the sophistication of facilities built into their packages without, I believe, really understanding the distribution problem.

Facilities to cope with waiting restrictions outside shops and the times of acceptance by shops are based on sophisticated mathematical approaches.

However the value must be doubted as the start time of journies cannot be known from the scheduling printout. Consequently the time of arrival at customers cannot be specified The majority of time constraints work on elapsed time of journies, start time assumed to be zero.

The form of the printout is also unacceptable to a company like Vono. It is of little value to ask for X units to be delivered, or loaded, when, as the load building model in chapter 9 indicates, the loading value of all products is based on a common factor. For example an instruction to deliver 12 units could be 4 divan sets (but which divan name), or 6 smaller divan sets, or 2 of a particular suite or a multitude of combinations.

To implement a vehicle scheduling package, if the above points were settled would involve major changes in the order processing systems. Orders would have to have load unit values included and also a code number for a town. Earlier programs required that all deliveries to a town were input as one delivery unit but in drops. All towns must be numbered and the order of feeding in the demand requirements was in this order. Consequently, unless orders were sorted manually a sort and addition program would have to be run before every routing and scheduling run. These aspects are not dealt with by computer specialists until full trials are required.

It was shown by the author that the ICL Mk.II package could produce delivery routes if orders were analysed and presented in the correct manner. However, a barrier pass-point for the River Mersey was not read with the result that deliveries to Liverpool were routed via the next barrier, in this example the Blackwall Tunnel in London.

Because of these problems relating specifically to the Vono operations the author envisages developments in routing along the lines adopted by J. Lyons & Co.Ltd. (see Chapter 11). The use of a large scale map with colour codes for closing days would enable a load builder to keep a constant picture of possible loads before himself all the time.

In the short term at least such a procedure would overcome the need for a considerable amount of work study data, and map reference codes for all delivery points or zones and would retain the ability to perform collections as at present.

Data collection is time consuming especially if it involves travelling with drivers to obtain unloading times,etc. Data available within most companies must be analysed to verify its accuracy which in the case of this research program resulted in new procedures for arriving at certain statistics. Data given in good faith can be inaccurate or incomplete, e.g. the cost master tape, while other data such as cost verifications for multiple day deliveries are not worked out let alone retained.

12.3 GENERAL COMMENTS ARISING FROM THE RESEARCH PROGRAMME

A list of inaccurate sources of data, lack of data, non-co-operation, etc. would make a tale of woe suitable for internal reports but not for a research thesis.

For academics teaching the mathematical techniques associated with OR a certain degree of disorder in the environment is accepted. However, the real world situations are usually very disorganised and the structure of problems unclear. During the research programme the extent of disorder encountered was considered excessive by university personnel who were willing to stop the project after less than one year. It was the author's contention that attempts at applying the scientific method to such a situation could be successful.

(i) There were two approaches apparent to the researcher, to take the company's money and produce a theoretical dissertation on aspects of the problem which could not be rigorously tested because of lack of data, etc. or

(ii) to involve oneself with the company, to try and understand the situation and act on it to structure a problem, model it and provide a better solution than existed at the time.

Both alternatives are fraught with danger, the former could lead to ostracism by the industrialist, the latter to ostracism by the academic.

As the IHD Scheme involves itself in a departure from conventional research for higher degrees the latter course was taken. On reflection this course has been fraught with more problems than the former. Reflection on the Machiavelli quote indicates the reasons.

> "There is nothing more difficult to carry out, nor more doubtful of success, nor more dangerous to handle, than to initiate a new order of things. For the reformer has enemies in all who profit by the old order, and only luke-warm defenders in all those who would profit by the new order. This luke-warmness arises partly from fear of their adversaries, who have the law in their favour, and partly from the incredulity of mankind, who do not truly believe in anything new until they have had actual experience of it."

Throughout the research program the problem of attempting to change the status quo has met the above quoted attitude. Attendance at lengthy meetings of the company to discuss aspects of the work only succeeded in wasting everyone's time, and discouraging the researcher.

By using an untested higher degree scheme to attempt to structure a problem in an operating company during a period of managerial change, the extent of which was not realised by the university, it was hoped to initiate a new order of things in both camps.

The IHD Scheme supervisors were hoping to act as agents of change regarding academic attitudes to post-graduate research by having a research student acting as an agent of change in an industrial environment. Experiments in Belgium and Egypt are under way into research programs involving participation in managerial decisions rather than observing them.

Agreeing research programs with industry can cause problems to the researcher unless the academic sponsors are prepared, or able, to recognise where such a problem fits in the company's overall policy. When a programme in a political and volatile area is agreed they should recognise the strain imposed on the student/supervisor/industrialist interface.

The approach of the University Grants Committee to treat supervision of industrial research programmes in exactly the same manner as theoretical university based research programmes indicates the lack of the situation.

Evidence of the students' committee is that IHD projects in general are more demanding of a supervisor especially where unusual research programs are concerned. During the formative years of the scheme it has become apparent that greater research is needed into the selection of projects and also the amount and quality of co-operation between the university and the company.

A change of discipline by a student calls for a planned re-orientation programme by the university. The experience of the author in this aspect was very poor and raised doubts in his mind concerning the sincerity of the information given in IHD brochures. The approach towards retraining was to attend selected lectures which were part of an undergraduate or post-graduate course. Such an approach is totally unacceptable when the student has 2 or 3 years to perform a task. In the author's case OR was taught at Aston on a day release course, one day a week for two years; requests to attend a 2 week full time course at the University of Birmingham were turned down.

The author was not alone in criticising the re-training approach of the Scheme, students accepted in the early years were similarly treated. However, the success of the academic supervisors as agents of change in the academic field will only become apparent in the long term.

Qualities impossible to teach must somehow be acquired if dealings with people are to be successful. In metallurgical research metals can be tested to find their breaking points under differing conditions: but phrasing a question wrongly to men can lead to false data.

When such men are directors of the company involved with the research the phrasing needs to be very general but precise.

Decision making attitudes of these men and their interpretation of the general problem area are crucial to the successful outcome of a research program involving them. Lindblom (15) observed that decision making at the policy level in government was essentially pragmatic. Interaction between groups and individuals pursuing their own interests and making the most of their power to achieve a mutual adjustment overall was also noted.

Associated with this is the belief that only marginal changes are desirable and can really achieve anything in a given situation. There is no reason to ignore these forces in the board rooms of companies, especially after company mergers and subsequent managerial changes. Complications can arise in the first stages of decision making, namely problem area identification, if beliefs are fixed in a rigid manner. While accepting Stafford Beer's statement of the four methods of fixing beliefs (16), Tenacity, Authority, Apriority, Science it was difficult to determine that method controlling the Vono board's beliefs on distribution.

Their beliefs concerning distribution appeared to be an amalgam of Tenacity and Authority. The method of Apriority played a part in, for example, stock holding situations. Specific interactions of methods between different management types were not investigated although evidence has indicated that beliefs however fixed were firmly held.

If beliefs are firmly fixed then problems will appear to have definite boundaries to the decision maker. However, the problem area is part of an infinite problem space with solutions to one problem generating others. This regenerative cycle owes nothing to the expertise of the researcher, rather it indicates poor methodology on his part. Setting the boundaries of a problem area requires skill and judgment of a researcher not taught on O.R. courses.

The author's experience of the teaching of OR at the University of Aston in Birmingham was apparently atypical. During the day release course there was a concentration on teaching the necessary optimizing techniques with minimal cognizance given to the methodology. This resulted from the standard of the four people on day release from industry but emphasised the problems facing the IHD scheme in retraining its students.

Apparently Aston's OR teaching is considerably more methodology biased than most universities which could explain the introverted nature of research papers. Theoretical depot sitings, theoretical stockholding models etc. assume so much but indicate no inter-action. Setting boundaries of a research program is similar to Lindblom's concept of partisan mutual adjustment. Decision makers learn to define problems by involvement and by so doing formulate their own policy decisions and courses of action. Tate (17) describes the techniques of OR in similar fashion to the above and concludes that the ideal OR man should be a deep thinking extrovert. The rarity of such creatures indicates the need for interdisciplinary teams, part to sell and part to do.

This interdisciplinary nature could also be evidenced from Bishop's discussion on the methodology of OR in the civil service (18). He believes that the success of a model depends on a decision-making dialogue between the decision maker and the model such that weightings can be modified.

It has been argued by the university that such a dialogue is missing from this research. However, load building models, carriage allowance models, warehouse reorganisation etc. were only possible with the active co-operation of certain managers in the company.

However, decisions involving multiple criteria often result in that decision which satisfies a given set of constraints, e.g. warehouse reorganization.

Without sounding too pessimistic agreement is found between this research and a belief of Lindblom (15) that it is practically impossible to model complex decision areas impinging on the responsibility of the company to the shareholders.

Evidence of the research programme bears out most of the above thinking.

Work concerned with tactical problems, e.g. load building models, carriage allowance program, sales analyses and departmental reorganisation was followed with interest. Assistance was not provided on any aspect but results were openly discussed. Strategical problems, e.g. transport types, warehousing and distribution manning were accepted but not discussed to any great depth.

Once the problem had been shown to be one of physical distribution in its widest definition, boundaries were not defined.

When the problem was computer routing of vehicles the company were able to impose their fixed belief that just routing of vehicles was concerned. Recognition of the datum on which such work is based led to confusion as the boundaries were not enclosed by one clearly defined managerial function.

Setting up sub-problems to fall within a specific managerial function while recognising the global problem leads to conflicting attitudes. Changes of management caused boundary definition changes. For example, the production director designate has an interest in warehouse stock levels although his predecessor had not.

Market research data was defined in the company as really order intake figures. Analysis to provide reasons for different sales levels or product groups in different sales regions was outside their scope.

A model of the distribution function of Vono Ltd. must include stock levels, recorder policies, production run sizes, service levels, raw material supplies, mileage charges, routing and scheduling of vehicles, number of vehicles, order intake, etc. Assuming one person in the company had control of the area of a model would have to include so many assumptions that it might be invalid. Even modelling of transport costs was difficult let alone a complete distribution model.

Perhaps the distribution problem has been investigated too closely to accept that gross simplification necessary to model aspects of it is feasible. The argument can be levelled at the pure mathematicians that complex mathematical formulations, e.g. vehicle scheduling, fail to meet the simple requirements of industry, e.g. a knowledge of what is to be delivered. However recriminations on either side would not solve industry's problems.

Evidence gained during the research program has led to some beliefs concerning the state of the art in distribution management research.

It has become apparent that too much emphasis has been placed on high level mathematical formulations of hypothetical delivery problems rather than on communicating the meaning of physical distribution management to all concerned.

These mathematical formulations offer sub-optimal solutions and are unlikely to deal with for example, closing day problems encountered with a Vono type delivery problem.

Micro-planning of routes can only be performed by routers used to the problems of specific shops, etc. Companies using routing packages tend to set up standard routes based on a season of relatively stable demand and to stick to them until the next season.

Forming routes assumes that a starting point for delivery is known. Whether the farthest points are routed first or the nearest is worthy of investigation.

The shape of routes is also important, manual routers appear to form clusters, similar to the Sussams maximum drop-density approach, shares standard programs produce mainly clover shaped patterns. A router will try to reduce the proportion of time spent driving to deliveries between the first and last delivery.

All packages are basically multiple scanning programs with heuristics included for loading a vehicle, approaches are aimed at either minimising mileage travelled or vehicle used.

Very little research has been published concerning the efforts of programmers and systems analysts to really comprehend distribution function. This area between the computer and the router is worthy of analysis because it is the router who the programmer is attempting to imitate. Customers are important and therefore the effects on them of accepting probably different schedules should be studied.

It is unfortunate that the majority of vehicle scheduling work has been developed in the oil industry where the product is homogeneous and a delivery note of X units is meaningful. The problems facing companies delivering mixed loads are more serious as the wasted volume (or unused vehicle capacity) will be higher.

Computer software personnel should involve themselves with the basic problems in the field of distribution: delivery order can affect vehicle occupacity for diverse products: collections by delivery vehicles are performed to a great extent although packages do not cater for this problem.

Argument must be taken with W.E. Norman (O.R.Conference) that routers will juggle loads to reduce the required number of vehicles or spread the load more evenly. During the two years of this programme,no such procedures were observed.

Any company which realises that routing is only one aspect of distribution management should enquire into the total concept. Different packages are offered for different aspects, e.g. inventory control, production control, payroll analyses, programs for monitoring the fleet efficiency can be written, depot siting exercises can be performed, sales forecasts can be produced etc. Each one seeks to optimise its own problem area by standard techniques. Medium sized companies cannot necessarily afford to employ the expertise necessary to co-ordinate all these areas. Consultants are expensive and cannot gain the background to a company's operation from cursory glances. One is left with the academic institutions.

Staff research projects offer scope for comparative analyses across industries on deep research into one aspect in one industry (not company).

Undergraduate or postgraduate work on for example, one year M.Sc. programs, provide the opportunity for forging links between capable students and industrial problem areas. Because of the time scale such work is unlikely to be concerned with solving deep seated problems.

Postgraduate research programmes lasting 2 to 3 years have been concerned with industrial problems although it is arguable whether the researcher has been involved in the company or merely at the company. The IHD Scheme is seeking to involve its students in the company and so doing appears to be assisting industry, students and gaining the acceptance by industry of academic involvement.

Research programs for example, in dynamic programing concerning replacement policies involving complex relationships between product groups and constraints may be assumed a management program. Similarly investigation into wage claims and settlements across an industry would involve discussions with both sides of industry and may therefore be a management programme.

Such programmes lack one main factor, involvement in the company and exposure to the strains experienced by the relevant managers.

By applying theories to problems in their operating environment one can learn to change the situational here-and-now of reality.

Re-organising and evaluating real-time problems that discriminate between taking action and talking of taking action is important if applied research programmes are to succeed. It is more difficult to be directly involved in action than to analyse the actions taken by others.

Experience gained during this research programme has indicated that self-motivation and a tremendous amount of self-confidence are needed in such action roles. It is also important to be able to analyse problems, propose solutions, indicate implementation procedures and to stand down when the relevant management accept the benefits while standing up to the drawbacks when they arise. No problem is too small if the backing of management is required, e.g. computer printout of miles and cost, but such problems should not be openly sought.

To rely on standard textbook solutions to standard problems can cause moulding of real life problems to suit solutions. It is surely better to provide a solution which is within the capabilities of the researcher and which matches the company rather than to bend facts for ease of computation.

During the research programme the fact that the company acted slowly in comparison to the researcher led him to feel the work was not accepted. However, the new load building model and carriage allowance costs are scheduled for full implementation in February 1973, the cost master tape is now maintained accurately, information on promotion, etc. is documentated fully, demountable body vehicles are operational and are beginning to show benefits, vehicle monitoring is being fully implemented after its benefits were proved, warehouse layouts and stocking problems are being approached along the lines proposed during the research and pre-allocation is being implemented.

Perhaps the most interesting result is that the company now appreciates to a large extent the costs and factors contributing to efficient physical distribution management.

Table 12 of the Introduction, reproduced here details possible savings which would arise from integrating the functions defined as part of physical distribution management.

However, an efficient information system will be required detailing not only the factors now being implemented. Knowledge of service level performance against the company standard would highlight problem areas if followed through rigorously.

The awareness of the complex inter-relation of apparently unconnected facets of the company's operation should assist the management not only in physical distribution management but also in the approach to any problem arising in the company.

Cost Area.	Proposed saving.
Transport Costs.	Company view that 10% saving possible by computerised routing. Researchers view maximum 3%
	Reverting to Vono management of distribution function 8% minimum.
	Alternative forms of transport - 8%
Warehouse costs.	Alternative site and procedures after first two years - £30,000.
	Pre-allocation of bedding to orders, 16% of finished bed stock value.

TABLE 1.2: Table of Possible Proposed Annual Savings.

12.4 REVIEW, SIX MONTHS AFTER COMPLETION.

During the period taken to prepare and check draft copies of the thesis the author was employed by Duport Ltd. and consequently was able to review the situation within Vono Ltd. after the research programme had ended.

The following are brief observations gained during February 1973.

The warehouse layout suggested in the thesis has been implemented. Work was progressing on final assembly of the new storage racks. It is the intention of the management to use an order picking technique based on the alternative suggested by the author. Sewn cover stocks were being implemented but were not operational as production line re-sitings and ancillary problems were still being sorted out.

Accepting the new storage racks implies that storage of finished beds will be critical because of the restrictions imposed.

Demountable body vehicles were being phased in but difficulty was being experienced with financing arrangements. Original earnings on these vehicles were less than the author forecast because no slave unit was provided to shunt demounted bodies round the site. A slave unit was provided in January 1973 and consequently it is too soon to say whether the earnings have improved. Vono Ltd. are still convinced that efficient use of demountables will produce savings and are pressing for full implementation.

Vehicle monitoring was still being used by the company and assisted in the haulage rate negotiations in January 1973.

Vehicle routing had not improved, the view of the author and Vehofreight personnel was that this aspect had deteriorated. Vehicles were being sent out approximately 60-70% full to maintain approximately 30 loads per day. This policy resulted in inefficient routes but the company were monitoring, by the carriage allowance program, the recovery of carriage allowance charges.

The carriage allowance charges developed from the new load building model have been built into the selling price calculations for all products and changes in the cost master tape been performed to enable out of range products to still be compared.

Although the situation appears to have improved since October 1970 greater control will be needed over the allocation and routing of orders.

CONCLUSIONS.

1. Physical distribution management within Vono Ltd. is an ill-defined function, different aspects being controlled by different line managers. However, the research programme has led to a greater understanding of the function within the company.
2. Modelling physical distribution as a single problem was not possible.
3. Sub-problem formulations enabled the constituent functions to be examined and improvements on the existing procedures to be proposed.
4. These improvements have been calculated as savings of approximately £130,000 per annum on a bill of between £½ million and £2 millions. (For security reasons the figure has not been broken down anywhere in the thesis but is derived from table 1.2).
5. Because of the nature of the distribution function, agents dealing with contractors who own the vehicles, it was not possible to fully implement proposals relating to alternative forms of transport.
6. Proposals relating to tactical problems were more readily discussed with and accepted by, the company than proposals relating to problems of a more strategical nature.
7. Research is needed into the use of computerised vehicle scheduling and routing packages by companies delivering mixed loads.
8. The impact of computerised vehicle scheduling and routing packages on the order processing and customer coding procedures operating within companies is not well documented in the literature.

CONCLUSIONS - Continued.

9. The Inter-Disciplinary Higher Degrees Scheme must concentrate more effort on the re-training of research students entering fields different from that of their first degree.

10. The Scheme must also accept that although industry co-operates by providing problems it need not accept the proposals resulting from such research work.

Suggestions For Further Work

1. Although efficient route planning can yield savings, work is needed into this area. The starting point of routes will have an effect on the latest time a vehicle can leave a depot, which in turn affects the work load of the loading bay personnel. Deliveries on routes are usually made throughout the journey but concentrating the deliveries into tight clusters may produce savings in time and costs.

2. Work indicated that the time drivers spent waiting for loads at Vono Limited was approximately $3\frac{1}{2}$ hours. E.E.C. proposals, now being discussed by ministers and committees in Brussells for implementation in 1975, seek, among other things, to reduce from 10 to 8 the hours per day spent driving. Such proposals will have a major effect on Vono with the present system of driver utilisation and will also affect the country as a whole. Urgent work is needed into the effect such proposals will have on the economy of the U.K. One proposal which could affect long distance hauliers especially concerns the need to carry two drivers for journeys of more than 280 miles per day.

3. The E.E.C. proposals could lead to an analysis of the distribution philosophy of the country with repercussions on the future of railways as a haulage system.

4. Alternative forms of transport, eg. demountable body

vehicles, could be investigated for haulage firms as a means of reducing the driving time spent waiting for loads.

5. Work is needed into determining the management structure best suited to handle physical distribution management as defined in this thesis.

6. At Vono Limited work is needed into methods of controlling the stocks of finished beds. Proposals in the thesis for controlling sewn cover stocks, although being implemented, need close monitoring. This work, associated with the stock information system simulation programme could form the basis of research into an integrated production control, inventory control and costing, and product allocation procedure. The need for such a procedure has been apparent as poor stock recording and over production have proved.

7. There appears to be little factual information concerning the effect delivery dates have in influencing consumers to buy in the upholstery and bedding markets. Work in this area would benefit the Duport Group with its powerful position in the bedding and upholstery markets.

Acknowledgements

The author wishes to place on record his appreciation for assistance received from the directors, management, and staff of Vono Limited, Staffordshire, especially Mr. N Little, Managing Director, and Mr. D. F. Layton, Financial Director.

The author is also very grateful of the support and encouragement offered by Dr. D. J. Van Rest and Mr. T. D. Law of the University of Aston in Birmingham, through countless hours of discussion.

