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Paper title: **An evaluation of logistics network modelling tools available to South Australian companies**

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Abstract (200 words):
The last decade saw a global progression from a focus on transport, warehousing and distribution to logistics networks and then to supply chains. This provides a full contextual perspective of transport and logistics operations. However, the complex nature of supply chains requires sophisticated modelling and powerful IT systems to manage transactions and address the large data sets required to provide comprehensive information for tracking, planning and scheduling supply chains. The benefits of using distribution network modelling systems in Australia are rather different from those places where such systems originated and are most frequently used – the USA and Europe. National distribution models for the majority of businesses will always have a limited number of options to explore. In practical terms, the question usually revolves around whether to centralise or decentralise, and attempts to balance three things: (1) service level, (2) transport costs and (3) inventory costs. A user with an understanding of logistics principles can often find an initial answer to such questions using relatively simple modelling tools or methods. This paper focuses on two important considerations that emerged during the study: (1) the search for software packages that are relevant to small to medium manufacturers (SMEs) and can solve the strategic transport network location problems often faced by these businesses, and (2) the need to develop an understanding of the theoretical aspects of strategic transport planning location problems.

Introduction

The aim of this project was to contribute to the competitiveness of South Australia as a location for manufacturers. The approach chosen was to investigate ways to improve the capacity of South Australian manufacturers to plan their distribution and supply using packaged logistics network modelling tools. The intended users are managers of small to medium enterprises who would have no specific education in logistics or modelling. In particular, they will need access to a printed learning guide and reference materials allowing occasional users to easily restore their proficiency in using the package. The tool should be capable of assisting in the resolution of practical business distribution issues for a variety of discrete products. These issues include:

- rationalising or dispersing distribution centres nationally or globally
- choosing the correct location of warehouses or third party logistics provider
- improving the reliability and timeliness of deliveries to customers
- planning and controlling inventory costs
- managing sales and distribution centres
- improving supply chain management

A set of decision criteria was applied to the identified packages. The aim of this investigation was to identify the best one or two packages that have local support, prompt availability and an acceptable price range appropriate to the target businesses. Identified packages would then be subject to testing and evaluation, to gauge their ease of use and applicability. The results of those tests will be reported subsequently.

The paper focuses on two important considerations that emerged during the study

1. the search for software packages that are relevant to small to medium enterprises (SME), and have the ability to solve the strategic transport network location problems that are typically faced by these businesses
2. the need to develop an understanding of the theoretical aspects of strategic transport planning location problems, and try to develop a '*back to basics approach*' that could be used to enlighten managers in SMEs on the merits and requirements of these types of software packages.

General approaches to logistics modelling

The role of models

Modelling provides a powerful tool for the analysis and design of logistics systems. It can have a key role at all stages of the planning and implementation cycle – strategic, tactical and operational. At the strategic planning level, models can assist with long term resource planning for the design and renovation of supply chains and logistics systems. Determining the optimum number and location of distribution centres would be an example.

In tactical planning, models can assist in 'fine tuning' or incremental adjustments to systems resource needs and overall operation, for instance in anticipating and responding to changing market conditions. Planning for the distribution and storage of a seasonal agricultural harvest (e.g. grain or grapes) would be a typical example.

Models for operational planning can assist with the day by day allocation of resources and the management and control of daily or real time operational procedures. Scheduling daily vehicle fleet operations and crew rosters would be an example.

Mathematical approaches to modelling

Modelling can be applied to individual components of a logistics system or to the system as a whole. When modelling complex logistics systems, there are different approaches that may be adopted. The nature and form of the model will depend on the particular approach adopted. D'Este (2001) identified the following three major approaches to logistics systems modelling: optimisation; simulation; network modelling.

Optimisation: Optimisation models are powerful and flexible planning tools for solving logistics problems, but like all modelling methods they do have limitations:

- most optimisation models cannot take account of the inherent variation in most logistics activities. Most optimisation models therefore represent the long run, steady state operation of a logistics system rather than cater for day to day variations in operations.
- all aspects of the problem must be reduced to a mathematical form for inclusion in the model. Those that cannot be represented by an appropriate mathematical expression are therefore likely to be excluded from the optimisation process and, unless care is taken, from the decision making process as well.
- changes to the basic operation of a system that change the constraints in the optimisation problem may require not just re-solution of the optimisation problem but possibly its reformulation

The basic restriction is the requirement that only systems components and interactions that can be represented by appropriate mathematical expressions can be included in the model, and this may limit the selection of realistic decision variables. Heuristic methods[1], for instance, may be difficult to include in the optimisation.

Simulation: Simulation modelling takes a different approach. While optimisation seeks the best solution or decision, simulation mimics the behaviour of the system. It then allows for the testing and evaluation of alternatives using a 'what if' approach, in which the analyst changes some component of the system and runs the model to compare performance between the original version and the modified version.