Finally, the support of Duport Limited is fully acknowledged, especially from Mr. G.A.D. Coghlan, Director of Personnel, Head of Management Services and Corporate Planning, also Mr. E. C. Sayers, Deputy Chairman and Managing Director, for permission to publish the results of research into a Group Company.

References

1. Stewart, W. M., The total distribution concept. Physical Distribution Management, Gower Press, London, 1970.

2. Cooper, L., Location-allocation problems. Ops. Res., 11, (3), 331-43 (1963).

3. Weber, A., Uber den Standort der Industriem. Tubingen, 1909. Translated as Alfred Weber's Theory of the Location of Industries, by Friedrich, C. J., University of Chicago Press, 1929.

4. Burstall, R. M., Leaver, R. A. and Sussams, J. E., Evaluation of transport costs for alternative factory sites. Opl. Res. Q., 13, (4), 435-54 (1962).

5. Hepburn, J. M., Distribution of blasting explosives. Distributive Systems Session, Proc. 4th Int. Conf. Ops. Res., Boston, 1966.

6. Haley, K. B., Siting of depots, Int. J. Prod. Res., 2, 41-5 (1963).

7. Shea, A., Determination of the optimal location of depots. Distributive Systems Session, Proc. 4th Int. Conf. Ops. Res., Boston, 1966.

8. Miehle, W., Link-length minimization in networks. Ops. Res., 6, (2), 232-43 (1958).

9. Efroymson, M. A. and Ray, T. L., A branch-bound algorithm for plant location. Ops. Res., 14, (3), 361-8 (1966).

10. Schycon, H. N. and Maffer, R. B., Simulation-tool for better distribution. Harv. Bus. Rev. 38, (6), 65-75 (1960).

11. Economic Development Committee for the Distributive Trades, Planning Warehouse Locations. 1967.

12. Menzies, A. F., Vehicle routing without computer. Information Note 70, Depot Siting and Vehicle Routing, British Institute of Management, 16-24, 1968.

13. Lewis, C. D., Scientific Inventory Control. Butterworths, London, 1970.

14. Buffa, E. S., Production-Inventory Systems: Planning and Control. R. D. Irwin, Illinois, 1968.

15. Ansoff, H. I., Business Strategy. Penguin, London, 1969.

16. Beer, S., Management Science: The Business Use of Operations Research. Aldus books, 1967.

17. Tate, T. B., Personal communication.

18. Bishop, B. C., A contribution to a discussion on the methodology of Operational Research. Opl. Res. Q., 23 (3), 251-60 (1972).

19. Gill, S. A., Vono warehouse, report on Unit 2, 1973.

APPENDIX I

Literature Review Of Vehicle

Scheduling And Routing Work

Because of the importance of vehicle scheduling and routing in physical distribution management the literature on the topic was reviewed.

The vehicle scheduling problem was originally posed as such by Dantzig and Ramser (I) and stated as follows:-

A set of customers each with a known location and with a known requirement for some commodity is to be supplied from a single depot by delivery vehicles of known capacity. The problem is to design the routes of the vehicles such that,

(a) the requirements of all customers be met

(b) the capacity of vehicles may not be violated

(c) the total time (or alternatively distance) for each vehicle to complete its route may not exceed some predetermined (legal or contractual) value

(d) there is an earliest and latest time within which a customer can accept a delivery and these limits must not be violated.

The objective of the solution is stated generally as that of minimizing the cost of delivery. Several sub-problems and associated problems may be formulated:-

(i) if the fleet consists of one sufficiently large vehicle such that constraint (b) can be ignored and if in addition constraints (c) and (d) can be ignored, the problem simplifies to the classical travelling salesman problem (19).

(ii) if constraints (c) and (d) are ignored the problem simplifies to determining the minimum fleet size. This problem is closely related to the classical knapsack problem (2).

(iii) for a given number of vehicles compatible with the constraints, design the vehicle routes so that the total distance of the routes is minimized. This is the usual interpretation of vehicle scheduling.

(iv) if the location of customers and their requirements are known for every day of the week, and successive weeks follow the same demand pattern, then for a given vehicle capacity the size of a company owned fleet can be compared with the size of a hired fleet so that total delivery costs are minimized.

The vehicle scheduling problem has been approached in various ways including total enumeration and mathematical programming. A brief outline of papers will be followed by a more detailed analysis.

Garvin et al. (3) formulated a problem in 1957, two years before Dantzig and Ramser discussed the more general problem, as an integer linear programme. Balinski and Quandt (4) also attempted total enumeration by formulating as a zero-one programme. Adaption of the dynamic programming approaches to the travelling salesman problem by Held and Karp (5), Bellman (6) and Gonzales (7) has also been attempted. Little et al. (8) proposed an optimising approach by branch and bound techniques which was really a distorted travelling salesman problem.

Although these solutions produce optimal solutions they are not in line with the Dantis and Ramser concept of producing reasonably efficient routes in a short time.

Clarke and Wright (9) developed a saving technique on which the majority of commercially available vehicle scheduling computer packages are based. Hayes (10) developed a conceptually different algorithm which attempted to copy the human despatchers subjective decisions.

Christofides and Eilon (11) published the "3 optimal tours" technique which was described as being more flexible than the savings technique.

Sussams (12) has recently developed a new technique based on Map Simplification and Maximum Drop Density.

Gaskell (13) attempted to compare techniques and concluded that criterion other than savings were sensible measures of priority and that none of the methods considered was uniformly better than any other.

Christofides and Eilon (11) also attempted comparisons and concluded that for their exercises the 3 optimal tours technique was significantly better than the Clarke and Wright savings technique.

Manual systems are nevertheless used by almost every organisation involved with distribution. It could be that the inflexibility of the techniques or the complicated nature of distribution is the reason. Vehicle scheduling computer packages are apparently used very little despite the number written. Packages investigated will be discussed together with operational problems after a discussion of the above cited references.

Dantzig and Ramser Formulation

(1) Given a set of n points pi (i = 1, 2 ..... n) to which deliveries are made from point Po, the terminal point.

(2) A distance matrix (D) = (dij) is given which specifies the distance dij = dji between every pair of points (i, j = 1, 2 ..... n).

(3) A delivery vector (Q) = (qi) is given which specifies the amount qi to be delivered to every delivery point Pi (i = 1, 2 ..... n).

(4) Truck capacity is C where C > max qi.

(5) If xij = xji = 1 is interpreted to mean that points Pi and Pj are paired and if xij = xji = 0 means that the points are not paired then

$$\sum_{j=o}^{n} \text{xii} = 1 \quad (i = 1, 2 \ldots\ldots n)$$

since every Pi is either connected with Po or at most one other Pj.

By definition xij = 0 for every i = 0, 1 ..... n.

(6) The problem is to find these values of xij which make the total distance

$$D = \sum_{i, j = 0}^{n} \text{dij xij}$$

a minimum under the stated conditions.

The method seeks to synthesise the solution in a number of stages of aggregation in which sub-optimisations are carried out on pairs of points or groups. The number of stages of aggregation to be performed is determined as:-

order the deliveries qi in sequence q1, q2 ..... qn such that qi   qi + 1 for any i = 1, ... n - 1.

If t is the maximum number of deliveries per trip depending on C and a given set of qi's, then 't' can be determined such that:-

$$\sum_{i=1}^{t} qi \leq C \text{ and } \sum_{i=1}^{t+1} C$$

Since q1, q2 ..... qt represents a feasible solution it may be the optimal and hence the method of calculating the number of aggregations must admit this combination n the final aggregation. This will be the case if N, the number of stages of aggregation, is determined such that:-

$$N \simeq \log 2\ t$$

since 2^N is the largest number of points aggregated in the Nth and final stage of aggregation.

A basic set of data is formed where all Pi's are linked to Po. During a rapid correction stage one element of this basic set is dropped at each iteration and replaced by a new element. Because there may be a large number of pairs of points with small inter-point distances a function is provided to overcome the problem of calculating the total distance in every case.

The function indicates how much the total distance D will vary per unit of increase of non-basic entry xij. If the function is greater than zero a reduction in D is possible. By iterating this procedure non-basic entries are brought into the basic set until no further improvement is possible, thus concluding the first stage of aggregation.

The second stage of aggregation combines pairs of points whose total demand does not exceed $\frac{C}{2^{N - r}}$ (where r = 2)

e.g. if N = 2 (from C, qi and t considerations).

1st stage links points whose total demand $\not> C/2$

2nd stage links points whose total demand $\not> C$

The procedure for finding the combination of aggregates which yields minimum mileage for 2nd and subsequent stages is as for the first stage.

Although no practical applications had been attempted it was assumed that provided qi's do not differ too widely then similar results could be obtained with other numerical problems. However, in practice qi's can vary considerably. The method as published only considered stage $C_2 = C_3 = \ldots C_n = 0$. Because of the restriction that in the first of N stages of aggregation only deliveries whose total demand does not exceed $Cl/2^{N-1}$ are linked, points which are far apart may be linked, resulting in a bar-bell effect. During the rapid correction stages obviously long links may be excluded although once two points (or groups) become linked in an aggregation they remain aggregated.

It would appear therefore to maximize vehicle space usage rather than minimize mileage. This indicates the complicated interplay between the knapsack and routing problems.

As the distance table in the Nth stage could require each cell to contain the shortest distance from the depot through 2^N points then the travelling salesman problem must be solved.

Clarke and Wright quote the following example:-

> assume after two stages of aggregation 100 customers are aggregated into 25 groups of 4 customers each, then the mileage table for the next stage would require the solution of 300 travelling salesman problems each of nine points.

Practical problems are not built into algorithms and will hence be discussed in relation to computer packages. It is obvious that qi is homogenous with respect to volume and miscible (e.g. oil, coal etc.). The order of loading and stacking difficulties are not mentioned for other types of products.

Clarke and Wright Formulation

A modification proposed originally by Clarke and Wright failed to produce an optimal solution and this led to the development of the savings method.

If the restriction that in the rth stage aggregations, only customers whose combined load does not exceed $Cl/2^{N-r}$ may be joined is removed, then it is possible to join customers whose combined load does not exceed Cl. Although the travelling salesman problem is still encountered the results for a number of examples was better than the Dantzig and Ramser method.

However the results, in line with the Dantzig and Ramser technique, depend on the variability of customer demand qi.

Savings Method

(i) x_i trucks of capacity C_i ($i = 1, 2 \ldots\ldots n$)

(ii) C_i ordered such that $C_i - 1 < C_i$ $(i = 1, 2 \ldots\ldots n)$

(iii) A set of delivery points P_j $(j = 1, 2 \ldots\ldots M)$ to which deliveries are made from Po the terminal point.

(iv) A delivery vector (qi) is given specifying the amount to be delivered to every P_j $(j = 1, 2 \ldots\ldots m)$

(v) A distance matrix (D) = (dyz) is given specifying the distance $d_{yz} = d_{zy}$ between every pair of points $(y, z = 1, 2 \ldots\ldots M)$.

(vi) $C_1 \ll \sum_{j=1}^{m} q_j$

(vii) x_i is infinite to ensure that some trucks may only be partially loaded.

(viii) q_j $(j = 1, 2 \ldots\ldots M)$ is such that one truck can be allocated to each customer; if not it is assumed that an allocation can be made by splitting a load into 2 or more full truck loads of the highest capacity available and only considering the remainder of that load an amount less than a truck load of the highest capacity.

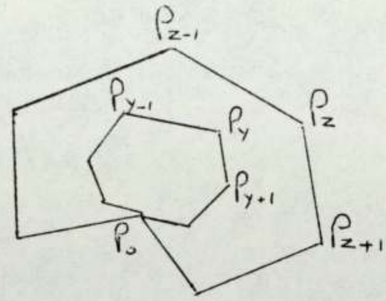
(ix) let $t_{y,z} = 1$ indicate two customers Py, Pz are joined on a route, otherwise $t_{yz} = 0$ for all y, z 0.

If a customer is served exclusively by one truck

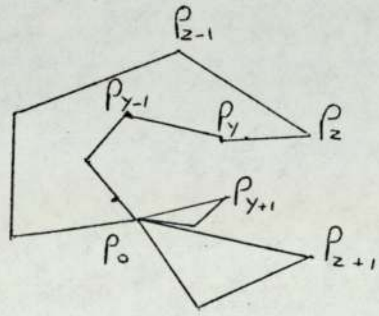
tyo = 2

hence $\sum_{z=0}^{y-1} t_{yz} + \sum_{z=y+1}^{M} t_{yz} = 2$

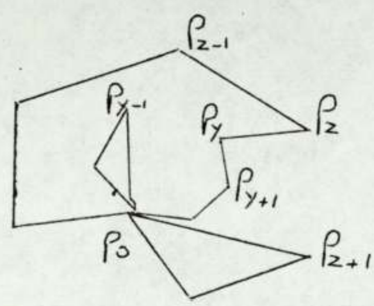
Assume a feasible allocation of trucks to loads in which each customer point is linked to two other points, one or both


Pz-1
Py-1
Py
Pz
Py+1
Po
Pz+1

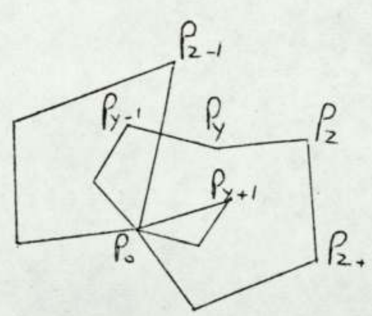
1


Pz-1
Py-1
Py
Pz
Py+1
Po
Pz+1

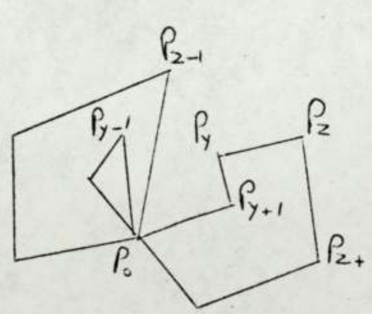
2


Pz-1
Py-1
Py
Pz
Py+1
Po
Pz+1

3


Pz-1
Py-1
Py
Pz
Py+1
Po
Pz+1

4


Pz-1
Py-1
Py
Pz
Py+1
Po
Pz+1

5

of which may be connected to the depot Po. Consider the points Py and Pz as linked to $P_y \pm 1$ and $P_z \pm 1$ respectively.

If P_y and P_z are linked directly then the savings can be calculated.

Diagram 1 indicates the positions of P_y and P_z in the feasible allocation. Diagrams 2, 3, 4, 5 indicate the four possible decompositions of these runs caused by joining P_y and P_z. These consist of the severing of links P_{y-1}, P_y or P_y, P_{y+1} with the severing of links P_{z-1}, P_z or P_z, P_{z+1}. The distances saved are therefore as follows:-

(2) $d_{y, y+1} - d_{o, y+1} + d_{z, z+1} - d_{o, z+1} - d_{y, z}$

(3) $d_{y-1, y} - d_{o, y-1} + d_{z, z+1} - d_{o, z+1} - d_{y, z}$

(4) $d_{y, y+1} - d_{o, y+1} + d_{z, z-1} - d_{o, z-1} - d_{y, z}$

(5) $d_{y-1, y} - d_{o, y-1} + d_{z, z-1} - d_{o, z-1} - d_{y, z}$

These four savings are calculated for each pair of points, the maximum being selected that would if linked, produce feasible routes consistent with truck availabilities and capacities. These two customers are then linked and the savings recalculated.

This is obviously equivalent in L.P. terminology to allocating two shadow costs to a customer, the shadow costs for Py being $d_{y-1, y} - d_{o, y-1}$ and $d_{y, y+1} - d_{o, y+1}$. When a link is severed the appropriate shadow cost is reduced by the value of the cell causing the severance. As maximum values are being considered whenever a point is linked to two other points (not Po) all its cell values become negative and is excluded from further consideration.

Hence the only links to be severed will be those connected to Po, if these were included in the linking of cell (y:z) the saving would be $d_{o, y} + d_{o, z} - d_{y, z}$. The savings for each cell is calculated $\left\{ d_{o, x} + d_{o, y} - d_{z, y} \right\}$ and (from ix) the t function) an initial basic solution is entered as $t_{y, o} = 2$ (y = k, 2 ..... M). The rows and columns of the savings matrix are searched for the maximum savings subject to the conditions that if this occurs in cell (y:z):-

(i) $t_{y, o}$ and $t_{z, o} > 0$

(ii) Py and Pz not already linked

(iii) amending the availability table by removing trucks allocated to Q_i and Q_j and adding a truck to $\theta_i + \theta_j$ does not exceed truck availability.

If these conditions hold $t_{y, z} = 1$ and other values of t_{ij} are amended subject to $\sum_{z = o}^{y = 1} t_{yz} + \sum_{z = y + 1}^{m} t_{yz} = 2$

The quantity vector Q is amended by

(i) make all $Q_j = 0$ if $t_{jo} = 0$

(ii) make $Q_j = \sum qi$ for run for all other j

If there are two or more equal maxima then it is suggested that one be selected randomly. The iteration is then completed until no more links are possible. The solution gives the order of visiting customers although it may be beneficial to solve the travelling salesman problem for each truck in the final allocation to obtain the true optimum order of visiting.

The answer is not optimal but is in line with the Dantis and Ramser concept of reasonably good routes in a short time.

If the constraints are tight the answer could differ widely from the optimum.

The algorithm is very simple to apply, even manually when a half matrix is suggested, and can be economical on computer time although storage of certain constraints will lead to excessive computer storage.

One problem which may possibly affect the optimallity of a solution is that once a link is made it is not removed. Its desirability is considered to be independent of the other links that may be chosen, regardless of the fact that it may prohibit the future choice of many other links whose savings are only slightly less than its own, whereas another less desirable link may allow those links to be picked at some future time. This problem would be aggravated if equal maxima arise at any stage in the solution.

As with Dantis and Ramser collections are not considered and the product is considered homogenous with respect to volume.

There have been attempts at modifying the algorithm to overcome the non-removal of links. Routes tend to be peripheral when load is the restriction.

Tillman and Cochran Formulation (14)

This formulation and algorithm differs from Clarke and Wright only in the way that links are selected. Instead of just picking the feasible link with the greatest savings at each stage a link is picked which when made allows a second best link to be made such that the sum of the savings of the two links together is largest.

Very little work has been done on comparing this technique with other savings methods. It would appear that the limiting factor to extending the criterion to examining 3 or more links sequentially is excessive computer storage and time.

Gaskell Formulation

Again the formulation is exactly the same as Clarke and Wright, the algorithm differing only in the measure of desirability of a link.

One slight difference to other techniques is that mileage allowance per drop is allowed, although this is not commented nor enlarged on.

Hayes Algorithm

This algorithm is conceptually different from all other algorithms attempting to solve the vehicle scheduling problem.

Decisions taken by despatchers are subjective and therefore impossible to quantify but a procedure is suggested as a reasonable approximation.

(a) produce a map of the depot area with delivery points known

(b) obtain a number of peripheral points. The first is chosen to be the customer, demanding a product, farthest from the depot. The second point is chosen so as to maximize the product of its distance from the depot and its distance from the first point (i.e. diametrically opposed to the first). Successive points are chosen to maximise the product of the distance to the depot and to all points previously selected.

(c) select a peripheral point to start a route.

(d) compute a score for each unplaced point as a linear combination of the following factors:-

(i) demand

(ii) number of other unplaced customers in its neighbourhood

(iii) distance from a straight line between the peripheral point and the depot

(iv) distance from the depot

(v) distance from the nearest other unplaced peripheral point

(vi) random element

for factors (i), (iv), (v), (vi) the higher the characteristic the greater the addition to the score, the opposite for (ii) and (iii).

(e) select the point with the highest score and allocate to the route under construction

(f) recompute the scores and repeat the iteration.

When a truck is loaded or time allowance used another peripheral point is chosen to begin a new route.

It was suggested that the travelling salesman problem be solved for each route.

By solving the problem with different values of the random element, solutions can be obtained from which the best is chosen.

The algorithm is very fast although obviously the results are not as good as any other algorithm.

The output could be used as an input for providing feasible tours for the 3-optimal tours although this has not yet been attempted.

In its way the algorithm is complicated but dependent on the random element. Observations of situations in traffic offices have indicated that the above procedure is not performed even implicitly.

Christofides and Eilon Formulation

The problem is as defined by Clarke and Wright, et al in that a set of customers Pi (i = 1, 2 ..... n) need to have quantities q_i(i = 1, 2 ..... n) from some depot point Po, by vehicles of capacity Ci. Constraint definitions are not included in the paper which is basically a statement of the principle of r-optimality.

The application to vehicle scheduling stems from work by Crues (19) who described how an intersectionless tour (i.e. minimal travelling salesman tour) could be obtained by replacing two links of any arbitrary tour and reconnecting the open four points by two new links. He referred to this process as inversion.

If no savings (in distance) are obtained by inversion (of Crues) then the tour is said to be 2-optimal. The two optimal is not necessarily the optimal neither is it unique, it being possible to have more than one 2-optimal tour for any problem.

The problem of 3-optimality involves opening 3 links and connecting them in the 8 possible ways.

Obviously the optimal tour through n points is the n-optimal tour, but as will be shown this is prohibitive in computing time.

For any tour the number of ways r links can be chosen is $\binom{n}{r}$. Removing r links will result in r disconnected chains of points, some of which will be single points.

let p_o = proportion of $\binom{n}{r}$ ways of choosing r links leading to 0 single points

p_r = proportion of $\binom{n}{r}$ ways of choosing r links leading to r single points

r chains of points, x of which are single point chains can be joined to form a tour $2^{r - x - 1}(r - 1)!$ ways.

Assuming an arbitrary tour the minimum number of checks necessary to ensure r-optimality is

$$T(n, r) = \tfrac{1}{2}\binom{n}{r}(r - 1)!\left(p_o\, 2^r + p_1\, 2^{r - 1} + \ldots\ldots + p_r\right)$$

In the limiting case;

$$r = n,\ p_o = p_1 = \ldots\ldots = p_{r - 1} = 0,\ p_r = 1,\ T(n, n) = \tfrac{1}{2}(n,n)!$$

i.e. total enumeration.

If $r \ll n$ and $p_o \simeq 1$ and $p_1 \simeq p_2 \simeq p_r \simeq 0$

$$T(n, r) \simeq (r)(r - 1)!\ 2^{r - 1}$$

If n large (Christofides and Eilon quote "a few tens") and r = 2

$$T(n, 2) \simeq n(n - 1) \simeq n^2$$

r = 2 $$T(n, 3) \simeq 4/3n(n - 1)(n - 2) \simeq 4/3^{n3}$$

The probability of optimallity increases as $r \rightarrow n$ but workers have shown the law of diminishing return applies. $n \simeq 3$ has been found to provide reasonably good tours in short times.

Christofides built this concept of r-optimality into an algorithm for solving the vehicle scheduling problem.

A cost matrix similar to Little et al is used where there are n imaginary depots (if n customers) each situated at the same point but with an infinite cost factor in going from one to the other.

The initialising condition is interesting; one feasible random tour is made up of routes containing one customer (the Clarke and Wright starting point). Other feasible routes for initialising can be obtained from the Clarke and Wright method, Hayes method or any other.

Computational experience of this and other algorithms is lacking. Christofides and Eilon have suggested that determining the 2-optimal tours and using the best of these to produce the 3-optimal tours.

Although the results quoted for an exercise comparing savings against 3-optimal indicated that the 3-optimal produced consistently shorter routes, the computing time on an IBM 7090 was 3 to 6 times greater depending on the number of customers.

Sussams Formulation

This is the latest technique to be published and is based on Map Simplification and the Principle of Maximum Drop Density.

Map Simplification is a method of reducing a map to a network of connections between centre points of grid squares. Straight connections are defined as North South, diagonal as NW-SE.

N = number of calls in each map square

Q = total amount to be delivered in the square

It is then possible to determine how long a van would spend in each map square. All the information for a scheduling run is entered on map square data cards and consists of:-

(i) time to next squares (N, NE, E, SE etc.)

(ii) time to depot by shortest route, using motorways if time is saved regardless of distance.

(iii) time to deliver goods to a cluster of customers within the square, volume of goods to be delivered.

(iv) standard time and overtime available on each vehicle

(v) times applicable to certain restricted areas or customers

(vi) squares belonging to an outer zone within which 2 day trips are permitted

(vii) squares belonging to an inner zone within which trips may be less than 1 day

The only problems with zoning of customers (as W. S. Atkins term this type of approach) is the large amount of data preparation necessary.

Specifying the road network is itself difficult; and standard times for connections between urban and rural areas, motorways and city centres must only be average figures. Each kind of connection needs analysing for every square, but obviously $t_{ij} = t_{ji}$. Commercially available packages are now realising the advantage of this type of zoning, customers can be added to squares without recalculating and basic data.

W. S. Atkins package uses the Clarke and Wright algorithm with a zoning technique.

Sussams proposes combining this map simplification with maximum drop density. The principle can be simply stated as the realisation that it is more economical to send a vehicle round a route in which the drops are concentrated in one area than to send it round a route with widely dispersed drops.

The conclusion is that tight clusters of customers should not be broken. This appears to be a "rule" applied by manual routers and as such approximates closer to real-life than the Hayes approach.

The map square method of vehicle scheduling is a procedure for identifying compact clusters of calls in descending order of compactness and of allocating these clusters to routes.

Allocation of routes to vehicles starts at outer zones and works inwards, allocating clusters of calls to vans, starting with the most dense clusters and working through the less dense until none remain. The procedure obeys all the constraints built in and seeks to leave any residual calls as near the depot as possible.

Searching in the outer zone is with 10 km squares, then 20 km, 30 km etc; this is then repeated for the middle zone, and finally the inner zone. Large towns may be broken down even further (e.g. Postal districts) but one-way restrictions etc. would involve so much effort for very little (if any) return that experienced drivers should be left to route such deliveries.

The method is apparently efficient in manual and computer versions. There is no iterative procedure to follow, the final route being obtained immediately. This method models the actual operation of scheduling closer than any algorithm developed earlier and would appear to represent a new phase in the problem solution process.

Vehicle Scheduling Computer Packages

Information on computer packages has come mainly from user documentation, discussions with personnel concerned with a particular programme and general discussions.

It appears that vehicle scheduling packages development has been in three stages.

(i) straight forward application of the Clarke and Wright algorithm. These packages were useful and successful in depot siting and fleet planning but not in daily trip planning.

(ii) these packages recognised the tactical aspects of trip planning. Correct specification of distances was recognised and road network methods were offered as alternatives. Taking account of acceptable delivery times and access restrictions results were most acceptable.

(iii) the third generation packages are being developed which illustrates basic changes in philosophy. Three important factors are now recognised

(a) for daily planning systems the Clarke and Wright algorithm is insufficiently flexible

(b) there are different ways in which the computer may participate in planning - varying from not at all to total involvement

(c) problems differ widely and it is inefficient to cater for all eventualities in each problem run

The various bodies offering packages have facilities for tailoring a package to suit the user. For this reason the comments on commercially available packages will be general.

A questionnaire circulated to all persons marketing vehicle scheduling packages by the National Computing Centre Limited in 1969 (15) indicated similarities between all commercially available packages.

All packages have the facility for handling geographical boundaries although the number permitted per run varies with the package used. The most popular method for locating drops is by grid references although delivery points can be specified as either individual points or zones of more than one customer. Although the number of delivery points permitted in the programmes is unlimited, setting up and storing a savings matrix for 6,000 plus accounts would be costly.

Despite sophistications regarding early closing days and complex cost parameters for 2 day journeys, the problem of prohibiting certain combinations of products in one vehicle has not been developed. A further practical difficulty not catered for is that of collections.

Of the 13 packages investigated only 2 did not use the Clarke and Wright savings file with a modified Clarke and Wright algorithm.

Of the packages available W. S. Atkins, Tripper (16), W. E. Norman, Triplan (17), and the ICL Mk I, II and XUVS were analysed in some detail. Analysis involved discussion with the originating bodies.

Tripper zones customers and barriers are limited to 3 per zone. Final routing would have to be performed manually, the extent of which would be determined by the zone size. A major drawback to the programme is that vehicles are assumed to leave at time zero (all packages seeking to provide sophistications as maximum working day or early closing day have this drawback). Although 2 day deliveries are permitted, complex cost parameters have to be determined to assess the value of such trips. This poses problems to national distribution from a central facility where 2 and 3 day trips are not uncommon.

One advantage over the ICL packages is that each zone can have different speed limits, thus deliveries in South Wales can be modified to account for the terrain.

Although the package appeared sophisticated it would need tailoring for individual users and would be run at W. S. Atkins Computer Bureau on a time sharing basis.

For Vono in particular loading sequence can be important but the programme does not give this.

Triplan (17) is basically a suite of 5 programmes developed over the past 8 years for use in the oil industry. It has recently been developed for application in bulk milk collection and distribution of various food products.

Two day trips are not catered for and hence it would be of little value to companies with distribution problems like Vono.

Although the Clarke and Wright algorithm is not used the principles used, quote " ... principles intended to correspond more closely with the thinkings of an experienced despatcher. These vary with the applications but utilise a common set of procedures for scanning locations, allocating trips and composing loads, and for the timing, costing and scheduling of trips" appear to be very similar to the Hayes algorithm (10).

<u>ICL Mk I and II and XUVS</u>

Mark I was a general package offering few sophistications, as it has been superseded by Mk II and XUVS (Mk III) it will not be discussed.

Mk II package experience was gained through analysis of the user documentation prior to running the package and discussions with ICL personnel. XUVS (Mk III) has not been run, discussions with ICL concerning modifications to the print-out caused problems they were unable to overcome.

Both packages are able to handle similar constraints, Mk III being much more sophisticated, even to the point of yellow line waiting restrictions outside customers. Unfortunately these are, in my opinion, window dressing as there is no way of knowing if a queue of delivery vehicles will be there etc. Mk III is more flexible with regard to speeds but average speeds must be used. Congested areas can have different concentric speed zones.

Both packages are based on the Clarke and Wright savings technique which means exceedingly long computer times every time a new customer is added.

Vono has approximately 6000 customers, the time to create this savings matrix would be excessive although once created it could be stored on disc. Problems could arise with new customer additions.

Unfortunately the packages are time oriented. Each drop is timed, 0 time being taken as time of leaving depot. How this can be applied to a fleet leaving at intervals during the day and take early closing days into account is unknown. There are many operational problems with regard to the Vono operation. Vono's products are not homogeneous with respect to volume, and apart from loading problems delivering x units would be meaningless to the company.

ICL were not amenable to modifying the printout to include the customer order to overcome these problems (however W. S. Atkins indicated that their packages could be "readily converted").

The routes selected by the Mk II package were considered reasonable by transport personnel, rather circular instead of combined.

One problem was the mis-reading of a barrier pass-point. Although this is a very infrequent event it seriously affected the results.

Although Mk III can handle 2 day trips it has not been fully investigated.

Experience from running the ICL package indicates that routes can be produced but basing deliveries on times when the time of leaving is unknown is a serious drawback.

Very little data is available on the extent to which packages are used. Some companies have investigated packages but implemented improved, manual systems. One possible use is to determine "best" routes through customers and then to fit customers to these routes. This system works in one company where vehicle scheduling is unknown as such.

The savings matrix is a static measure of priority whereas some sort of dynamic decision rule is needed. This could be the present - promised date. Urgent Orders could be given highest priority easily.

This approach is tending towards customer (i.e. user and consumer) benefit, comparisons with standard techniques might provide some cost factor which could be attributed to service.

REFERENCES

1. G. B. Dantzig and J. H. Ramser, The Truck Despatching Problem. Mgmt. Sci. 6 80 - 91 (1959).
2. P. C. Gilmore and R. E. Gomory, The Theory and Computation of Knapsack Functions. Ops. Res. 14 1045 - 1074 (1966).
3. W. W. Garvin, H. W. Crandall, J. B. John and R. A. Spellman, Applications of Linear Programming in the Oil Industry. Mgmt. Sci. 3 407 (1957).
4. M. L. Balinski and R. E. Quandt, On an Integer Programme for a Delivery Problem. Ops. Res. 12 300 (1964).
5. M. Held and R. M. Karp, A Dynamic Programming Approach to Sequencing Problems. S.I.A.M. Rev. 10 196 - 210 (1962).
6. R. Bellman, Dynamic Programming Treatment of the Travelling Salesman Problem. J. Assoc. Comp. Mech. 9 61 - 63 (1962).
7. R. H. Gonzales, Solution to the Travelling Salesman Problem by Dynamic Programming on the Hypercube. Tech. Rep. No. 18 O.R. Centre. M.I.T. (1962).
8. J. C Little, K. G Musty, D. W. Sweeney and C. Karel, An Algorithm for the Travelling Salesman Problem. Ops. Res. 11 979 - 989 (1963).
9. G. C. Clarke and J. W. Wright, Scheduling of Vehicles from a Central Depot to a Number of Delivery Points. Ops. Res. 11 568 - 581 (1963).
10. R. L. Hayes, The Delivery Problem. Carnegie Institute of Technology, Graduate School of Industrial

Administration, Pittsburg. Report No. MSR 106 (1967).

11. N. Christofides and S. Eilon, An Algorithm for the Vehicle Despatcher Problem. Opl. Res. Q. 20 309 - 318 (1969)

12. J. E. Sussams, Vehicle Routing - A New Technique. Transport Study Group Meeting. O.R. Soc. Ltd., London (1971).

13. T. J. Gaskell, Bases for Vehicle Fleet Scheduling. Opl. Res. Q 18 281 - 295 (1967).

14. F. A. Tillman and H. A. Cochran, A Heuristic Approach for Solving the Delivery Problem. J. Ind. Engineering 19 354 (1968).

15. Computers in Vehicle Scheduling. National Computing Centre Ltd. 1969 pp 50 - 55.

16. Discussion: W. S. Atkins and Partners, Epsom, Surrey.

17. Demonstration of Triplan - 5 - A programme for the generation of schedules of trips to be run repeatedly throughout a season of comparatively stable and predictable demand. W. E. Norman, Transport Study Group, O.R. Soc. Ltd. 1970.

18. J. B. Kruskal. On the Shortest Spanning Subtree of a Graph. Proc. Am. Math. Soc. 7 48 (1956).

19. G. A. Crues. A Method of Solving Travelling Salesman Problems. Ops. Res. 4 61 (1958).

APPENDIX II

Precis Of

North East Distribution Point Operations

September 1971

Precis of: North East Distribution Point Operations

1. Introduction

The Northern Warehouse Services Limited depot at Stanley, near Newcastle-upon-Tyne acts as the north east depot for Vono Limited. Loads are back loaded from Tipton by NWS transport (2500 cu. ft.) as orders dictate and are broken down and stored prior to delivery to customers. A stock of mainly bedding is maintained as the depot also accepts orders from customers.

Storage space allocated to Vono was 5500 sq. ft. for which no rental was charged. Other users of NWS facilities pay approximately 1½p/sq. ft./week.

Vono does not pay for the services of a warehouseman who works exclusively on Vono business nor the clerk who takes and types Vono orders for part of her working day.

The overall cost to Vono was £88 per load, made up as, £45 for delivery from Tipton to Stanley, £15 for handling and storage, and £28 for delivery from Stanley.

2. Analysis

2.1 Order Processing

The order processing system was found to be poor, there being no file of orders just a folder in which they were stored randomly. If multi-product orders were placed, confusion could arise. It was noticed that up to 3 hours was necessary to sort through the folder of orders after delivery of a load from Tipton. There was no stock record sheet maintained at Stanley nor Tipton and hence queries regarding delivery forecasts or product availability were not based on facts. Orders for products which had been dropped from the catalogue over 6 months ago were still live due to the poor communications between Tipton and Stanley. Depot requisitions placed on Tipton by Stanley had been delivered to some other depot(s) consequently Stanley had been credited with them and the requisitions cancelled.

2.2 Service

A minimum delivery service was provided as:-

Monday - Newcastle and Sunderland areas

Tuesday - Berwick area

Wednesday - No deliveries, early closing problems

Thursday - Newcastle and Sunderland areas

Friday - Middlesborough and Darlington areas

Hexham area whenever possible

There was no load building model in use although vans were apparently sent if over 50% full.

During the week 13th to 17th September 1971, 7 loads of Vono deliveries were despatched at an average mileage of 90 miles/load.

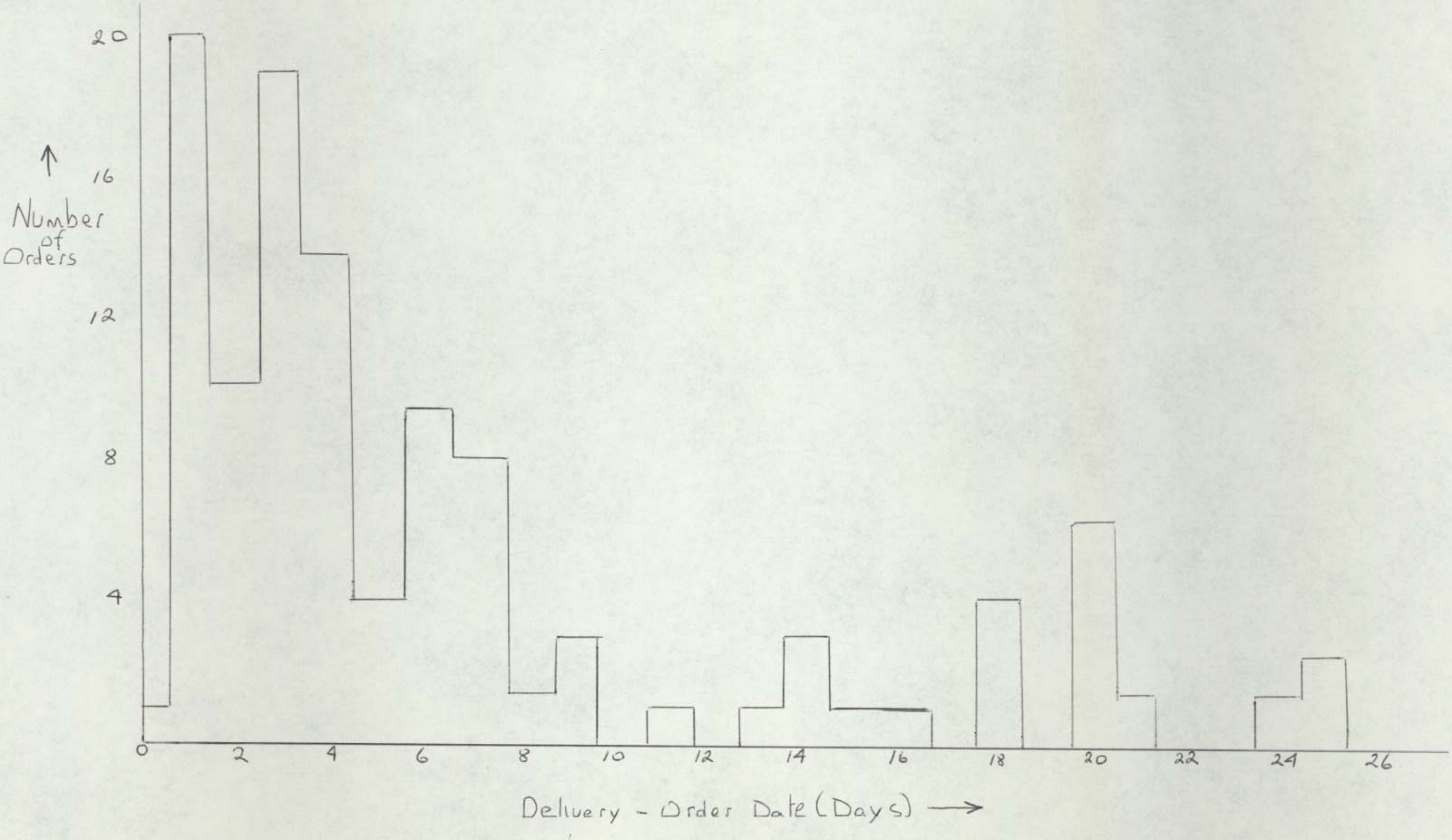
Damaged or faulty goods were collected from customers at a charge per item depending on location relative to Stanley.

The value of Stanley as a sales office is difficult to define although Vono sales management consider it an essential factor. Reference to Table 1, a comparison of Vono's sales in its depot regions does not bear this out.