Two basic types of simulation model can be identified. These are discrete simulation models and continuous simulation models. Discrete models process the items as individual units, and progressively move them through the system by updating their state each time some process or event takes place. Since most goods are moved in discrete packages or consignments, the discrete modelling approach is most commonly used for logistics systems, especially at the tactical and operational levels. The continuous approach looks at flows of material. It is more applicable to the strategic planning level.

[1] A heuristic method in mathematics is a problem solving approach for which no conclusive proof exists that the method will find a correct solution to the problem under study, but which has been found to generate useful answers in previous applications to similar problems.

Thus, as for the optimisation models, simulation has its strengths and weaknesses (D'Este, 2001). The strengths are:
- the ability to model complex dynamic systems involving feedback, non-linearity and probabilistic variations
- the breakdown of a complex system into component processes, from which complex systems dynamics emerge naturally as these processes interact
- sensitivity to the timing, sequencing, magnitudes and interactions between events, because the simulation model tracks the evolution of the system over time

The weaknesses of simulation models are:
- the simulation model does not directly find the conditions for the optimal performance of the system. It test the performance of scenarios devised by the analyst but cannot find the best scenario
- the inherent variability in modelled processes that is a strength of the simulation model is also a weakness if it is not properly accounted for by the analyst. For the simulation model, repeated model runs and the assessment of the average characteristics of modelled factors are required. Well-established statistical theory exists to assist in this task of model interpretation (Young, Taylor and Gipps, 1989)
- careful validation of a simulation model is required. Only after validation can it properly be used to test the relative performance of different scenarios. Young, Taylor and Gipps (1989) describes methods and tests for simulation model validation

Properly validated simulation models are especially well suited to 'what if' scenario testing of complex systems with inherent variability. The simulation approach is well suited to tactical and operational planning as a consequence. It may be used to test the robustness of an existing logistics system to changes in the operating environment, including inputs and the performance of individual components of the system. It can also identify potential bottlenecks and weaknesses in a logistics system.

Network modelling: The third general approach to logistics systems modelling is to consider the logistics system as a network of linked activities, i.e. as a network of links connecting nodes. This has long been the preferred approach for modelling flows in passenger transport systems, and there are many established model packages in this field (e.g. see Ortuzar and Willumsen, 1995). In many instances network models can be converted to an equivalent set of equations in an optimisation model format, so there is some commonality between these two approaches.

The strength of the network modelling approach is that it is well suited to modelling transport systems and can efficiently represent and optimise a large, complex transport network. In addition, the formulation of the logistics system as a network model is relatively easy to comprehend and visualise because there is a direct correspondence between model components (nodes and links) and real world features. However, as for the other modelling approaches, a network model is still a highly idealised representation of the real world logistics system. In particular, the standard algorithms applied in network models are not particularly good at accounting for the discontinuities and granularity that characterise logistics systems. Network models generally consider flows as continuous, such as the number of passengers using a public transport system or the numbers of cars on a road. Whilst these are still discrete flow units the continuous flow analogy is a useful approximation for them. This is much less true for logistics systems. D'Este (1996) provides a full critique of the network modelling approach.

The network approach provides a general framework suited to strategic planning of freight transport systems but perhaps less well suited to modelling logistics systems.

Modelling supply chains and logistics networks

An important distinction needs to be drawn between logistics networks, supply chains and a whole of systems approach. A *supply chain* is a network of facilities and distribution options that performs the functions of procurement of materials, transformation of these materials into intermediate and finished products, and the distribution of these finished products to customers. Specifically, supply chain is a term used to describe the flow of goods and materials from source to point of consumption. The *logistics network* is defined as the infrastructure of production, consumption, storage and transit nodes connected by shipping, air, road, and rail linkages which supports the flow of the goods and materials.

Decisions in Supply Chains

Supply chain activities provide the elements of a complex system and numerous decisions are involved in successful design and operation of supply chains. Supply chain decision making is a complex process. Some of the important reasons for the complexity of the decision making process are: large scale nature of the supply chain networks; hierarchical structure of decisions; randomness of various inputs and operations; dynamic nature of interactions among supply chain elements.

Supply chain decisions have been classified based on their temporal and functional consideration.

- ➢ Temporal Classification
  - ✓ Strategic planning
  - ✓ Tactical planning
  - ✓ Operations
- ➢ Functional Classification
  - ✓ Procurement Decisions
  - ✓ Manufacturing
  - ✓ Distribution
  - ✓ Logistics
  - ✓ Global Decisions

Methodologies for Supply Chain Decision Making

Because of the inherent complexity of decision making in supply chains, there is a growing need for modelling methodologies. In the supply chain context, both deterministic and stochastic models are relevant. Also, we are concerned with both descriptive (or analysis) models and prescriptive (or optimisation) models. Important descriptive models for supply chains include: Markov chains, queuing networks, stochastic Petri nets, and simulation. Important prescriptive models include: linear programming, mixed integer linear programming, heuristic optimisation models, and simulation (Narahari and Biswas 2000).