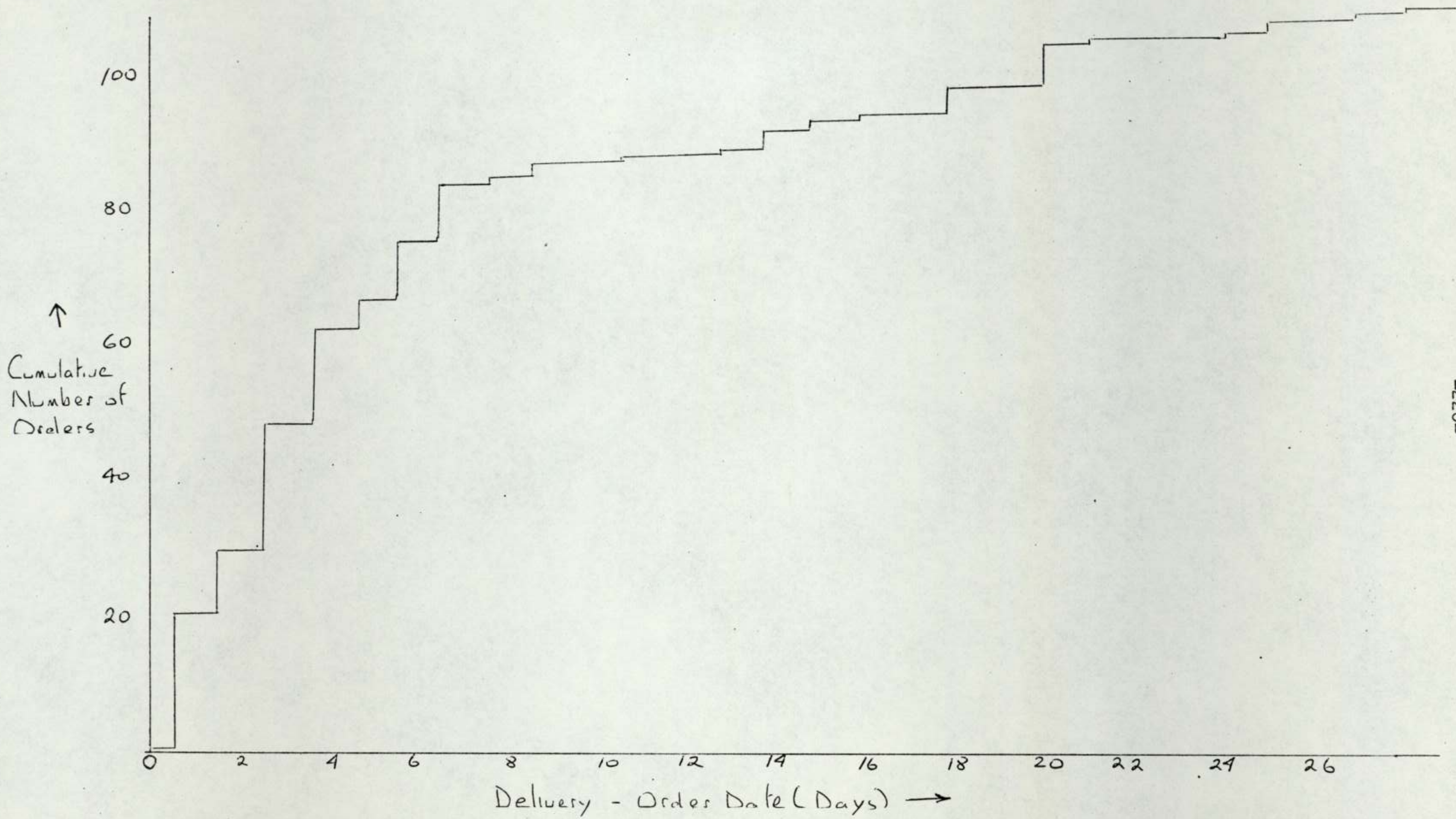
Graphs 1 and 2 illustrate the ability to meet delivery forecasts for orders placed on Stanley. These results were

Area	Vono Bedding £	Vono uph. £	Vono Total £	S'land Bedding £	Vono Bed / pop. £/head	Vono Total / pop. £/head	S'land Bed / pop. £/head
M31 Attleboro'	60,504	34,758	95,262	223,333	0.041	0.064	0.151
M34 Ynysybul	62,226	59,973	122,199	290,549	0.028	0.058	0.138
N47 N. East	98,531	51,947	150,518	352,362	0.033	0.056	0.132
S21 Bovey	78,206	52,309	130,515	264,218	0.069	0.115	0.23

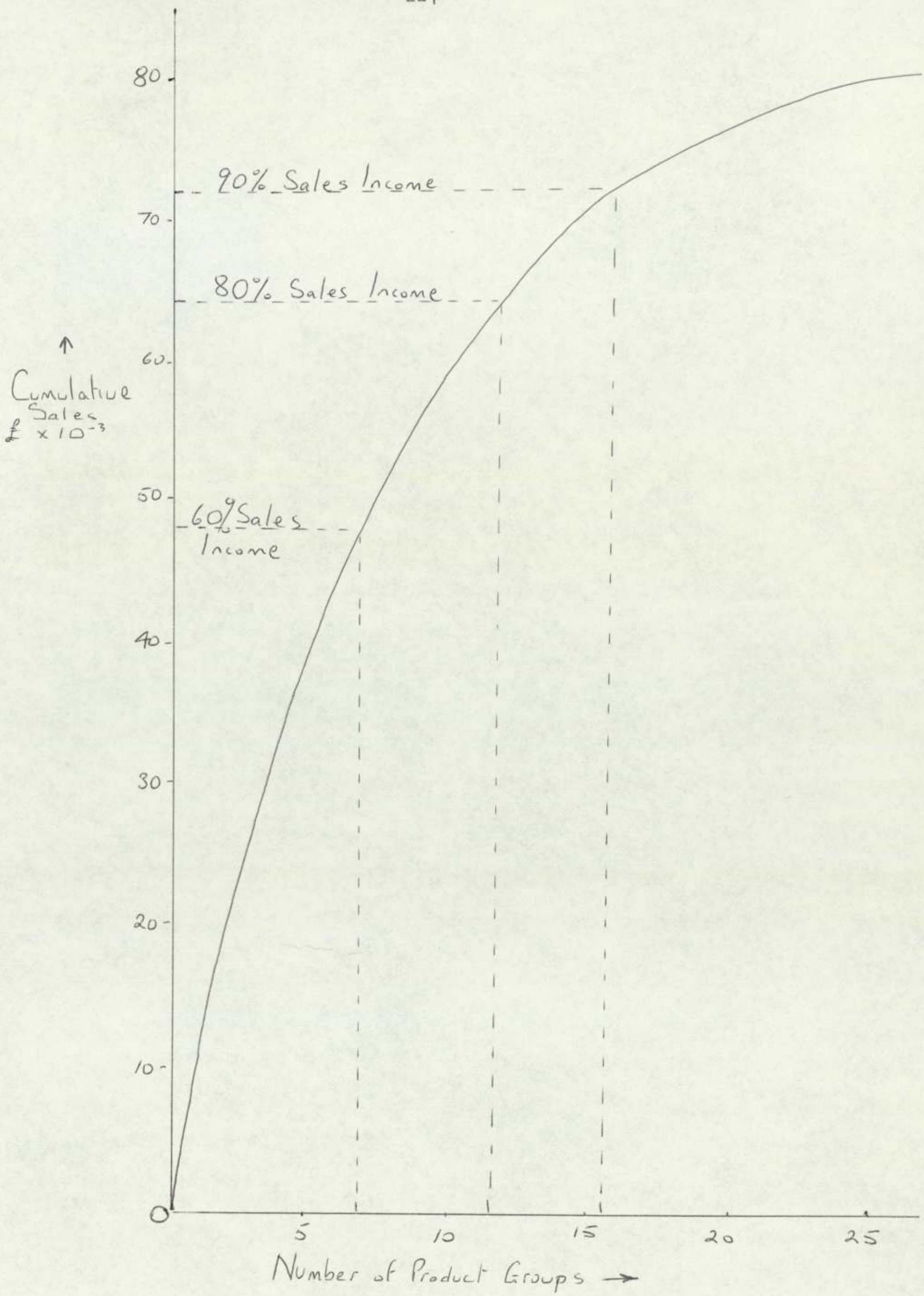
Table 1. A Comparison of Vono Depot Area Sales



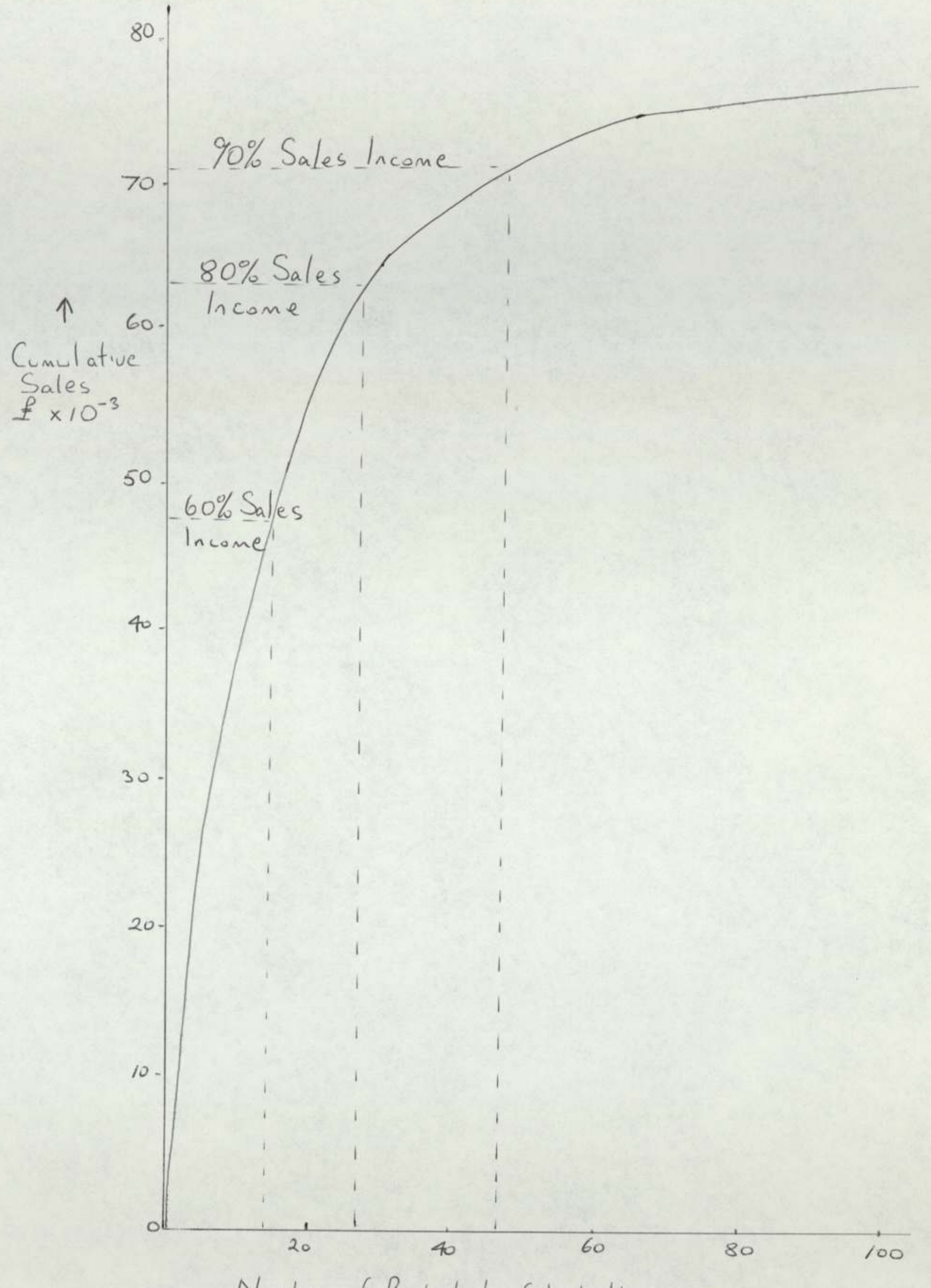
Graph 1. Illustration of Delivery-Order Date against number of orders for each date



Graph 2. Cumulative distribution of Delivery-Order date data



Graph 3. Cumulative sales by product groups



Graph 4. Cumulative sales by product

worse than those obtained from a similar exercise performed on deliveries from Tipton. Apart from the poor order processing system at Stanley the imbalance between demand and stocks must have played a part. Stocks of poor selling products were at very high levels while fast movers were almost ignored. One customer in Newcastle had his own label beds in stock although he didn't know and had placed a further order on Tipton. Some own label beds were known by NWS staff to be of a wrong specification and had been held for over 6 months.

2.3 Sales Analysis

As a prelude to inventory control proposals a complete sales analysis was performed for N47. The object was to perform an ABC analysis by turnover for bedding products. Stock holding policies could then be formulated from these results.

Unfortunately the representatives' order intake summary classifies beds by name only, size and tick are not recorded. A product/size/tick mix model in use by the company, Table 2, was found not to contain all bed types. Records for the country were analysed in detail to produce a new model, Table 3, which was found to differ considerably from the much simplified company version.

Modifications to the order intake analysis were necessary because orders placed on Stanley (or any depot) for out of stock products would not be recorded as demand data for up to 6 weeks later. This arises because the depot has to requisition from Tipton, await normal delivery times, check into the depot and build into a load and after delivery send the invoice note to Tipton for processing. Only 50% of depot invoices were processed within 5 days of delivery. The cumulative effect of these delays combined with the weekly sales analysis performed by the company led to inaccuracies in demand patterns.

The selling price of products can vary between customers depending on their discounts. Beds were also offered at a discounted price to all customers during sales promotions. To overcome these difficulties the trade price according to the latest published price list was used.

Graph 3 was produced by product group name, i. e. all Astras were grouped together, the turnover being determined from the price mix using the marketing department product/size/tick model. Graph 4 was by stock items, e. g. Astra 3 ft. blue F.E. set, using the more comprehensive model.

3. Discussion

The situation was put to the financial and sales directors in great detail. Immediate results were that over £3,400 (retail value) of shell chairs were recalled to Tipton to meet outstanding orders. Over 50 out of specification bed sets were sold to a customer in Liverpool. Because Vono paid no-one to look after their interests at Stanley there was no-one who could be held directly responsible. Rather than analyse the procedures at Tipton and co-ordinate vehicle movements from Stanley with allocation and load building at Tipton, the procedures were allowed to remain. It was agreed however that inventory control evaluation be continued, the area to act as a training ground before inventory control were attempted on the whole factory.

Within one month the company had decided to close the depot and that all analysis of it cease.

(One year later the depot is still operating but at a cost of over £40 per week more).

Improvements suggested included modifying the depot requisitioning procedures and instituting inventory recording of depot stocks at Tipton. Alternative distribution procedures were proposed but were either unacceptable to NWS or D. W. Wilson. Delivery by Freightliner container direct to Stanley caused NWS management to threaten to stop operating for Vono if this were agreed by Vono. This indicated that NWS were more concerned with earnings per vehicle rather than storage fees. Neither Vono nor D. W. Wilson were prepared to use this as a lever for lower storage charges.

APPENDIX III

Testing Of The Hypothesis That "Contribution To General Overheads Produced By Sales In A Given Depot Region Will Be Reduced If That Depot Ceases To Operate."

June 1971

SYNOPSIS

An evaluation of Ynysybwl depot has been performed as a preliminary to depot location exercises. Comparing costs of operating the depot and delivering direct indicated that closure rather than re-siting would be more beneficial on the basis of the assumptions used.

Stock value and insurance of the depot have been neglected.

The expected cost of operating the depot in 1971 was calculated as:-

£19414

The expected cost of delivering direct by Vono vehicles for 1971 was calculated as:-

£13855

producing an expected saving of:-

£ 5560

The expected cost of delivery direct by contractors for 1971 was calculated as:-

£15052 to £17282

producing a saving of:-

£ 4362 to £ 2132

The expected cost of delivering 80% by Vono and 20% by contractor for 1971 was calculated as:-

£14158

producing a saving of:-

£ 5256

The savings produced were set against loss in profit from sales by closure of the depot, and it was calculated that Gross Profit produced in the region would need to fall 17½% before breakeven point was reached.

Other strategies are mentioned as future areas for the research programme.

1. Introduction

Depot location, stock holding and delivery patterns are obviously important factors in an efficient distribution system. Instead of performing depot location exercises, first it was decided to fully analyse an existing depot, if the hypothesis to be tested was proved correct then depot location exercises could be performed.

Selection of the depot was based on vehicle operating costs per mile. Other criteria were turnover or contribution; unfortunately, the turnover records were incomplete, for example, 19 towns in Ynysybwl area had no figures against them and two sets of data obtained from the same source disagreed, the depot contribution records came to light too late in the investigation.

The depot selected was Ynysybwl and hence the hypothesis to be tested was that "the contribution to general overheads at Tipton produced by sales in the South Wales region will be reduced if Ynysybwl depot ceases to operate".

Only one strategy has been compared with the present operation, that of closing the depot and maintaining all accounts.

2. Investigation

2.1 Depot Selection

A complete record of all costs and miles travelled for each Vono (i. e. leased) vehicle is kept by the distribution department.

Grouping the vehicles under the base from which they operate the figures for 1970 were:-

Attleborough	12.20 p/mile
Belfast	19.74 p/mile
Bovey Tracey	12.00 p/mile
Glasgow	15.69 p/mile
Tipton	13.24 p/mile
Ynysybwl	14.00 p/mile

Belfast and Glasgow cover the largest areas and have high depot operating costs, i. e. wages and salaries, personnel costs and rents and rates.

Attleborough, Bovey Tracey, and Ynysybwl have comparable costs and hence the one with the highest cost per mile was selected, Ynysybwl.

This depot, located between Pontypridd and Mountain Ash, services the south and mid Wales area extending from Chepstow via Monmouth, Rhayader to Aberystwyth in the east and north, and over to the coasts on the south and west.

The personnel involved are 2 drivers, a warehouseman and a depot manager, the vehicles being approximately 1500 cu. ft. capacity and leased on a 4 year contract by Vono Limited.

Depot costing is based on figures supplied by the Accounts Department of Vono Limited for 17 weeks ending 28.11.70 and scaled up to one year.

To arrive at 1971, operating costs, salaries, etc. have been increased by 10%, S.E.T. from July 1971 onwards halved etc.

Vehicle costs are for the full calendar year and adjustments made for 1971 rates. Rates charged by hauliers have been taken as those agreed at present between D. W. Wilson (International Distributors) Limited and Vono Limited.

The number of loads supplied to the depot was obtained from Distribution Department records, similarly for loads delivered by the depot.

2.2 Depot Costing

Expense		Last ⅓ 1970 (£)	Assumed 1970 (£)	Expected 1971 (£)
Salaries		401	1203	1323
Excess expenses + overtime		42	126	126
Holiday pay	*	104	312	343
Training	*	15	45	50
National Insurance	*	58	174	174
S.E.T.	**	65	195	136
Depot Staff Pension Contributions	*	39	117	117
Government Pension Contributions	*	25	75	75
Labouring and transport		544	1632	1792
Electricity	**	28	84	90
Indirect material incl. petty cash		172	516	516
Building repairs		14	50	50
Travelling		4	12	12
Telephone	**	152	456	456
Rates	**	52	156	156
Rent	**	65	195	195
Hired Transport		401	1203	1203
TOTAL			6551	6814

* Apportioned expenses

** Budgeted expenses

2.3 Vehicle Costing

Complete breakdown of costs are not available for the full year but total figures are kept.

The total cost of Vono vehicles at Ynysybwl comprises:-

tyres

fuel and oil

mechanical maintenance

body and paint

mech. act. cost to date

" " " " " recovered

body and paint act. cost to date

" " " " " " " recovered

wages including N.I.H.

subs

hire charges

road tax, insurance, holiday pay

establishment charges

Of the total cost of these vehicles of £6601.88, £1878.90 was attributed to the hire charges, road tax, insurance, holiday pay and establishment charges.

Discussions with the Road Haulage Association indicated how difficult it would be to project costs forward even 12 months, but running cost increases in the region of 8% were considered reasonable. Running costs accounted for just over 2/3rds of Vono costing, and therefore an increase of 6% overall would appear reasonable.

The expected vehicle costing for 1971 for Ynysybwl vehicles therefore is £6997.99 (£7000).

2.4 Total Cost Of Operating Depot

The total cost of operating the depot will be 2.2 plus 2.3 plus the cost of moving loads to Ynysybwl.

During the year 1970, 187 loads were delivered to Ynysybwl but, unfortunately, it is not possible to state how full the vehicles were. Some were delivered as back loads at a cost of approximately £18.50 per load while others went by contractor. During the year the rate (for 1750 cu. ft. vehicles) prior to July was £24.50, after July £26.95.

It is of academic interest only to record the total expected cost for 1970 for delivery to Ynysybwl. Records revealed 102 loads at £24.50 and 85 loads at £26.95 giving a value of £4799.75. This assumes all loads by contractor and will err on the side of the hypothesis.

The rate currently charged by D. W. Wilson Limited for Ynysybwl deliveries is £29.95 (June 1971). Assume that turnover in the region remains constant and that the number of loads into the region remains at last year's figure, then the expected cost of delivery to Ynysybwl will be £5600.65.

It could be argued that assuming the June rate all year may introduce inaccuracies but if deeper analysis were performed of loads to Ynysybwl at £18.50 last year to produce accurate figures would answer the argument.

Therefore the expected total cost of operating the depot in 1970 was £17951.63.

The expected cost of operating the depot in 1971 based on the above assumptions is £19414.65.

This latter figure does not take into account any increase agreed between Vono Limited and D. W. Wilson Limited regarding rates. It had been mentioned that a 2½% increase is due any time and certain contractors have expressed concern over applying, to D.W.W., new rates.

These figures also discount the value of insurance of Ynysybwl depot and also the value of its stock. If these figures approach £1000 then the total operating costs will be in excess of £20000.

2.5 Vehicle Utilisation Factors

Based on available data 187 loads were received by Ynysybwl in the 12 months January - December 1970 and 322 loads delivered.

ASSUME all loads from Tipton were 1750 cu. ft. vehicles

ASSUME an average utilisation factor of 90%, then

187 1750 cu. ft. loads at 90% = 220 1500 cu. ft. loads at 90%

(based entirely on volume considerations, also that whatever is delivered to a depot over the year will be delivered from the depot if the stock level at the close approximates to that at the opening. The depot size in question is such that if all the stock were cleared it would probably be only 3 - 4 van loads).

However, 322 loads were delivered giving a utilisation factor of 61%.

If loads from Tipton were on average 80% 1750 cu. ft. loads then Ynysybwl utilisation factor reduces to 55%.

If loads from Tipton were a mixture of 1750 cu. ft. and 1500 cu. ft. the factor reduces even more.

Assuming 1750 loads therefore produces the 'best' picture of the depot, again erring on the side of the hypothesis.

2.6 Customer Service Levels

Theoretically bedding should be delivered from the depot stock and upholstery delivered to the customer via the depot.

The delivery patterns for Ynysybwl depot are a minimum of:-

Monday - far west to Haverfordwest and Aberystwyth

Tuesday & Friday - eastern side of depot area

Monday, Wednesday & Friday - western side of depot up to Ammanford

As at Tipton other loads are sent if demand exists.

Analysis of loads to depots revealed that the majority of orders for Ynysybwl were placed on Tipton (see report March 1971, 1521 T number orders, 275 depot requisition orders). The period analysed was 1.1.70 - 31.7.70 and deeper investigation may be valuable.

Discussions with the depot manager (June 1971) revealed that the company reacted to the report by sending to the depot all orders placed directly on Tipton for the depot to issue a requisition order. This serves to decrease the service level in the majority of cases.

It would be interesting to study the ordering habits of customers in the area, and the spread of shops using central buyers to clarify certain intangibles in the problem.

A further analysis was performed on loads to Ynysybwl, every fourth load being selected. The loads were primarily analysed to determine the length of time they had waited before delivery to Ynysybwl. Knowing the alleged delivery patterns this analysis would be useful as a guide to simulation.

Time did not permit a full analysis of all loads selected, only half were analysed. From Tipton it is possible to determine how long a T number order has waited but not products on a depot requisition.

Of the loads analysed results were:-

Days waiting	Number of loads
11	1
6	1
5	2
4	3
3	3
2	5
1	3
0	1

The days waiting is the time between receipt of the 'last' order and loading date. To these days must be added the day for loading, delivery and inloading and then the wait at Ynysybwl to fit into its pattern.

The depot therefore adds 2 to 3 days minimum on to these figures. It should be stated that all the above were T number orders and hence a customer was waiting.

3. Strategy: Deliver Direct From Tipton

This strategy will assume that the depot ceases to operate and that the loads are delivered as multi-drop deliveries from Tipton.

This section must be based heavily on assumptions, those concerning sales having been obtained from Sales Department personnel, those concerning vehicle costing from the Road Haulage Association and the mileage figures from analysis of the problem.

Assumptions will be clearly indicated.

There are two alternatives:-

(i) to operate the Ynysybwl vehicles from Tipton as the Leeds, London and Oldham vehicles

(ii) to operate with contractor's vehicles

Each section can be further sub-divided into what it would cost Vono by paying direct and what it would cost Vono under the contract with D. W. Wilson Limited. All sub-divisions will be evaluated.

From earlier figures Ynysybwl vehicles covered 49366 miles during 1970, averaging 153 miles per load and at a utilisation factor of approximately 60%.

ASSUME the service volume of sales in the region for the year 1971 and hence the same number of loads at 90% full would be required.

ASSUME that the vehicle utilisation factor is reduced to 80%; with multi-delivery loads the packing will not be as efficient, it may also be necessary to send out smaller loads for service level considerations. Again slight erring in favour of the hypothesis.

ASSUME the average expected delivery mileage per the expected mileage will be 82530 giving a total cost of £14030, BUT if a 6% increase in rates is assumed (which is approximately 2% less than for Vono vehicles) the total expected cost will be £14871; if a full 8% increase is assumed the figure will be £15052.

If, however, 1500 cu. ft. vehicles are used then the cost will be £16002.50, allowing a 6% and 8% increase in rates, the total expected costs will be £16960 and £17282 respectively.

As the contractor's fleet comprises both 1750 and 1500 cu. ft. vehicles the cost to Vono Limited by this method will be between £15052 and £17282.

The total expected cost of servicing the South Wales sales region (but not including stocks and insurance) for 1971 is £19414.65.

3.1 Expected Savings

The savings by using contractor's vehicles and paying direct will not be stated (but should be noted) as under the contract with D. W. Wilson Limited all charges are paid to them.

3.1.1 Using Ynysybwl vehicles based at Tipton. Neglecting the cost of insurance and stocks the expected will be £6740.

3.1.2 Using Ynysybwl vehicles based at Tipton but allowing for D. W. Wilson Limited surcharge. Neglecting the cost of insurance and stocks the expected savings will be £5560.

3.1.3 Using contractor's fleet based on D. W. Wilson Limited costs. Neglecting the cost of insurance and stocks the expected savings will be in the range £4362 to £2132 (1750 to 1500 cu. ft. vehicles). It is debatable whether the service levels could be maintained with 1750 cu. ft. vehicles only and hence a suggested saving would be the average.

3.2 Expected Service Levels

If the order processing system inside the factory is efficient and loads loaded to suit the delivery pattern, then there should be no decrease in service levels, indications are that it should improve.

Re-organisation of delivery patterns for the Wales region would be necessary, a preliminary suggestion being:-

the area to Swansea and Neath (including Hereford)

the area over to the west and to Aberystwyth

Service level minima could be two deliveries per week minimum to Swansea and one per week over to the west.

This will give approximately three deliveries per week minimum to the region, this could be boosted to the expected figure of 250/year 1500 cu. ft. vehicles at 80% utilisation factor.

If demand at the rate of five loads/week does not exist then the costing figures will be proportionately modified. If the vehicles are used to deliver locally on Tipton while awaiting Welsh loads, then the company may save even more by paying only 13p/mile instead of 17p/mile or £1.38/hour.

4. Discussion

The costs used on this section of the research programme have been obtained from the accounts department and hence assumed accurate.

The same cannot be said for the figures obtained from the sales department concerning sales/town in the region, from which it was hoped to produce an average value of £contribution/£sales. Figures supplied by C.K.M. for April and June 1970 depot contributions were used giving an average value £0.258/£sales (excluding Ynysybwl depot costs) or £0.242/£sales for contribution to general overheads at Tipton.

Being unable to obtain (readily) accurate sales and contribution figures meant that the depot contribution sheets were used to obtain overall averages for £contribution per £sales.

The term used will be GP1 to indicate the Gross Profit less material price variance, usage variance provision, discounts and rebates allowed and agents commission.

Overall country averages were:-

£ GP1/£ Sales = 0.3302

£ GP /£ Sales = 0.379

The sales in Ynysybwl for April and June 1970 were £13,500 giving an expected figure for the year of £81,000.

Using the GP/Sales figure gives an expected GP £30,699.

Using the GP1/Sales figure gives an expected GP1 £26,746.

If it is assumed that sales drop 10% then GP would be expected to fall by £3,069 and GP1 by £2,674.

The cost of distribution would obviously decrease by a factor although not necessarily anywhere near 10%. To obtain the worst view of the situation assume that distribution costs remain at the expected values obtained earlier, then by operating with Vono vehicles (at a saving of £5560 neglecting stocks and insurance which could be easily £1000) a saving will still be apparent.

It can be seen that GP needs to fall approximately 17½% with the same distribution costs before the breakeven point is obtained. To arrive at a really accurate figure requires time and assistance from the company on data collection, etc.

Using the costs for Vono long distance drivers should cover any increase in drivers' expenses due to night out. One serious problem will be to maintain service at an acceptable level.

Discussions with the drivers at Ynysybwl indicated that the only two-day journey was the one over to the west coast, the remainder being readily performed in one day. Delivering directly from Tipton should enable a pattern to be established of about 4 loads per week. It should be remembered that part of the region is to the east of Ynysybwl.

Deeper investigation of possible delivery patterns using Vono vehicles only will be needed, the cost to Vono of one extra vehicle on contract will be approximately £67 per load.

These factors cause others to spring to mind, namely, the role Vono plays in delivering Grovewood products.

Grovewood products are delivered by Ynysybwl at a cost in 1970 of £0.50 and £0.20 per unit depending on size. Costs of this service not recovered from Grovewood for November 1970 to June 1971 and comments were made in a memorandum to the Marketing Director dated June 1971.

An alternative strategy involves closing accounts with £500 per year turnover. Immediate problems spring to mind, the west coast of Wales is a poor buying area in general (notable exception Haverfordwest). If small accounts in the west closed then delivery by present or suggested methods may prove too expensive and hence alternatives would be considered, e. g. carrier from Swansea, dealerships, etc.

The alternative strategy will be more difficult to formulate but should prove much more interesting.

If Vono vehicles (i. e. leased) are going to cover a larger mileage the question arises 'is it cheaper to buy or lease?' if the depot is closed. This question can be answered once the strategies have been agreed, the time being right as the leases are due for renewal within the next year.

The value of stocks and insurance of Ynysybwl depot has not been included but inclusion would only have served to increase the savings by at least £1000 in every case.

The savings quoted in Sections 3.1.1 may appear difficult to meet if five loads per week are to be delivered by Vono vehicles. If Vono vehicles are only able to deliver four and one contractor's vehicle per week is used, the saving will be £5256.

The whole strategy may be difficult to accept but if the basic assumptions are accepted and the sales force maintain their effort then the savings expected should approach the theoretical values obtained. If economic costing of Grovewood deliveries were performed and the delivery patterns in the area integrated the savings on a Group basis would be higher.

5. <u>Conclusions</u>

1. The research has effectively disproved the hypothesis that "Contributions to general overheads at Tipton produced by sales in the South Wales region will be reduced if Ynysybwl depot ceases to operate".
2. The only conclusion to be drawn is that, bearing in mind the assumptions, greater benefits will accrue by closing Ynysybwl depot and delivering direct.
3. The research should not be considered in isolation; certain other strategies need evaluation in this region.
4. Doubts must be cast on the viability of <u>all</u> other depots if an efficient distribution system is to be obtained.
5. The expected savings would have a breakeven point at slightly above 17.5% drop in sales assuming an average £ GP/£ sales figure, and also that transport costs did not fall with loss of sales.

APPENDIX IV

Precis Of

Vono Distribution System,

Report Of Phase I

March 1971

Precis of: Vono Distribution System, Report of Phase I

1. Introduction

Vono Limited offers two types of service, a bespoke service for the majority of upholstery lines and an ex-stock service within 7 days for standard bedding products. Upholstery products are offered against 10 to 12 week delivery forecasts, and the company believed that one day or so over this period was not critical. However with a short delivery forecast it is important that delivery should not be delayed. The company firmly believed that over 80% of all bedding orders were met within the delivery forecast. It was decided to investigate the actual delivery performance attained by the company for the period 1/5/70 to 31/10/70.

2. Analysis

2.1 Depots

The service provided by a depot is an amalgam of its stock holding policy, its and Tipton's order processing system, delivery performance from Tipton, sales point value, vehicle utilisation and managerial expertise. The importance of a depot to the company is simply the profit the depot contributes towards the general overheads of the Tipton factory. Only part of the overall system can be investigated from Tipton, it is hoped that all aspects will be investigated in detail at a later date.

For the period 1/5/70 to 31/10/70 the percentage of all loads which were delivered to depots are given below. The figures correspond to between 18% and 25% of all loads despatched from Tipton; the vast majority of loads being deliveries to retailers direct from Tipton.

Depot	May	June	July	August	Sept.	Oct.
Attleborough	1.48	2.04	2.17	1.43	1.98	1.05
Belfast	2.22	2.04	1.08	1.79	2.15	1.43
Bovey Tracey	2.10	3.50	2.53	1.61	2.15	1.43
Glasgow	4.81	5.10	4.22	5.20	4.88	4.79
London	3.95	5.84	6.25	5.00	5.40	3.36
N. East	3.46	3.94	3.50	3.58	5.00	4.50
Ynysybwl	1.85	2.18	2.29	1.43	2.63	1.73
All Depots	19.87	24.64	22.04	20.04	24.19	18.29

corresponding to numbers of loads as:-

Attleborough	12	14	18	8	15	11
Belfast	18	14	9	10	16	15
Bovey Tracey	17	24	21	9	16	15
Glasgow	39	41	35	29	37	50
London	32	40	52	28	41	35
N. East	28	27	29	20	38	47
Ynysybwl	15	15	19	8	20	18
Totals	161	175	183	112	183	191

Based on these figures and the original quotes from Freightliners Limited for delivering to the above Vono depots, calculations revealed that an increase of approximately 16% in volume of sales would be needed to justify complete use of Freightliners on depot runs. This means that a 16% increase in business could be accommodated with no increase in the number of vehicles under contract. As contracts were for 5 years and contained penalty clauses for minimum mileage per week, the use of Freightliners may be more flexible.

A measure of the value of depots as sales points should be related to the percentage of the orders delivered which were placed directly on the depot. These would show up as depot requisitions, orders having been placed directly on Tipton being identified by the code T before the number. In the table below the term 'full depot loads' refers to loads which comprised depot requisitions only, all other loads being a mixture of depot requisitions and direct orders. The figures indicate that the depots were not functioning as sales points as customers were ordering directly from Tipton.

Depot	Total No. Loads	Full Depot Loads	Total No. Orders	T-No. Orders
Attleborough	98	11	1130	601
Belfast	98	38	954	343
Bovey Tracey	124	19	1609	920
Glasgow	210	65	3267	592
London	319	189	2518	1181
Ynysybwl	134	8	1796	1521

It was not possible to analyse the North East depot fully because orders were filed differently to Vono depots. The total number of loads delivered in the period was 5011.

2.2 Home Retail

100 orders, representing 2.5% of home retail orders delivered in the period were selected for analysis. At the time orders were date stamped on receipt by each department concerned. Each order was therefore analysed for date of order, date of allocation, date of receipt by distribution and

date of loading onto a vehicle. There is no way of checking the date of receipt by a customer but an average of 1 day can be added to the time calculated.

The time a load waited before delivery was the time from receipt of the latest order to the loading date. For the sample of loads selected the average waiting time was 2 days with approximately 40% waiting 4 days and above. Some orders were observed to have waited in excess of 30 days between receipt by the distribution department and loading.

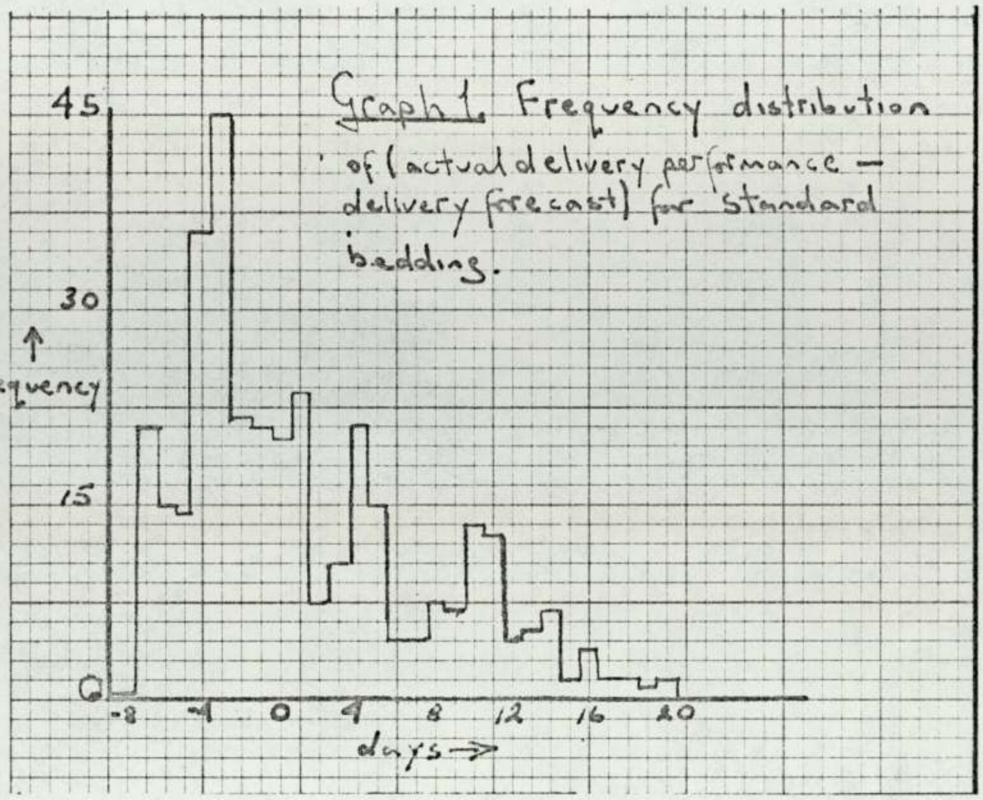
Histograms were produced for the waiting time distribution of all major product groups, Graphs 1 to 4 being a sample from the original report. These graphs refer to orders not the number of products. Bearing in mind the company's definition of service, the concept of failure to meet an order was considered to indicate more of the performance of the system than the number of products supplied on time. Implicit in this assumption is the belief that all customers are equivalent.

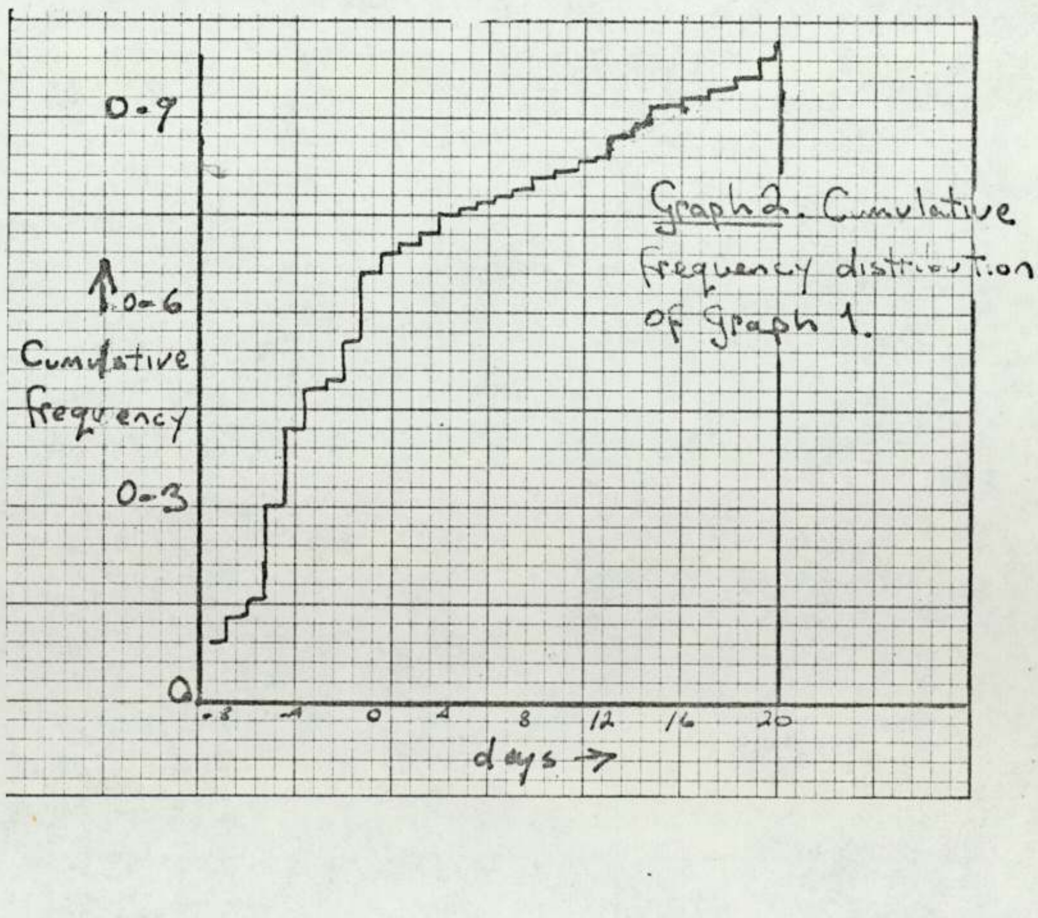
Where orders were held back on customer requests, the requested date was taken as the delivery forecast.