Criteria for model evaluation

Evaluation Criteria

The evaluation criteria for the software packages covered issues such as price, complexity, databases included, implementation, availability and support, populating the model, transparency and system requirements. The criteria assess the ability of software products to provide an SME with a way of solving strategic transport network planning issues. Some of the key logistics network issues that SMEs deal with include: the number of distribution centres / warehouses to have; the location of distribution centres / warehouses; transport costs; alternative transport modes; vehicle fleet issues.

The likely SME clients have turnovers in the range of $5 million to $60 million. They are likely to be manufacturers or distributors of wine, food, automotive components, plastics and furniture. Their products are discrete and have a variety of specifications.

A suitable model is not required to analyse production systems or to analyse pick up and delivery systems. It should address facility location decisions, but not daily operational planning issues. The package is to have optimising capability. The project aimed to identify a strategic decision support tool capable of optimising a distribution network on a ‘once off’ basis, rather than an everyday operational tool.

The following package selection criteria were discussed.

Price	• Cost of ownership – Package purchase price, system requirements, upgrade and training costs, etc • The price point for products is less than $5,000 including package and a little training. The next segment would be $30,000 for a package and consulting support. The evaluation should sort offerings by price including initial training.
Databases included	• The model should incorporate standard data for Australian distribution operations including road and rail locations and vehicle performance characteristics including costs per tonne kilometre for common Australian road freight vehicles and for rail operations. It should calculate distances by road and rail between locations, transit times between locations by road or rail. The model should include a capacity to reset performance costs for changes in key inputs such as fuel prices.
Populating the model	• An evaluation criterion will be the time required to provide the model with the data relevant to the test problem. • The model should be able to be populated quickly using accounting or Manufacturing Resource Planning system data. The model should accept multiple supply points, multiple inventory service locations and multiple markets. It should accept annualised or quarterly demand data by location of market.
Transparency	• How well does the model and associated packaged training explain to the user a basic understanding of the logistical concepts it uses to solve the target problems?
Support	• The package should be capable of providing a variety of purchase and

	delivery options, either by the vendor or by a local agent. Are there Application Service Providers or specialist support teams available in SA? Can an SME obtain consulting support, or help desk support? • Vendor support for software in South Australia, such as help desk, upgrades, training quality and cost are not an important criterion. A successful package should attract a local support agent.
Installed base	• How widely is the package used? Is there a user group and reference desk? Where? What sort of users? What industry sectors? • Widely used packages will be favoured.
Complexity	• Model complexity should be appropriate to the scope described above. The tool should preferably operate on the basis of 'x tonnes p.a. from A to B', rather than considering the size of each line on each order over a given period. • Evaluation of complex software requires a level of understanding that may take some time to acquire. The 'top end' tools are known to be expensive, complex, and require significant training before a user can be considered competent. For example, three days of training is seldom enough to actually use these software packages. • Overly complex packages should be screened out in the preliminary evaluation. One of the criteria will be how easy is it to learn the software.
Model problem capacity	The client is shipping product to market and seeks answers to questions such as: • Where should DCs be located? On site? At port? • Which existing DCs should be closed? What if a selected DC is closed? • Can we rely on line-haul operations to this selected market? • Should we use a third party logistics provider? • How could I optimise customer service and delivery time? • What is the least cost distribution arrangement to serve these markets? • What is the optimum warehousing capacity for my business? • What will be the response times to changes in market demand provided by the selected configuration of the distribution system? • What storage volumes and capacities should we provide if we choose a particular configuration? • How sensitive is distribution cost to changed patterns of demand? • Provide an analysis of weekly shipments by type of product to provide information on consolidation of freight. • How many warehouses/DCs should I have? • How much will it cost to operate them (at different levels of throughput)? • What will be the impact of different warehouse numbers and locations on inventory levels? • What sort of vehicle should I use for line-haul - or should I use rail, or even sea? • How many vehicles will I need for line-haul? • How many vehicles will I need for final delivery? • What will my total transport cost be? • What service level to customers (time required to make a delivery) can I offer with confidence? • Where should I source my Raw Material requirements (assuming there is a choice)? • What will my RM transport costs be? • Provide optimisation • Provide multiple run sensitivity analysis and statistics

These considerations imply the ability to model a range of scenarios. Thus the test problem(s) to be used in the evaluation needed to take the form of a few scenarios that the software would be required to model. Further, any test problem needed to be appropriate to the potential customer base. The data sets to be provided with problems should not include the geographic and vehicle characteristics data expected to be incorporated in the model package.

Table 1 shows a complete list of the criteria that were used to evaluate the software packages, and Table 2 lists the software packages that were included in the initial evaluation.