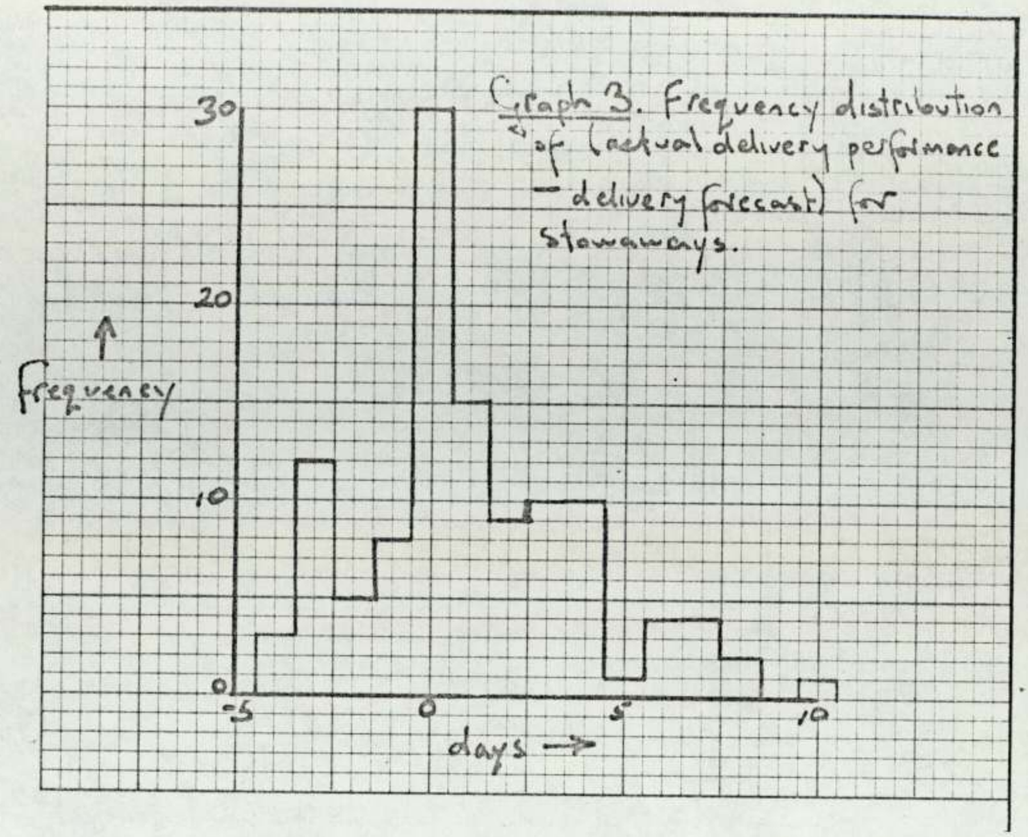
3. Discussion

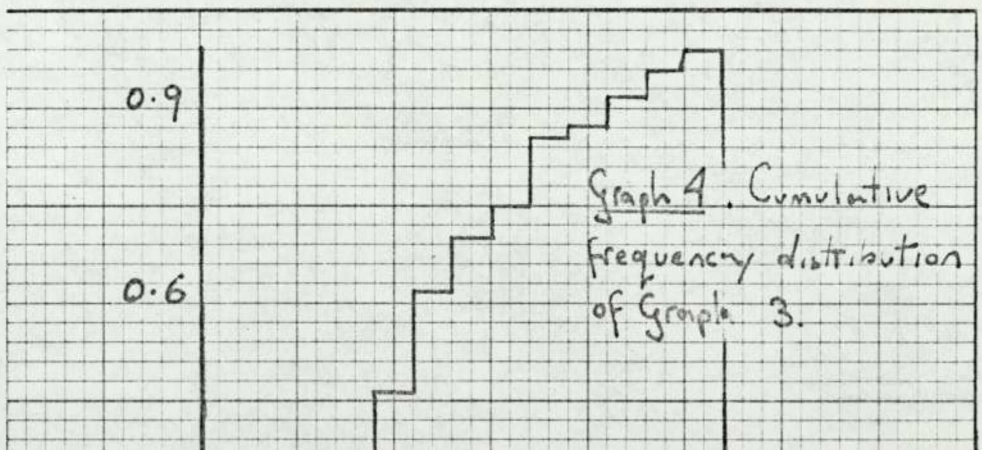
The period selected for Home Sales investigation was thought to be an acceptable period, before the January sales rush and after the summer slack period. Any nearer the present would have produced different results because of the decrease in loads caused by the postal strike and the February stock period.

The argument that one dissatisfied customer is as dissatisfied as any other may be refuted by the company. It


Graph 1. Frequency distribution
of (actual delivery performance - delivery forecast) for standard bedding.
45
30
15
0
frequency
-8
-4
0
4
8
12
16
20
days


Graph 2. Cumulative frequency distribution of Graph 1.
0·9
0·6
0·3
0
Cumulative frequency
-8
-4
0
4
8
12
16
20
days


Graph 3. Frequency distribution of (actual delivery performance − delivery forecast) for stowaways.
30
20
10
0
frequency
-5
0
5
10
days


Graph 4. Cumulative frequency distribution of Graph 3.
0.9
0.6
0.3
0
-5
0
5
10

could be that the company would want to weight the degree of dissatisfaction by reference to the size of each account. As no comments were made by the company, no weightings were applied to customer service levels.

On Graphs 1 and 3, movement to the left of the zero indicates orders met; to the right, orders failed; while the zero itself needs deeper investigation. If it is assumed that an average value of 1 day be allowed for delivery, the graphs may be more meaningful. Reference to the cumulative probability graphs indicate the probability of an order for a specific item meeting the delivery forecast, which for standard bedding items isn't very high. It is interesting that for Weston and Double Up bunk beds and M42 headboards the figures are exceedingly good.

These results should prompt investigation into the stock-holding policy of M42 headboards, if the delivery forecast is to be accepted as reasonable. This investigation may have been foreseen by knowledge that headboards are to be ordered from sales intake.

Examination of the dates for the 4-day waits revealed that 26 of the 29 were Monday or Tuesday. Allowing 2 days for the weekend (not valid if Saturday working were in operation) these can be reduced to a 2-day wait. A similar exercise may 'reduce' the number of 3-day waits. A further factor which may explain part of the original 2-day waits would be early closing days. If the effect of early closing days and week-ends is therefore subtracted from the graph then there would still remain the large proportion of 2-day waits.

These factors need a deeper investigation, the full implications not being realised until the graph was studied. A tentative conclusion from the sample chosen would be that loads on average wait 2 days after completion of the load in distribution until loading, with approximately 2/5 of the loads waiting 4 days due to weekends.

This statement should be borne in mind when delivery forecasts quoting 7 days delivery are formulated.

Complications also arise, especially in slack periods, because of the scheduled runs. Observation revealed that certain runs could have gone on time, or earlier, if drops en-route had been included. An alternative would be to have the runs on a given day each week regardless of how full the vehicle is.

At present the delivery runs are as they were before the sales territory re-organisation. W. Hitchings has commented that he will try to guarantee delivery of orders within 7 days of receipt by distribution.

The system of back deliveries is used mainly on No. 2 items because bigger areas are used. This separation of No. 1 and No. 2 delivery systems is considered by distribution personnel as essential, but surely greater co-operation would speed delivery.

Analysis of the loads revealed that long waiting times were sometimes accounted for by NA or VF on at least one occasion. Where no such record was evident the system of load building is at fault.

One disturbing fact about NA and VF is that the loaders on the loading bay decide which customers will wait. It was suggested that the loading procedures be modified to allow the supervisors to make this decision. The loading bay supervisors rejected the suggestion as being counter-productive. Effectively what would have happened was that when NA or VF was recorded the supervisors would check the order copies for any other order for the affected products. A listing of priority according to loading date would be obtained which could lead to reallocation of products.

I could not accept that unloading and reloading the vehicles would be necessary as NA situations would be known in advance of loading if warehouse management were in control of the situation. It was possible for the men to determine whether a given load would fit into a particular van before half of it was loaded.

Assuming that the problem of NA should and could be overcome, less drastic measures are suggested. Before any sophisticated system can be arrived at let alone implemented once a green copy is received in distribution then it <u>must</u> be available. Three problem areas immediately spring to mind:-

(a) <u>Stock Recording</u> - At present products are recorded on leaving the production line before entering the warehouse. If items are damaged in the warehouse they are not cancelled from the list. Also damage has been spotted inside covers while in the warehouse. For allocation to know accurately the number of serviceable products in the warehouse is important, and hence it is suggested that a separate column is added to the checkers' lists to record damaged items (from the warehouse only).

(b) Allocation in Anticipation of Production - Difficult to determine the extent to which this is performed. If production control information were to be accepted then it would be valuable to distribution as they could plan routes better.

(c) Raising of Order Sets which By-pass Allocation - This is not a big problem but is known to happen in distribution. It would occur, for example, if a driver found one item short on an order, on return if distribution accept the driver's word then a set would be raised for the item. As drivers sign to say that they have accepted the goods onto their vans in good condition, the situation should never arise.

A more difficult problem is that of VF: the solution can only come from a thorough analysis of vans under load in the hope that a better formula can be given to the load builders. Great difficulty arises because the vans are not standard with respect to each other. W. Hitchings has stated that plans to standardise interiors will be drawn up, but so far the old system is operating. Capacities of 1400, 1500 and 1750 cu. ft. and the different shapes do not help (paper) load building. When full production is resumed the new range of products may also cause problems.

Overcoming the NA and VF problem is only a matter of time but I feel that in the interest of customer service a system could be implemented immediately.

Every day at say 4.00 p.m. (by which time loading will be nearing completion) a list could be sent from distribution to P. Hill in sales department containing all NA and VF orders for that day. This would give the sales staff 1 hour to see which orders were close to (if not over) delivery forecasts (especially if firm promises had been given); and to then telephone the customers to advise on late delivery. It is surely better to inform the customer of late delivery than to have him complain when his order doesn't arrive.

The information is already collected in distribution from loading sheets although only NA records are sent to sales department but only for re-allocation.

Finally on the subject of deliveries, a system of searching the orders on live file in distribution every day for orders waiting more than 6 days would improve performance. These orders could be built into loads for delivery, bearing in mind early closing days, back deliveries and No. 1 and No. 2 products in consultation with W. Hitchings, J. Bennett and Vono staff, to ensure that the situation presented in Table 2 does not arise again.

This is just one facet of customer service, determination of an acceptable level being vital in such a competitive trade.

The graphs and tables point to certain relevant questions regarding customer service, delivery forecast and the cost of any such decisions. Based on the assumption that finding the correct level of customer service is important the following points are made.

It is suggested that a decision be reached on a measure of customer service performance. Usual ones quoted include the % of orders met without stockout, or % met to delivery forecast. The % met to delivery forecast has been used as a measure of performance of the system in this research, but before it can be used to monitor customer service performance the company needs to be certain that its delivery forecasts are meaningful.

Delivery forecasts appear to be drawn up with regard to raw material stocks and probable production loading the next week, and also what it is considered the market will take. Distribution department is not consulted. A more scientific basis would be to investigate the market from a requirements viewpoint. It is felt that a tie-up with Slumberland on this type of investigation may be beneficial. The questions needing answers include:-

(a) where does the company stand with respect to its competitors?

(b) how much faith have customers in delivery forecasts in general and in Vono forecasts in particular?

(c) what do the customers (shopkeepers) consider reasonable, bearing in mind their customers?

(d) for Birmingham area how much increase in sales can be expected by cutting delivery forecasts?

For the country as a whole a representative section of customers and areas needs selecting. A suggestion would be one Times, Debenham, Co-op, etc., in various regions, backed by certain small shops. This section of the research could be broadened to cover all markets including depots and tied in with No. 2 factory policies.

Export department have unique problems, delivering to the docks before ships close. Obviously accurate production information is needed, if last minute rushes in production are to be overcome.

From the loads examined cutting the delivery quotes on certain products should have little effect on stock as dates were met well. The delivery forecast would help set a base on which to study distribution systems, especially if these forecasts were known to be permanent in the medium term. Of course there may still be problems with depots because of their small stockholding potentials.

The basis for believing that good customer service (at reasonable cost) is important stems from interest shown in a suggestion in the Interim Report of November 1970, namely increased customer service in a local area. It has been stated that a 10% increase in turnover in the local area would result from such a move.

Mention was made earlier of stock recording, it is therefore not surprising that stockholding and warehouse layout are considered.

If a stock control procedure were developed then stock-holding costs should be reduced, improvements in layout should result in easier load building. As a start an ABC analysis would reveal which products are important and point to the level of control necessary. The present would appear an ideal time with the new range, if it can be assumed that business has fallen off right across the range. At this stage no further comment will be made on possible controls.

Warehouse layout would assist (physical) load building by reducing the time wandering round the warehouse ostensibly looking for products.

Turning now to future work, considered to be essential in providing an effective distribution system bearing in mind cost, customer service levels and depots.

Once the depots have been investigated fully regarding their delivery patterns, stockholding and customer service levels, exercises can begin.

Interest has been shown in computer routing packages, but at this stage discussions are still proceeding with ICL concerning modification of their package to suit Vono needs. A brief description may assist as the package was developed for delivery of products homogeneous with respect to volume.

The products need to be coded into a 'volume' figure: the load printed out just contains this figure after the customer's address, not the order. This means that the route produced will have to go to sales department for a search of allocated orders to extract the green copies and then to distribution. The search procedure would be done by computer but because of the random listing of customers in the route high speed discs would be needed if computer time was to be reasonable.

The modification sought is the facility of entering the order with the coded order on the order sub file as a 'COMMENT', the full order being printed out and used as a load sheet while order copies are obtained. However it is not possible to amend standard packages unless the issuing company, i. e. ICL, considers that a basic error is present or greater profitability will follow.

There are problems to be overcome before the above can be perfected, mainly concerned with allocation by computer. Suggestions have been put forward but comment will not be made until their logic has been analysed and some idea of mill time requirements obtained.

It is apparent that the earlier part of this discussion concerned preparation for a full scale analysis of the complete physical distribution system of Vono.

4. <u>Recommendations</u>

(1) Accurate stock recording and control is needed to overcome NA situations. This could be associated with a stock control investigation.

(2) Decisions are needed regarding standardisation of vehicle interiors in an attempt to overcome VF situations.

(3) An analysis of loads under load should be initiated to assist formulation of a new load building model.

(4) A system of reporting all NA and VF orders daily to sales department would enable the company to advise customers of late delivery.

(5) A search of the live order file in distribution for orders which have been allocated over 6 days should overcome the excessive waiting periods observed for some orders.

(6) A survey should be performed to obtain information regarding delivery forecasts provided by competitors and information on what customers would accept.

(7) A full investigation into all aspects of depot delivery systems coupled with investigations into depot siting, sizing and stockholding should be continued.

(8) Before a decision is reached concerning computerised vehicle scheduling, discussions should proceed with ICL concerning modifications of their packages and the logic of the Mk III package.

APPENDIX V

Report For The Financial Director

Concerning Distribution Procedures

October 1970

1. All the contractors operate on open 'O' licence with Vono as the general user.

   Vono also operates on 'O' licences, 12 having been applied for at Tipton, but only 6 are used. One of these vehicles is used only as a spare.

2. Theoretically mileage is calculated from odometer readings taken at the start and finish of each journey. When odometers are not working, the majority of cases examined, mileage is calculated as:-

   road mileage (from AA Members Handbook) between towns plus 2 miles per drop over one per town.

   The company believes that the formula errs on their side.

   Depot deliveries are paid a fixed sum, less than the equivalent mileage amount.

3. Vehicles are obtained on casual hire when loads for delivery exceed vehicles available. Usually the owner asks for his vehicle to be used for a week rather than just one delivery.

   Payments depend on the bargaining power of the owner, for vehicles on mileage hire the rate can be the same or higher than that paid to contractors. Hourly rates also show some variation.

4. For the period 7/9/70 to 12/9/70 the average deliveries per load was 9.23. Discounting depot deliveries the average was 13.7. For the period 21/9/70 to 26/9/70

the figures were 11.75 and 14.2. For both weeks 34 mail order loads were despatched.
For both weeks the average loads per vehicle for contracted vehicles was 2.15.

5. The booking in procedure is relatively straightforward. On arrival at the factory the driver calls at the traffic office where the time, contractor, vehicle driver and vehicle number are entered on a daily work sheet. When a loading bay becomes free the next load and the next vehicle on the list are allocated to it. The time when loading starts and finishes are also entered on the work sheet. Pass-outs are retained by the traffic office until the driver books out, no vehicle being allowed out of the gates without a pass-out.

6. For the month of September 1970 the following is a breakdown of depot runs, daywork journeys and average miles/vehicle/week.

Contractor	Depot Runs	Daywork Journeys	Vehicles	Weeks	V.W.	Miles Per Month	M/V/Week
A & H	3	1	2	4	8	8182	1022
Gordons	1	2	2	4	8	6131	766
Hadley	12	2	8 1	4) 2)	34	18793	553
Hastilow	Non recorded		2 2	4) 2)	12	9066	755
Howell	14	3	9	4	36	32395	898
Johnson	41	12	10	4	40	21061	526½
Kendrick	2	4	4	4	16	13480	842

Contractor	Depot Runs	Daywork Journeys	Vehicles	Weeks	V.W.	Miles Per Month	M/V/Week
Linny	9	1	6 2	4) 3)	30	15692	526½
Round	1	-	1 1	4) 1)	5	1757	351
Rutter	2	2	4 1	4) 3)	19	12431	653
WM	2	2	2	4	8	4610	576
Wright	4	-	3	4	12	11482	957

7. The following is a list of vehicles under contract by each contractor:-

Contractor	Vehicles	Capacity (cu. ft.)
A & H	2	1750
Gordons	2	1750
Hadley	10	1750
Hastilow	2	1750
Howell	10	1750
Johnson	7	1750
	4	1500
Kendrick	2	1750
Linny	9	1500
	1	1750
Round	1	1750
Rutter	4	1750
Wright	3	1750

WM do not have a contract but operate almost as if they were on permanent hire.

Liddle (North East depot) sends as many vehicles as there are loads but has no contract.

Duke operates similarly for Belfast depot.
Hawthorn operates 2 at 2500 cu. ft. and 1 at 1850 cu. ft. for Glasgow depot.
Wright operates 4 at 1200 cu. ft. and 1 at 1750 cu. ft. at London depot, delivering on an hourly payment basis Vono operate 3 at 1750 cu. ft. and 3 at 1500 cu. ft. from Tipton although only 5 are on the road at any one time.
Casual hire is on average 10 to 12 vehicles per week.

8. Except for London and the North East depots, Vono operates its own vehicles from them.

Depot	Vehicles	Capacity (cu. ft.)
Attleborough	1	1500
Belfast	2	1500
Bovey Tracey	2	1500
Glasgow	4	1500
	1	1750
Ynysybwl	2	1500

9. A minimum service is provided to all areas but loads are usually sent to no set pattern other than to avoid closing days.

7

APPENDIX VI

Comparison Between D. W. Wilson Limited Costs

And Vono Limited Expected Costs

For February - May 1971

July 1971

Introduction

Since D. W. Wilson (International Distributors) Limited took charge of Vono's distribution system their personnel have attempted to reduce costs by reducing mileage claims by contractors.

It was decided to compare costs over a period with costs over the same period which could have been expected had the system been operating as in pre November 1970.

Export costs have not been compared nor studied for this present exercise.

Transport costs incurred at London Depot emphasise comments made in an earlier report (June 1971: Testing of the hypothesis that "Contribution to general overheads produced by sales in a given depot region will be reduced if that depot ceases to operate") already circulated.

Method

Costs were obtained for a 17 week period ending 31 May 1970 for Tipton Road and Rail Transport and similarly for 1971. For interest the sales in these periods were also obtained.

The number of loads to each depot for the periods and the cost relevant to each period were also obtained. To arrive at the costs Vono could be expected to pay in 1971 the rates Vono were paying in November 1970 were used. As far as can be ascertained these costs have not been increased to the contractors.

An additional cost of 1p/mile travelled by Vono vans has now to be borne by Vono Limited, the number of miles in the period was available.

Problems arose with Trade and Ministry deliveries which for ease of calculation were included in the number of loads delivered other than Mail Order, Vono and Depot.

The expected cost to Vono of paying direct was arrived at by:-

$$\left(\text{cost for period in 1970} - \text{cost of delivery to depots}\right) \times 112\% \times \frac{\text{1971 loads}}{\text{1970 loads}}$$

and then adding this to the cost of delivering to depots for 1971.

<u>Results</u>

	Feb-May 1970	Feb-May 1971
Total number of loads	2795	2694
Mail order loads	290	357
Trade & Ministry loads	196	284
Vono loads	240	193
Depot loads	692	622
Loads from Tipton less mail order, Vono, depot	1569	1522

Table 1:
Loads Delivered From Tipton For Home Retail (and Depot) Markets

Depot	Loads Delivered	
	Feb-May 1970	Feb-May 1971
Attleborough	45	56
Belfast	45	56
Bovey Tracey	66	55
Liddle (N. East)	126	111
London: Contractor	114	112
Casual	44	4
Vono	13	6
Glasgow: Freightliner	-	74
Contractor	135	93
Casual	24	-
Ynysybwl	66	50

Table 2:
Loads Delivered To Each Depot

Depot	Cost (£)		
	Feb-May 1970	Feb-May 1971	Feb-May 1971. DWW
Attleborough	32	38.50	41.50
Belfast	100	100	103
Bovey Tracey	44	48.40	51.40
Liddle	67.75	71	(71)
London	25	28.50	31.50
Glasgow - Freightliner	-	52	61.75
Contractor	61	66	70
Ynysybwl	24.50	27	29.95

Table 3:
Cost Of Loads To Each Depot

Depot	Cost (£)		
	Feb-May 1970	Feb-May 1971	Feb-May 1971. DWW
Attleborough	1440	2159	2321
Belfast	4500	5600	6290
Bovey Tracey	2900	2660	2825
Liddle	8510	7900	(7900)
London	4280	3510	3650
Glasgow	9600	10000	11070
Ynysybwl	1635	1350	1490
Total	32865	33179	35546
Vono Miles Surcharge			529
Total	32865	33179	36075

Table 4:
<u>Total Cost Of Delivering To Depots</u>

Total cost for Tipton Road and Rail for February-May 1970

£114701

Total cost of serving all Depots for February-May 1970

£ 32865

Therefore Total Cost of Tipton Road and Rail (+ Trade and Ministry for February-May 1970)

£ 81836

<u>Assume</u> that the same mileage claim system was still in operation in 1971 as 1970, then as the rates have increased 12% from February 1970 to February 1971, it would be reasonable to expect that the cost would have increased by 12% for the same number of loads. If this figure is modified by the factor

$$\frac{\text{1971 loads}}{\text{1970 loads}}$$

then the expected cost of this part of the delivery system will be given as £89000 for February-May 1971. Therefore the Total Expected Cost if Vono Limited paid direct to the Contractors for the period February-May 1971 would be

£121865

It could be argued that Vono Limited would not be using Freightliners to the same extent as D. W. Wilson Limited, although the suggestion was mooted before D. W. Wilson Limited arrived.

Using this argument the cost of serving Glasgow would be approximately £11530, thereby increasing the cost to Vono Limited by £1830. As Freightliners were being used it is felt that pressure would have caused more widespread use and hence an addition of only £1000 will be made to Vono's expected operating costs. Therefore the amended cost to Vono Limited could read as

£121865 to £123695

Accounts Department records revealed that payment to D. W. Wilson Limited for this period was

£128593

The figure is £5000 more than Vono's expected figure or £6900 if it is assumed that Vono would be using Freightliners to the same extent.

Discussion

Trying to base a year's operating costs on 4 month's figures could be creating arguments and hence the majority of the comments will be general.

Since their arrival D. W. Wilson personnel were very severe on mileage claims. Discussions with the contractors revealed that claims were reduced by between 5% and 10% and that the actual figure was negotiated from the reduced value. Whether excess mileage claims were more blatent than before is impossible to prove. I feel that the drivers were testing the integrity of the new management as complaints were not very forthcoming.

Even if this were not true, Vono are paying 2p/mile extra than they would otherwise pay, and also 1p/mile for their own vehicles and a premium on depot deliveries (most noticeable for Glasgow Freightliner prices).

Had the same mileage reduction exercise been performed by Vono personnel their transport costs could have been reduced considerably. D. W. Wilson personnel have not taken a firm hand on routing as the same Vono personnel perform those functions as previously.

A useful exercise would be to compare costs in a similar exercise in one year's time to see if the mileage claims can be reduced more or if we are at a level at which we should have been operating in 1970 and before.

It may be of interest to quote the sales for the relevant periods:-

Sales	Feb-May 1970 (£)	Feb-May 1971 (£)
Home Retail	1447.1	1591.4
Trade and Ministry	141.5	240.6

The home retail increase could be covered by the price increases almost exactly while the Trade and Ministry indicates increased trade.

Conclusions

It would appear that although D. W. Wilson Limited gave the appearance of severely reducing transport costs they did not contain them at the 1970 level.

The premium Vono Limited paid for the services for 4 months' operation was nearly £6900, or approximately £21000 per year over what they could have expected to pay.

Had Vono Limited employed its own staff to perform transport management effectively the savings to the company would be:-

£21000	from above
£14100	from 5% mileage reductions
£35100	

Therefore with the minimum effort Vono Limited (based on the figures and assumptions in this report) would reduce its transport bill by approximately £35000 per year. On this evidence a reappraisal of its transport management function is recommended.

APPENDIX VII

A Cost Comparison Between Rigid Chassis

And Demountable Body Vehicles

For Vono Operations

November 1971

1. Introduction

The use of demountable body vehicles will not by itself decrease transport costs, in fact without planning the costs are more than likely to increase. However, the facts below should provide a datum from which to work.

A system has been chosen by the vehicle owners and it is anticipated that the first batch will begin operations around April 1972.

The principle behind demountable systems is that one chassis is able to service more than one body (box). A vehicle would arrive at the factory, drop its empty box, pick up a loaded box and leave within, say, 15 minutes. The co-ordination of allocation, load building, scheduling and box loading to meet this constraint does not exist at the moment.

2. Analysis

Discussions on theoretical systems are not the immediate concern but costs compared with the present system are.

The approach used is to compare fixed costs, to an operator, of operating rigid and demountable body vehicles. As all system costs are approximately the same, no major financial advantage will be offered by the choice.

The chassis unit would be depreciated over four years, hydraulic equipment would be depreciated over eight years, box would either be depreciated over ten years or leased.

Without full and open co-operation of Vehofreight Limited, the accuracy of the figures could be questionable. Anomalies arise if figures provided by Vehofreight Limited are used and then a breakeven analysis performed.

Factors are considered under headings as:-

2.1 Present system and proposed system of costing

2.2 Breakeven analysis at rate agreed

2.3 Increase in productivity investigation

2.4 Alternative methods of paying for transport

2.1 Present System and Proposed System Costing

	Present System	Proposed System
Chassis	2200	2200
Body	900 (absolute maximum)	1050 per body but $1\frac{1}{2}$ 525 per chassis
Hydraulic	-	562
	£3100	£4337
Depreciation period	6 years	6 years chassis 8 years hydraulic 10 years body
Leasing arrangements	-	Lease body (why not also chassis?)
Straight line depreciation	£516/year	£777.75/year
Fleet size	approx. 60	eventually 40
Vehicle insurance per vehicle	approx. £196	approx. £150
Operating licences	£126	£126
Gross Wages/ vehicle	£2000	£2000

Assume that the fleets were complete

Depreciation (total fleet)	516 x 60 = 30960	777.75 x 40 = 31110
Wages	2000 x 60 = 120000	2000 x 40 = 80000

Insurance	196 x 60 = 11760	150 x 40 = 6000
Licences	126 x 60 = 7560	126 x 40 = 6040
Tax saving from increased depreciation	40% of 100	40
Fixed costs/ vehicle	£2838	£3053.75 per year

Therefore, demountables approx. £4/week/vehicle, i.e. on 700 miles approx. ½p but:-

The present fleet average mileage is assumed to be 650 miles/week (discussions with contractors confirm this figure).

It is reasonable to assume that under the present routing and scheduling system the total miles travelled per year will be constant. Therefore, since we would operate 2/3 the number of vehicles, each vehicle would cover 3/2 the distance (this was also assumed in the depreciation figure).

In the Midlands, the effective working year is 46 weeks.

Therefore, fixed costs/mile Present: $\frac{283800}{46.650}$ = 9.5p/mile

Proposed: $\frac{305375.2}{46.650.3}$ = 6.8p/mile

Therefore fixed costs/mile reduced by 2.7p/mile if 975 miles/vehicle/week average is attained.

Hence, at present cost, total EXTRA savings to the contractors as a group if the fleet were demountables, etc. would be PER YEAR:-

975 x 2.7 x 40 x 46 = £48392

Running costs, e.g. tyres, oil, diesel, maintenance are assumed to increase proportionally to mileage, hence the cost/ mile is assumed constant.

One problem in the above assumption is the cost of purchasing equipment on hire purchase. This is why leasing of chassis is suggested. Establishment charges have not been included due to the vagueness of its meaning. It is quite possible that £x per rigid could become £$\frac{3x}{2}$ with demountables.

2.2 Breakeven Analysis at Rate Agreed

Using the figures provided by W. Hitchings as below:-

Rate agreed 16.25p/mile

Wages	2000	
NIGP	100	
Insurance	160	
Est. charge	350	
Licences	126	
Box lease	460	
Depreciation	650	4 year
	£3846	

From Pengco Limited (suppliers of hydraulic equipment for demountable systems)

Tyres 1p/mile

Maintenance 1p/mile

Diesel 2.1p/mile

Variable is mileage/week x

$$\text{Therefore } 16.25x = 4.1x + \frac{384600}{46}$$

$$12.15x = 83500$$

$$x = 690 \text{ miles/week}$$

On these figures, the breakeven mileage per vehicle for demountables will be 690 miles.

As rigids will be paid 16.25p/mile, breakeven for these will be:-

$$16.25x = 4.1x + \frac{338200}{46}$$

$$12.15x = 73500$$

$$x = 605 \text{ miles/week}$$

On figures for the rigid vehicles the breakeven mileage is 605 miles/week.

Profit can be given by:-

$$(y - x)\ 12.15$$

Therefore for rigids at 650 miles/week, profit per vehicle/week = 45(12.15)p

= £5.25

Therefore for demountables at 975 miles/week, profit per vehicle/week = 285(12.15)p

= £34.6

Therefore if the breakeven analysis figures are accurate and also the vehicles are capable of covering the assumed miles, the contractors' profits will increase.

At present rigids have a guaranteed fleet average minimum of 700 miles/week, i. e. Vono effectively guaranteeing approx. £11 per vehicle profit.

2.3 <u>Increase in Productivity Investigation</u>

243 loads were analysed for time of booking in and leavings (includes waiting and loading times).

Average waiting time:	3.6 hours
Driving time	10.5 hours/day
Meal Breaks	1 hour/day

Therefore 9.5 hours maximum approx. per day. Approx. 50 hours/week if a 55 hour week worked.

Average loads/week is approximately 2, hence 7.2 hours on average are spent waiting in Vono. Therefore 42.8 delivery hours per week are available.

If 700 miles/week	650	600
hourly speed		
16.5 mph	15.2 mph	14 mph

With demountables, assume 15 - 30 minutes waiting time at Vono, therefore 6.5 hours extra delivery hours per week, i. e. 16% increase in delivery hours.

If new assumed average miles/week is 900 miles, this will not be achieved by 16% increase in time <u>unless speeds increase also</u> by 14%, 18%, 25% respectively.

With the present system these figures appear unreasonable.

It could be that hidden incentives will prove useful in ensuring that drivers return to Vono as quickly as possible.

At present, if a driver returns later than 3.00 p.m., there is little chance of being loaded.

Using the figure of 16% increase in productivity, possibly a fleet size could be determined:-

$$\frac{7.56}{8.76} \times 60 = 52 \text{ vehicles}$$

If this figure is to be the new fleet size, all figures would need amending.

'What is the optimum fleet size' is yet another question worth answering.

2.4 Alternative Methods of Paying for Transport

(i) One cost which so far is not agreed is the hourly rate paid for local work.

At present the rate is £1.38 per hour, a direct continuation of what Vono were paying in October 1970. My figures have indicated £1.68 to be breakeven; the contractors are demanding £2.00. This rate may seem unimportant but underlies a lot of the problems over rates in general.

(ii) Ideas are being formulated on alternative modes of payment.

Why not pay all expenses <u>at cost</u> and then a margin of say £5 per vehicle per week?

Vono used to charge an establishment charge of £3 per week compared with the contractors' figure of £7.

With demountables the savings to Vono would be enormous. Suggestions on payment/load as a percentage of value, etc. are others under investigation.

(iii) Anomalies in costing are that (rigids) fixed costs of approximately 9p/mile and variable of 4p/mile indicate 3p/mile operating profit. On 650 miles a profit of £19.50 per week.

APPENDIX VIII

Vono Warehouse Considerations

May 1972

1. Introduction

Vono Limited is operating two factories but by mid 1973 it is the intention to amalgamate the smaller one into the main factory at Tipton.

This will produce one integrated production unit but may cause stock holding problems.

The present warehouse within the Tipton factory occupies 135000 sq. ft. in Unit 3, see Diagram 1. There is a usable height of 14 ft. except for an area of 6500 sq. ft. which has a usable height of 10 ft. The total area serves as storage, packaging and loading areas for Home Retail, Contract, Export and Mail Order products and also as storage area for wooden upholstery frames.

Company policy to offer licences to overseas companies will eventually reduce the storage requirements for Export products, thereby releasing space for products from the existing small factory.

There were two approaches to the investigation:-

(i) to produce efficiencies in the existing Unit 3 warehouse

(ii) to analyse alternative locations within the Tipton factory and alternative administration systems for the handling of all Vono products from a single warehouse.

2. Warehouse Operations

2.1 Export Warehouse

There exists within Vono Limited a report (2) prepared with the assistance of the researcher detailing the operation

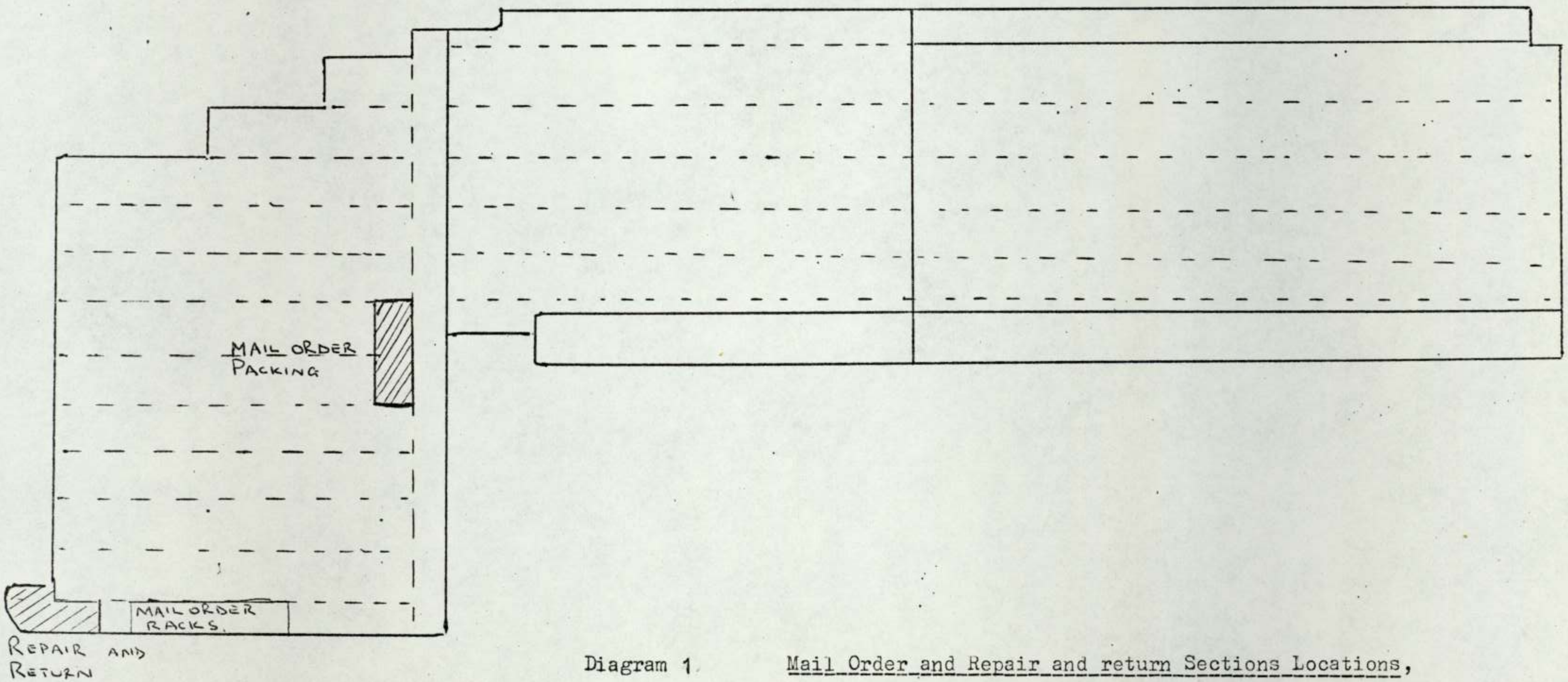


Diagram 1 Mail Order and Repair and return Sections Locations,
October, 1970.

and functions of the Export warehouse. As the function will become redundant in the re-organisation, the work will not be reported here except to comment that poor management and ineffective inter-departmental management communications were felt to be the root cause of the poor operation.

2.2 Mail Order Warehouse

The range of products offered to Mail Order customers is much smaller to Home Retail customers. Orders are meant to be despatched within three days of receipt by the company. All products are packaged and carriage is by British Rail or Bullens Transport, the cost of which is borne by the mail order companies.

Products entered the warehouse and were stored similar to the Home Retail products, which will be discussed in detail later.

2.3 Home Retail Warehouse

Bedding and upholstery products enter the warehouse, from the production area, at one point. Products are stacked on flat trucks, five of which are linked together and towed by an electrically powered motor. This 'truck-train' visits storage locations in the warehouse where products are fork lifted, or manually lifted, into their storage racks.

Upholstery racks are modified bedding racks and are hence an inefficient storage method.

The individual trucks could contain more than one product group. There was no logical pattern to the layout of the storage racks, thus causing confusion with both storage and

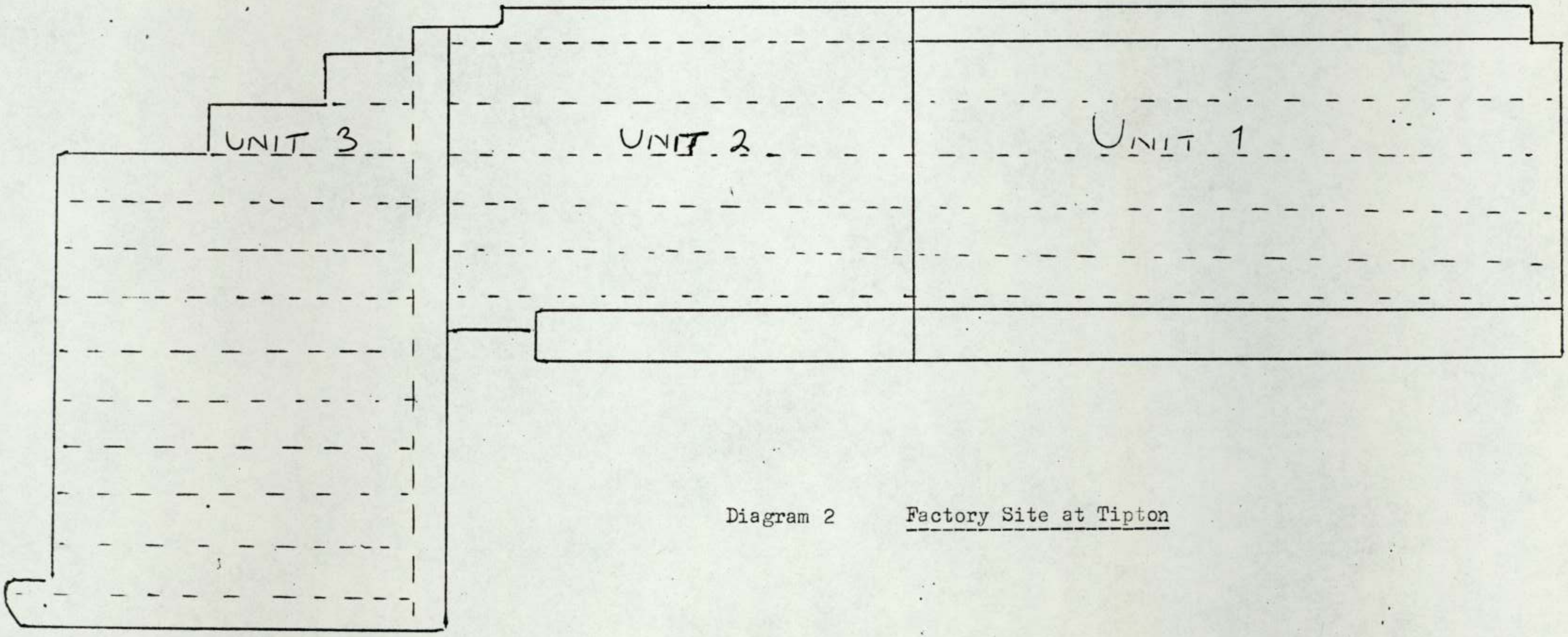


Diagram 2 Factory Site at Tipton

Retail loads could have been despatched. Also the damaged products at the rear would be open to scrutiny at the front of the warehouse. Apathy towards damaged products was apparent and bringing the repairs function into a more prominent position was considered necessary.

With assistance from a consultant civil engineer a report was produced (5) indicating that for a capital outlay of £550 and the salaries of 2 men, approximately £4000 gross, a 16% increase in productivity could be obtained. To achieve a 16% increase in productivity by employing one more picking and loading gang would have cost approximately £6000 gross.