Table 1: Evaluation Criteria for Software Packages

Price, including
- Purchase price
- Cost >$ 5,000?
- Cost of training
- Upgrades

Complexity
- Typical application of software
- Industry sectors covered
- Type of modelling tool
- Ease of use
- Economic analysis capabilities
- Network analysis capabilities

Database included
- Geographic road network
- Geographic rail network
- Vehicle characteristics
- Costs (per tonne km)
- Ability to import/export data

Implementation
- Ease of implementation
- Availability, no and experience level of implementers

Availability and support
- Package documentation
- E-support
- Consulting services
- Discussion forum
- Worked examples
- SA service providers
- Application service provider
- Installed user base

Populating the model (for selected case studies)
- Time required to provide model with data
- Accept annualised or quarterly supply/demand data

Transparency
- Explanation of logistics concepts that it uses

System requirements
- Operating system
- RAM
- HD

Others
- Demonstration version available
- Published reports on the software
- Comments
- Source of information about software (web address, etc)

Table 2 - Software packages considered

Manugistics	SageTree	LogicNet
I2	SCT	Merant
SAP	SKYVA	Ortems
Planimate	SynQuest	Proginov
CAST dpm	IBM Supply Chain Optimizer	Qualiac
ARCLogistics Route	SCAplanner	Digital Supply Chain
SCOR	Australian Supply Chain Management	Viper
Viper Scan	Road Train 2000	Logility Voyager Solutions
Movex	Freight Logic	Demand Solutions
Reflex	iRenaissance.scm	IBS
Aspen Strategic Analyzer	MFG/PRO	Mercia Software
J.D.Edwards	Planning Systems	PeopleSoft
Trans2000 *PLUS*	OptiNet Supply Chain Optimisation Service	Prescient Systems
impact	Oracle	DCSITE
moveit	Celerity Solutions Supply Chain Planner	DIPS Strategic Module
Consignor	Logistics Pro TMS	iBaan for SCM
SAILS 21	SeeChain Logistics	Thrive Technologies
SLIM/2000	Simulation Dynamics Supply Chain Builder Home	Frontstep Digital Supply Chain
CAPS Supply Chain Designer	Cristallize Supply Chain Solution	
c2g	BK sytemes	
Cognos 7	Exceed	
Descartes		

The preliminary review applied the criteria listed in Table 1 to information about the software packages obtained primarily from the Internet. No software packages met these criteria. Sample software was provided for a few, and these were subjected to more detailed investigation. Most of the software packages found model the entire supply chain process and are quite sophisticated, and require intensive training and resources that are beyond the scope of an SME. While some of these supply chain packages have internal modules that deal specifically with strategic transport network planning issues, these modules are not available separately at lower cost. Seven packages had strategic transport network planning capabilities and were considered for further evaluation. These packages are listed in Table 3. While they did not pass all the criteria they are the most suitable candidates found.

Table 3 - Short Listed Packages (vendor software)

InterDynamics - Planimate	Logic Tools – Logic Net
DIPS – DIPS Strategic Module	Distribution Solutions - DCSITE
SLIM Technologies - SLIM 2000	Insight - SAILS 21
CAPS – Supply Chain Designer	

More detailed information on the functionality, inputs and outputs that are provided by some of these short listed products will follow.

Gaps in the Toolbox?

The major omission from the toolbox uncovered in the model evaluation concerned a general lack of simple strategic planning models, (say) using optimisation methods to indicate the best locations of DCs or the best configuration of a set of DCs. Whilst these procedures were included in some of the models identified, in all these cases they were part of much larger modelling packages. There were no stand-alone commercial available models of this kind. At the same time the work of Zak, Redmer and Jaszkiewicz (2000) clearly indicates that such models do exist in the research institutes. For the future, further investigations about the possible translation of these research models for more widespread practical applications should be a priority.

Descriptions of selected models

The following detailed descriptions are provided for two of the models identified in this review.

Planimate

InterDynamics is a South Australian based provider of a logistics network modelling platform called Planimate, which is used by many medium to large size Australian and International corporations, including Alcoa, the Australian Defence Force, the Australian Grain Industry, BHP Billiton, Coles Myer, CUB, Orica Explosives, National Rail, Pacific Access, Queensland Rail, Swedish Rail and Rio Tinto.

InterDynamics confirmed at the commencement of this project that it had not developed logistics modelling tools for SMEs, as this was a price sensitive market which was difficult to supply viably. It supported this project by making available to the review team a number of leading examples of logistics network models which had been developed for its clients. In offering these models it was highlighted that the models were developed for use by analysts who had been trained in the use of sophisticated Planimate models. It was highlighted that these models were not designed to be user friendly or easy to understand for SMEs who had little appreciation of logistics network modelling issues and approaches.

The following evaluation is based on the experiences of study team members in using General Merchandise Logistics (GML) - a Planimate based model developed by InterDynamics - to solve the test problem based on the data set shown in Figure 1.

Supply	3 million	tons	per annum
Adelaide	60%		
Newcastle	40%		

Seasonality	Supply
1st Qtr	30%
2nd Qtr	20%
3rd Qtr	20%
4th Qtr	30%

Demand	3 million	tons	per annum

Seasonality	Demand
1st Qtr	10%
2nd Qtr	20%
3rd Qtr	30%
4th Qtr	40%

Applies to all markets

Demand Spilt	
Brisbane	25%
Sydney	25%
Melbourne	25%
Perth	15%
Adelaide	10%

Delivery Distance Profile	
0-15k	10%
15-30k	20%
30-45k	40%
45+	30%

Delivery Weight Profile	
0 - 1	10%
1 - 5	20%
10 - 15	25%
15 - 20	30%
20+	15%

Location Type	Open Time	Close Time	DOW
Plant	06:00	18:00	-MTWTFS
Customers	07:00	18:00	-MTWTF-
Dist Centre	06:00	15:00	-MTWTFS

Figure 1 - Data set for test problem

The problem includes a production centre in Newcastle, NSW from which 40 per cent of the production originates (i.e. 40 per cent of the total 3 million tonnes p.a.) while the other 60 per cent comes from Adelaide. The markets are Brisbane, Sydney, Melbourne, Adelaide and Perth.

The questions to look at are:
(1) What is the optimal number and location of distribution centres among these markets?
(2) For the optimum solution, what would happen to total cost if the Newcastle supply point is dropped and 100 per cent of the supply is from Adelaide?

Functionality: The original purpose of the GML model was to simulate the behaviour, calculate the costs and assess the performance of merchandise transportation in and around distribution centres (DCs), and between suppliers, DCs and retail stores.
In order to address the requirements of the test problem many modifications had to be operated to the GML model. The merchandise transportation between production centres (PCs) and distribution centres (DCs) was modelled keeping the basic structure of the original model.

GML could be used as a strategic modelling tool to look at different distribution scenarios (i.e. number of distribution centres, resource requirements, etc) and analyse the performance of the system.

Data Requirements: GML requires quite a large amount of input data, due to the fact that it was designed as an operational / performance analysis model rather than a strategic planning model.

The main data requirements for the test problem are as follows:

- location of PCs, DCs (geodetic coordinates: latitude, longitude)
- classes of vehicles to be used, with characteristics of each class in terms of capacity, cost functions, ability to carry each class of merchandise, etc.
- for any given day, the volume of each class of merchandise to be transported between the various supply and demand points. Volumes are in pallets or full truckloads
- the prices charged for journeys based on the location of the source and destination and the number of pallets to be transported
- the loads for each day, or parameters of the distribution from which loads for the day may be randomly sampled by the simulation
- capacities and time constraints at DCs , PCs.

Ease of Use: In order to run GML for the proposed test problem the user has to perform a series of alterations to the original model. These require a certain familiarity with the model and its simulation engine (Planimate) as well as a good knowledge of general logistics concepts. Even after these issues are overcome the GML model would require several runs in order to solve the simple problem that has been put forward. The underlying issue is that simulation while conceptually being able to solve the problem is not the best modelling approach in order to achieve a result for the test problem.

A new user of GML has to spend considerable amount of time making sense of the model as it is not intuitive and behaves unpredictably. In most of the cases debugging is a slow and meticulous process. While conceptually simulation is a good way of displaying the problem to new users, the precise syntax required to edit input data and the analysis required in order to get results is likely to be beyond the scope of logistics managers in an SME.

Results and Reporting: Results are comprehensive, giving details of:

- vehicle movement (vehicle ID, number of trips, origin, destination, number of pallets, day, time of day); a record of the vehicles movement from one location to the other is generated;
- extra vehicle use (day, location ID & name, and vehicle ID);
- vehicle performance (day, vehicle ID, pallets, km, driver hours, running cost, overtime cost, standing cost, driver cost); the utilisation performance of individual vehicles and the fleet as a whole is identified;
- pool performance;
- pallet costs (source set, destination set, cost, pallets, pallet-km, delivery cost, unassigned cost, total cost);
- distribution centre cost totals (distribution centre name, delivery cost, unallocated cost, total cost, pallet-km);
- order log (order ID, source ID and name, ID destination, destination name, product type, quantity pallets, target departure, actual departure, target arrival, actual arrival);
- roll over log (day, source ID and name, rolled over orders and pallets, postponed orders and pallets);
- drawdown log (order ID, location ID, product type, inventory pallets, day, time of day);
- location arrival (distribution ID and name, location ID and name of production centre, vehicle, weekly orders, orders received, weekly pallets, pallets received);
- demand summary (location ID, location name, pallets).