3.2 Stock Layouts

Because there was no logical pattern to the layout of storage locations, an ordered layout was considered. Sales by volume were analysed to produce a ranking of bed names (1). Storage space was then allocated proportional to each bed's sales to total sales. High visitation areas were located nearest to the loading bays to reduce time spent walking round the warehouse, thereby decreasing the vehicle turn-round time (3).

It was noted that the delay between allocation and loading was on average 3 days, indicating that 3 days production was held in store above any agreed stock levels. If the warehouse were stocked such that all locations were full of the designated products then there would have been 3 weeks demand, according to sales forecasts. Allowing for the allocated products it meant that the company would have been able to deliver ex-stock on all bedding products.

By monitoring the quantities in each storage location a feed-back to production control would have been possible.

This monitoring system was to have been the rudiments of a stock information system.

The apportioning of space to products was performed for the 1972 range of bedding based on 3 months sales forecasts.

3.3 Alternative Warehouse Locations, and Systems, within the Tipton Factory

As the company was not profitable during 1970 to 1971, the analysis of alternative locations assumed minimum expenditure. Basically it was necessary to fit the proposed storage requirements into the alternative locations and to develop procedures for the administration of the warehousing function. As it had already been shown that stacking beds horizontally made more efficient use of space than stacking vertically (4), alternatives based on the latter were not evaluated.

The alternatives considered were:-

(1) the existing warehouse and the existing order picking system

(2) the existing warehouse and a different order picking system

(3) Unit 2 warehouse and the existing order picking system

(4) Unit 2 warehouse and a different order picking system

3.3.1 The Existing Warehouse and the Existing Order Picking System

The total available floor area in Unit 3 is 135000 sq. ft., all of which was considered available for storage purposes.

The following table illustrates the present and proposed storage requirements based on the existing warehouse management practices.

	Present Storage Requirements 000's sq. ft.	Proposed Storage Requirements 000's sq. ft.
No. 1 Upholstery	15	15
Bedding	43	43
Mail Order	4.4	4.4
Export	24	8
Repair and Return	1.5	1.5
No. 2 Upholstery	16 (but on Unit 3)	10

All the proposed storage requirements could be reduced by pre-allocation to approximately 90% of the above figures. Co-ordinated production control and sales policies and distribution procedure could further reduce the proposed requirements and at the same time reduce the amount of capital tied up in stocks.

Because of the company's policy to sell licences to overseas' markets and the packaging arrangements with external firms the export space has been drastically reduced.

3.3.2 The Existing Warehouse and a Different Order Picking System

Because pickers had been observed to walk 12 miles per day, this indicated that 3 to 4 hours per day were taken up by functions other than order picking. One way to overcome this was to have men pick products but to have the trucks moved mechanically to the loading bays. Use could also be made of this system to bring products from the production areas into the warehouse.

Three alternatives were originally considered but only one analysed fully. For safety reasons pulling trucks by an overhead conveyor was rejected by the company despite greater flexibility over a sub-floor tow-line system. The other rejected choice involved forming a truck train, one truck being in electrical contact with a conducting strip set into the floor. The system investigated fully was the sub-floor tow-line conveyor.

Basically a chain runs in a channel in the floor, at certain pre-determined locations spurs for alternative directions are selected depending on the programming of the truck. Programming consists of putting a peg in a hole a given distance from the centre line of the truck which will contact and thereby activate a switch mechanism set a corresponding distance from the channel in the floor. Trucks are hooked into the system by dropping another peg, set at the centre line of the truck, into the channel where it contacts a link in the chain.

To use the system to move products into the warehouse, each product group must have a known location. Production must be in batches which are a multiple of a truck load otherwise time will be wasted sorting out products for storage as at present.

A new order picking system is proposed to make full use of the mechanical movement of products.

Order Picking System

As the warehouse can easily be considered in sections this will assist. Assume these sections to be:-

shell furniture

conventional and occasional furniture

sleep products

(i) Delivery notes for six loads in delivery sequence are placed on a desk.

(ii) One copy of each order in delivery sequence is taken (note: an order consists of a 3 piece order set when it leaves distribution office).

(iii) Each order in a load is stamped with the load and drop numbers (note: this load number can be different from Vehofreight load number).

(iv) Each load is separated into piles according to the broad product classification above.

(v) The top copies from shell load 1, 2, 3 are taken, then the second copy etc., and similarly for conventional and sleep products. Loads 4, 5, 6 are then completed.

(vi) There are now 3 piles of orders for load picking. If necessary one pile (probably sleep) can be sub-divided into 2 piles.

(vii) The piles will be assessed by the supervisor for balanced work load according to decision rules yet to be finalised.

(viii) Each load will be allocated a particular loading bay.

(ix) The remaining 2 copy order sets will be simply split for each load for attachment to the first truck sent to the loading bay. One set will be used in marshalling and one set for loading and delivery purposes.

(x) The pickers collect their notes and proceed to pick orders, note the load and drop number on each truck and programme each truck to its loading bay, with the spacer bar in position.

(xi) Trucks will arrive at the marshalling area where they will be sorted into correct loading sequence and passed to the loaders. Kimble tickets can be removed (for Stock Valuation and update purposes) and the marshalling personnel will check that each load is complete.

(xii) Empty trucks will be returned to circulation probably by the loaders and information on availability of loading bays passed back to the control centre electrically (e. g. by pressing a button to extinguish a bulb).

3.3.3 Unit 2 Warehouse and the Existing Order Picking System

Although the total floor area in Unit 2 is only 85824 sq. ft. the usable height is 18 ft. against 14 ft. in Unit 2.

Based on the existing warehouse management practices, the following table gives the proposed storage requirements.

	Floor Area 000's sq. ft.	Effective Storage Space 000's sq. ft.
No. 1 Upholstery	13	40
Sleep	36	90
Mail Order	2	4
Export	4	8
Repair and Return	0	1.5
No. 2 Upholstery	5	18

Repair and return will be on the mezzanine floor at present housing the training school, which will move to the factory floor.

There are two alternative positions for the loading bays:-

(i) present site

(ii) part of the present sewing room

The present site would involve no extra outlay but would reduce the productivity measured as loads despatched per gang unless the new order picking and administration system were used. To construct loading bays in the sewing room would cost approximately £15000.

If the present warehouse management practices are continued then there would be no space for a marshalling area in Unit 2 and therefore if loading bays are constructed in the sewing room the existing administration system appears appropriate.

3.3.4 Unit 2 Warehouse and a Different Order Picking System

The order picking system will be as described in 3.3.2

and the existing loading bays will be used. To utilise the 18 ft. of height available either the racking will have to be modified or new stacker trucks will have to be purchased.

4. Discussion

Although the major factor in all the alternatives is cost, no cost (whether ± 10%) has been produced by the company for any equipment and hence assumptions have been made.

Assumptions for the cost of the subfloor chain conveyor were formulated after discussions with one manufacturer. Costs for fork lift trucks are based on catalogue prices and probable discounts.

For the majority of alternatives the assumptions concerning manpower have been made on experience in loading and delivering beds and also on elementary time studies. The company could not provide any accurate information on time to store products etc. nor any assistance with proper time study work.

The cost of manual systems is the wage bill plus the cost of new equipment and modifications. It is anticipated that the wage bill will greatly exceed the equipment costs.

The conveyor systems will have a high initial capital expenditure which can be written off according to company policy, and a relatively lower wage bill.

Manning of the export function will not be considered in any alternative as the function will become integrated with Home Retail, and packaging will be performed by contractors.

4.1 Existing Warehouse and Administration System

Management produced the following breakdown of labour at present.

Electric truck drivers	5
Storers	8
Stacker truck drivers	7
Loaders	18
Supervisors	3
Mail Order packers	2
No. 2 Supervisor	1
No. 2 Loaders	4

These figures were used as a basis for manpower requirements for alternative (i).

No. 1 factory loaders, at present 18, will have to be increased by 6 when demountables become operational as drivers will not be available to assist in loading vehicles.

If the present maximum of 40 loads per day is to be reached then, as the 6 gangs in No. 1 factory produce only 35 loads/day, one extra 4-man gang (i.e. No. 2 gang) will be required.

Therefore, to achieve <u>present</u> output 28 loaders will be required. If the company is to meet the objectives laid down in its 5 year plan then bonus payments and extra 4-men gangs will be required.

Therefore the following breakdown is offered as the manpower requirements for an integrated function.

Electric truck drivers	5
Storers	7
Stacker truck drivers	7
Loaders	28
Supervisors	2
Mail order packers	2
Total	51

4.2 Existing Warehouse and Different Administration System

If a conveyor system were in operation the electric truck drivers would not be required, hence a saving of 5 men and 5 trucks.

This is above question but the following is open to discussion. Due to the lack of accurate data, assumptions have been made.

ASSUME 35 loads/day of beds only (1 double bed = $^1/_{30}$ of a load)

= 2100 units

= 4/min

i. e. 1 bed unit (divan or ISM) must be placed on a truck every 15 secs.

ASSUME 35 loads/day upholstery (1 suite = 4 load units)

= 140 units/day (i. e. suite units will be stored as such)

= 1/3 minutes

ASSUME 35 loads/day chairs only (1 chair 1/40 of a load)

= 1400 units/day

= 1/18 secs.

These will be used for picker requirements

ASSUME 1 load of beds to be loaded into a van

1 load = 60 units (double)

120 single bed units

Product mix assume gives 100 pieces to be loaded. Two men per gang, therefore each man to load 50 pieces. Check must be made against load sheet and empty trucks taken from loading bay to spur for re-location in moving chain.

As each gang will be supplied with the products in loading sequence from experience 15 secs. is not an unreasonable loading time per item. On this basis 30 mins/bed load would be reasonable. i. e. approx. 15 loads/day/gang.

1 load upholstery

40 units = van load, settee = 2 load units
chair = 1 load unit

Based on reasoning as above again ½ hour would appear reasonable per load.

THEREFORE If a 2-man gang is supplied with products in loading sequence 30 minutes per load would appear a reasonable loading time.

It follows from this argument that 3 loading gangs will be sufficient to meet the company's present requirements - with spare capacity available.

On the basis of a 3-gang loading system, 3 checkers would be employed at the marshalling spurs.

PICKERS These people must work as a two-man gang also. It would be difficult for one man to load a suite of furniture onto a truck.

Pulling a truck with approximately 7 ISM (or DVN or alternative) even relatively short distances (102 ft. maximum) would reasonably require two men.

The duties involved, marking each truck load with load and drop numbers, checking against order list, obtaining empty trucks etc. also indicate 2-men gangs as being necessary.

Each loading bay gang will be required to load a van every $\frac{1}{2}$ hour therefore they must be supplied with products within this time period.

ASSUME that a van load = 14 trucks

Therefore every 30 minutes 42 trucks must be at the loading bay area, i. e. 1 truck must be loaded about every 40 secs. if only 1 gang are working.

2 gangs would mean 1 every 80 secs.

3 gangs would mean 1 every 2 mins.

4 gangs would mean 1 every $2\frac{1}{4}$ mins.

It is in this area that accurate method study and time study work is needed.

Certain trucks will only contain one suite which will be stored on a platform for easy loading anyway.

It could be that 6 gangs may be needed, giving approximately 4 minutes loading time per truck.

Based on 14 trucks/load, each truck could take only 2 double beds complete. This type of problem needs careful consideration before consultation with the Unions.

At present 12 men serve the loading bay to produce approximately 36 loads/day.

If 40 loads per day required (11% increase) are produced by the same number of men it could be said to be an improvement.

Personally I feel that 4 - 2-men gangs will suffice. Discussion with Vono's administration manager and works manager is obviously called for.

THEREFORE 6 loading bay men

3 checkers

8 - 10 pickers

Stacker truck drivers will be required to load products into storage locations.

From production figures for November 1971, average daily bedding production was:-

100 ISM/hr) 30 trucks/hr
50 dvn/hr) (assume 5 pieces per truck)

Upholstery production was approximately 10 trucks/hr. (usually 3 pieces/truck loaded).

No. 2 factory production figures were not available.

Truck drivers also assist pickers at present. It is hoped that in future this will not be necessary <u>but</u> as they were included in the manual system because of lack of knowledge, then they must be included here.

The original idea was one man per stacker truck to assist (or so it appears on paper). It is debatable whether this is necessary especially if bedding is to be stored as required. Subjectively 4 men may be needed to assist <u>mainly</u> but not entirely with upholstery.

4.3 Proposed Manpower Requirements

Based on the above assumptions the following are offered as proposed manpower requirements for the alternatives discussed.

Function/Number	Alternative		
	A	B	C
Electric truck drivers	-	-	-
Storers	4-7	4	4
Stacker truck drivers	7	6	6
Loaders	6	28	6
Pickers	8-10	-	8
Checkers	3	-	3
Supervisors	2	2	2
Mail Order	2	2	2
Total	32-37	42	31

4.4 Equipment Costs

Alternative (i) would require extra racking, the amount and cost are unknown factors. Part of the Export function is unracked, some of the existing upholstery racks could be moved enabling purpose built racks for upholstery to be obtained.

It has been estimated that £1500 per year should be allowed for batteries on the electric trucks used.

Alternative (ii) would require a similar amount of racking.

Major equipment costs would be for the sub-floor chain conveyor and associated trucks. A cost of approximately

£40,000 had been assumed for the track in December 1971. Assuming 200 trucks will be required at approximately £100 each will give a total equipment cost of £60,000.

No new fork lift trucks will be purchased as a direct result of this alternative, although they could be replaced as part of a general maintenance policy.

Alternative (iii) would require purpose built racks for upholstery storage. If the company insist on storing to 18 ft. then a complete new set of racks will be required. It is assumed that the cost will be at least 5 times the cost of racking the present export function, based on area and height considerations.

The present fork lift trucks have a maximum lift of 12 ft. and operate in approximately 12 ft. gangways. The company can either keep these trucks and lose storage space or purchase a means of lifting in narrower gangways.

Work has indicated that efficient stock control and recording will enable the present gangways to be used.

Therefore assuming the only new equipment to be purchased will be purpose built upholstery racks this cost will be the constant factor in (i) and (ii).

Alternative (iv) would require purpose built upholstery racks as above.

The company must also decide, as above, whether to completely re-rack or use the existing bedding racks and stack to approximately 14 ft. only.

This alternative also requires a sub-floor chain conveyor and trucks. Based on the previous assumption regarding cost/foot a total conveyor cost of £23,000 will be assumed. The same number of trucks will be required, giving a total cost of £43,000.

If the company buys new racking it may have to purchase new fork lift trucks.

4.5 Modification Costs

Alternatives (i) and (ii) will require no major structural modifications. The area is at present in use as a warehouse and therefore the lighting and heating are considered adequate.

Alternative (iii) requires at least modifications to Unit 3 to convert it into a production area. A cost of £17,000 towards relighting and reheating Unit 3 has been quoted. Installing racks into Unit 2 and production stations into Unit 3 and also sectioning off the loading bay area should account for a further £5000. A total modification cost of £22,000 is therefore assumed if the existing loading bays are used.

If loading bays are built by taking part of the sewing room, a further cost of £15,000 will be involved. Therefore if new loading bays are constructed a modification cost of £37,000 is assumed.

Alternative (iv) uses the existing loading bays and hence the modification cost will be £22,000.

4.6 Total Costs

To avoid confusion all alternatives and costs will be presented together.

Alternative (i) existing warehouse and existing administration system

Alternative (ii) existing warehouse and different administration system

(iii) Unit 2 warehouse and existing administration system using existing loading bays

(a) Unit 2 warehouse and existing administration system using existing loading bays plus new racks and stacker trucks.

(b) Unit 2 warehouse and existing administration system using new loading bays.

(c) Unit 2 warehouse and existing administration system using new loading bays plus new racks and stacker trucks.

(iv) Unit 2 warehouse and different administration system using existing loading bays

(a) Unit 2 warehouse and different administration system using existing loading bays plus new racks and stacker trucks.

Reason/Cost £'000	Alternative							
	i	ii	iii	iiia	iiib	iiic	iv	iva
Labour	102	64	84	84	84	84	62	62
Equipment	1.5*	60	-	18.9**	-	18.9**	43.4	62.3**
Modification	-	-	22	22	37	37	22	22

* annual cost
** does not include cost of re-racking, to date no assumption of cost has been made.

It is to be expected that gross labour costs will rise by 8% per year.

For elementary cost comparisons (pay back period and DCF analyses) the profit resulting from any investment will be the difference in labour costs between the alternative (i) and the investment alternative.

(i) Payback Period Analysis Results

(These figures are before tax and depreciation allowances have been charged).

Alternative	Payback Period
(ii)	2 years
(iii)	$1\frac{1}{2}$ years
(iiia)	4 years (allowing £50,000 for racks)
	$2\frac{1}{2}$ years (no allowance for racks)
(iiib)	2 years
(iiic)	6 years (allowing £50,000 for racks)
	3 years (no allowance for racks)
(iv)	$1\frac{1}{2}$ years
(iva)	$3\frac{1}{4}$ years (allowing £50,000 for racks)
	2 years (no allowance for racks)

As with all payback period analyses the results can be misleading. One firm conclusion is that any choice except (iiia) and (iiic) with £50,000 for racks would appear acceptable.

(ii) DCF Analysis Results

The following procedure has been applied:-

40% allowance in year 1

25% allowance each year thereafter

write off period 10 years

Corporation Tax 40% year 1 and thereafter

labour costs increase 8% per year

discount factor of 10% used initially

Not all alternatives have been evaluated yet, but alternatives (ii) and (iv) are equal 'best'.

However, to expand upholstery production capacity over the next 5 years indicates that siting the production in Unit 3 is desirable. This is yet another complicating factor indicating that financial appraisal only would not necessarily produce the 'best' result.

Data required on warehouse plans have been obtained and indicate that the sub-floor chain conveyor would isolate the toilets in alternative (iv). The cost of re-siting the facilities have not been used as there are existing facilities in the distribution office area.

5. Conclusions

1. Mail Order modifications were far short of those recommended by two independent investigators and have been of little value.
2. Warehouse layouts rejected by the sales management would have assisted in the managing of the distribution function.
3. Pre-allocation should reduce stocks of sleep and flowline upholstery products by approx. 15%.
4. All systems proposed will handle the present level of business.
5. The sub-floor chain conveyor systems are designed to handle 50% more business for only 6 additional staff.
6. Greater inter-departmental management co-operation is requested for the company to achieve its five year plan.
7. Distribution costs can be reduced other than by reducing clerical staff.
8. New purpose built racking will be required for whichever alternative is chosen.
9. Upholstery production expansion indicates that siting the warehouse in Unit 2 would be more beneficial than siting it in Unit 3.
10. Bearing in mind the company's five year plan and financial appraisal techniques, the following is offered as the best of the alternative systems considered:-

<u>equal</u>

existing warehouse and sub-floor chain conveyor system; Unit 2 warehouse with sub-floor chain conveyor system using existing loading bays with existing racking (neglecting the problem of toilets).

References

1. North East Distribution Point Operations
   S. A. Gill October 1971

2. Investigation into the Export Procedure
   W. Cleave April 1972

3. Demountable Body Vehicles
   S. A. Gill February 1972

4. Stacking Modes for Upholstered Beds
   S. A. Gill April 1972

5. Mail Order Bays
   S. A. Gill
   and A. J. Eaton January 1971
   (Industrial Design and
   Construction Limited)

APPENDIX IX

Service Cost Of Urgent Orders

May 1972

Service Cost Of Urgent Orders

A new load building model has been developed and is at present under trial. If distribution management and personnel co-operate fully in development we should have a more useful model.

Basically all products are given a % value of a van load (1750 cu. ft.).

Advantages claimed over the present model:-

(i) it is possible to see how full a van is by just looking at the total number of new units

(ii) management can set minimum parameters for a van load depending on order intake

(iii) carriage allowance calculations should be easier

(iv) a cost can be put on urgent deliveries eventually by unskilled personnel

This service cost calculation is illustrated below for a hypothetical case together with the management reporting system necessary.

Assume a sales clerk (or manager etc.) demands delivery of a product tomorrow:-

(i) W. Hitchings analyses the file to obtain a load such that the stated product will be delivered on time

(ii) the new units are added to give say, X therefore X% full (not counting the product but assuming there is space for it).

(iii) 100 - X = Y% space for the urgent product

(iv) a first estimate of mileage is made by W. Hitchings to give cost of delivering the load.

(v) Y% of this cost is allocated to the urgent order <u>BUT</u> £Z already allowed in the price for delivery

THEREFORE

Service cost of delivery = Y% mileage cost - £Z

(vi) W. Hitchings notes the T number and service charge and informs sales staff

The onus is then on the sales management to either pass this charge to the customer or accept it as an internal cost.

A similar situation would hold for production department problems, but in this case the cost would be purely internal.

Use could be made of these costs in management control of the various operations and to assist the deeper understanding of physical distribution which is becoming apparent in the company.

If the company set permissable van loads at less than 100 different scales will be worked out.