The outputs can be printed directly from the model in table format. For any further analysis, graphical representations, etc the data has to be exported to a spreadsheet.

Pallet Costs

	Source Set	Destination Set	Cost	Pallets	Pallet-km	Delivery cost	Unassign'd cost	Total Cost
1:	Adelaide P	Adelaide	$13.97	71.36	1427.2	$928.48	$68.14	$996.62
2:	Adelaide P	Melbourne	$59.97	111.40	86560.8	$2,548.60	$4,132.84	$6,681.44
3:	Adelaide P	Brisbane	$123.20	10.62	194904.3	$4,321.60	$9,305.71	$13,627.31
4:	Adelaide P	Perth	$177.14	32.77	82578.5	$1,862.00	$3,942.71	$5,804.71
5:	Adelaide P	Sydney	$106.42	31.92	45043.5	$1,246.60	$2,150.60	$3,397.20
6:	Newcastle	Adelaide	$131.82	26.54	38480.8	$1,220.00	$2,278.33	$3,498.33
7:	Newcastle	Melbourne	$79.75	70.04	62685.4	$1,874.00	$3,711.41	$5,585.41
8:	Newcastle	Brisbane	$39.71	22.00	2948.0	$699.00	$174.54	$873.54
9:	Newcastle	Perth	$125.04	70.73	105601.0	$2,591.60	$6,252.32	$8,843.92
10:	Newcastle	Sydney	$324.15	31.87	127238.5	$2,795.80	$7,533.40	$10,329.20

DC Cost Totals

	DC Name		Delivery Costs	Unallocated Costs		Total Cost		Pallet-km
1:	Adelaide P		$10,907.28	$19,600.00		$30,507.28		410514.2
2:	Newcastle		$9,180.40	$19,950.00		$29,130.40		336953.7

Figure 2 – Example of vehicle costs output

To answer the questions of the problem different scenarios (i.e. different number of DCs, eliminate a PC) will be tested and the outputs in terms of costs compared.

Dynamic representation: GML provides an animated representation of the distribution operation on a map of Australia showing the locations of DCs and PCs and icons for trucks moving from origin to destination.

Issues
The following issues have been identified in relation to the use of GML model:

- could be used as a strategic modelling tool
- level of detail too great for the test problem proposed
- data hungry
- not easy to use
- not-intuitive
- requires a basic understanding of simulation concepts and good knowledge of Planimate simulation software for any alterations
- the software documentation provided is not detailed enough; some elements of the specification are not actually included in the GML model
- no on-line ‘Help’ available for GML
- no explicit description of logistics concepts that it uses
- system requirements: Windows on a PC with a RAM of 128 MB or better, CPU speed of 600mHz or better, hard disk of at least 20 MB, monitor and video card that will handle a display resolution of at least 1024x768 and at least 32k colours
- not all the data tables can be edited in ‘Input’ mode
- use of multiple selection then copying and deleting data was not intuitive
- modeller mode had to be initiated for full editing capabilities, this was not obvious within the documentation.
- could not import data from MS Access database as stipulated in documentation
- numerous problems with links generation
- some redundancy in the data input
- links between databases seem to be missing
- input data update time consuming
- demand in pallets but no definition for the pallet (assumption: 1 pallet=1 tonne)
- residual data in output
- output can be edited

CAST *dpm*

The following comments are based on the experiences of study team members in using CAST *dpm* in Australia and South East Asia.

Functionality: CAST dpm has the following abilities:
Strategic modelling. The user can set up a series of scenarios involving:

- the number and location of warehouses
- the number and location of suppliers
- the number and location of customers
- the available fleet of vehicles
- supply and delivery volumes

Given this information, CAST *dpm* can then determine:

- the size and resource requirements of the warehouses
- the number and configuration of the vehicle fleet required to make collections and deliveries

In other words, it develops the optimum solution based on the parameters supplied for it.

Centre of Gravity – Volume. Based on the volumes being delivered to or from one or more warehouses, CAST *dpm* will determine the theoretical optimum location for each based on centre of gravity concepts. In practice, this can result in warehouses being proposed in some very unlikely locations as no account is taken of road access, land prices, availability of services etc.
Centre of Gravity – Cost**.** As above, but the calculation is based on cost rather than volume.
Isochrone modelling. CAST *dpm* can display the time taken to deliver from the nominated warehouse to customers as a series of 'time contours'.
Mixed Integer Programming Optimiser. CAST *dpm* can find an optimal supply and distribution solution, including the determination of whether or not to include warehouses at the specified locations.

Data Requirements: CAST dpm is very data hungry. Normal data requirements are shown below.

Customer Data Field Details. These data identify customers (i.e. delivery points) and order volumes. Details of individual orders for a specific period (e.g. one month) must be collected.
Dedicated Vehicle Data. These data define the types and running costs of all dedicated vehicles, such as: vehicle type, capacity, fixed cost per day, drivers cost per hour, variable cost per km, length of operating day, delivery/collection time, etc.
Transport Costs – Freight Rates (Non-Dedicated). A matrix of freight rates against distance is constructed.
Facility Cost And Resource Data. This summarises the data required for all storage and transit (cross-dock) facilities. In practice, determining the elements of the fixed and variable costs can be a difficult and time consuming process, often requiring some creative thinking to reach an appropriate level of accuracy and robustness.
Supplier Location Data. These data covers supplier locations. It is similar to customer data.

Ease of Use: Significant training and support is required before an analyst person can be considered proficient at using CAST dpm. Like any major piece of software, continuing use brings skill and expertise.

Also, like other major software, it is not without its idiosyncrasies. When a strategy is run, it is common at first to have a number of unallocated customers, suppliers or depots. Finding out why this is so is usually a long, slow painstaking task. It is also not uncommon to have to devise workarounds for certain situations that do not behave as expected.

Results and Reporting: Results are very comprehensive, giving details of individual deliveries to customers and all associated costs. Collection, delivery and storage costs are all reported in great detail. However, the format of the report is not friendly, consisting of a text file (132 columns) that is created and printed. Other than laboriously copying and pasting there is no way of extracting reported data and putting it into a more useful format.

CAST *dpm* contains a map system that presents a visual display of the results of strategies and other runs.

Issues: While having no major concerns about the software and its ability to do what it purports to do, it must be remembered that it works on averages, creating average drop sizes and the like. While this is probably acceptable for high level strategic modelling, this fact must not be overlooked when extrapolating from the results.

A way forward

On the basis of the literature review and the model evaluations undertaken in the study, it became apparent that not only was there no suitable logistics network modelling tool – in terms of the criteria specified – but that there is a real need to lift the level of understanding of supply chains and logistics networks in the business sector. Effective use of sophisticated modelling tools can only be made when the processes and phenomena that the tools investigate are properly understood. Consequently, the study team has formulated an awareness program aimed at lifting the level of knowledge and understanding using a set of broad principles for logistics management and the consideration of relevant case studies for SA business

The broad principles recommended for inclusion in an awareness program take the form of the following eight steps in improving the performance of a logistics network:

1. Understand the character and doctrine of the logistics network
2. View the supply chain and the logistics network
3. Focus on the economic and service performance drivers
4. Determine the capacity of the logistics network
5. Attack the inventory through a focus on process response capacity
6. Focus on contract structures to improve performance
7. Improve planning and operations systems
8. Establish monitoring systems and forums to review improvements

An awareness program based on these steps can generate participation of logistics practitioners in initiatives to improve the performance of their supply chains. Case studies developed from the experiences of participants will become teaching materials in subsequent presentations.

Understand the Character and Doctrine of the Logistics Network

Importance of an Integrated Demand/Supply/Inventory View: A whole of system view of the relationship between customer orders, production and inventory can be obtained by graphically overlaying inventory levels, customer orders, daily sales projections, and production runs. This serves to emphasise the crucial interrelationship between marketing and production/distribution.

Logistics Network Structure Definitions: There is a real need to promote an awareness of the structure of logistics networks. This structure is broadly defined by considering the network structure in terms of the following components:

- nodes, links and routes
- commodities and carriers
- storage and inventory
- demand and supply profiles

The Controlling Doctrine - Push or Pull or both: Most logistics networks are controlled by both Demand Pull and Scheduled Inventory Push supply systems. Scheduled production can be appropriate to standard, high volume products. On the other hand, JIT Demand Pull Supply Systems are appropriate to customised, made to order, small production run stock items and tightly vertically integrated industries such as the automotive industry. Many logistics networks are driven by both push and pull doctrines. The greater the accuracy of demand projections, the greater the opportunities to reduce inventory levels with associated reduced storage, working capital, freight and materials handling costs.

Logistics Network Diagnosis: Comparison of the performance of logistics networks using distance based freight cost (e.g. net tonne-km) and service timeliness profiles can identify opportunities to improve overall logistics service performance and to reduce overall logistics costs.

The Role of Models - Optimisation vs Simulation: Optimisation tools provide valuable assistance in identifying optimal logistics solutions. These solutions must, however, be qualified by their assumptions and scope. Simulation models assist in the evaluation of the validity and robustness of the identified optimal solution. They can be used to suggest optimal solutions. Animated simulation models are particularly valuable in representing the structure, scope and operational behaviour of supply chains and their logistics networks.

View the Supply Chain and the Logistics Network

A Focus on the Dynamics - Seasonality and other time Based Patterns: Significant logistics improvements can be achieved by promoting greater awareness of:

- planning horizons and responsibilities by a focus on planning time frames i.e. annual>quarterly>monthly>weekly>daily
- merits and dangers of aggregates and averages
- benefits of progressing into addition levels of detail and time periods

Product Segmentation – Filtered Views: Filtered views of supply chains and their logistics networks assist in planning and management. These views require appropriate units for analysis i.e.

- high level units: tonnes / volume / pallets
- intermediate levels: product families
- detailed units: SKUs (discrete products), grades (commodities)

Focus on the Economic and Service Performance Drivers

Impact of Production Strategies on Logistics Network performance: There is often a lack of awareness of the impact of production strategies on logistics network performance and associated costs. Of particular relevance is the impact of production run sizes and breakdowns and maintenance strategies.

There is also a tendency to use Materials Requirements Planning (MRP) approaches to plan and/or schedule key processes. Whilst MRP approaches are valuable for individual stock item considerations, they are usually too detailed for process and work centre planning. These are often best planned or scheduled by focusing on process capacity.

Linking Marketing Decision-making to logistics costs: There are often poor communications between the marketing and the logistics and production functions. Significant logistics cost reductions can be achieved by improving the linkages of marketing/ product pricing decisions to logistics operations costs and capacity limits. Simple tools or rules that provide guidance of logistics constraints to marketers are often the best solution. It is valuable to remind marketers that achievement of annual revenue and cost targets can be undermined if the logistics network has insufficient capacity to catch-up.

Determine the Capacity of the Logistics Network

Capacity Determination: Capacity constraints determine logistics network throughput costs and performance. Logistics network capacity is based on linkage (linehaul) and intermodal capacities. Linehaul capacity is based on cycle times, carrier capacity and breakdown profiles. Intermodal capacity is based on load and unload rates, shift patterns and terminal availability

Cycle Time Management: Understanding cycle time management is fundamental to understanding logistics network capacity:

- cycle time management is based on the repeating cycles of load, run full, unload, run empty
- weekly linehaul capacity determined by cycle time profiles and number of cycles achieved weekly
- maintenance strategies directly impact on weekly linehaul capacity.

Attacking the Inventory via a focus on Process Response Capacity

The role of inventory is to buffer the flow of goods and products to the market. Buffering can be achieved with inventory and production process response. Storage and warehouse sizes can be reduced by a focus on process response capacity. Storage and warehouse sizes can also be reduced by smoothing the commodity flow.

Focus on Contract Structures to prove performance

Managing the Logistics Network Interfaces: Contract structures have maximum impact on promoting behaviour that will improve logistics performance. These contract structures should focus on linking contract performance to throughput and service levels achieved. Further, contract structures should focus on ensuring that there is a clear understanding of the capacity that is available to service defined levels of demand.

Improve the Planning and Operations Systems

Ensuring appropriate capacity settings: Planning and operations systems should have a primary focus on ensuring that there is sufficient capacity to promote good operational performance. Importantly, planning systems should avoid micromanaging the operational environment.

Scheduling for Logistics Networks: Robust logistics scheduling solutions are usually based on an integration of the following scheduling techniques:

- constraint based
- leadtime
- progressive layering
- smoothing flows
- dynamic balancing of demand and supply

Establish monitoring systems and forums to review improvements

Sustainable logistics improvement will only be achieved when logistics principles are incorporated in the culture of the business. Critical to ensuring sustainable improvement is the establishment of monitoring systems and forums that regularly review the lessons learnt from the implementation of the logistics principles.

Conclusions and recommendations

The broad conclusions of the study are that no low cost, simple and accessible modelling tool is currently available, and the available tools are not capable of supporting a user without a good understanding of logistics. In most cases cost is the critical barrier. Improved awareness in the business sector of logistics principles should be a primary aim.

The general findings of this study are as follows:

- Logistic problems are complex, requiring a practical and theoretical understanding of the practices and processes of materials handling. Expert and experienced analysts can choose approaches and use software packages to solve complex logistical problems quickly. However, the modelling package does not substitute for the knowledge and experience of the operator.
- The analyst has to have enough understanding to match the problem and available data with a selected modelling approach (optimisation, network analysis, simulation, location) and to interpret the package outputs in terms of the particular business decision faced. Model selection and output interpretation requires education
- Software for models cannot substitute for the education of the modeller about logistics and about the feasible outcomes of modelling. Integrated software can provide options for an educated modeller, but it cannot substitute for the knowledge and understanding of the modeller.
- Models cannot operate without data. Most types of logistics analyses require a body of generic data such as distances between major Australian centres by road, rail, sea and air, or vehicle operating costs per tonne kilometre by type of vehicle.

The recommendations following from these findings and conclusions are thus:

1. No simple accessible and commercially available modelling software is priced for small to medium enterprises, and useable without a good education in logistics. The user who understands logistics can choose from a variety of useful software tools. The shortlist points to some, albeit costly, examples.

   a. A guide to selection of models would assist end users who understand of logistics and this would contribute to the competitiveness of South Australian business.
2. The competitiveness of small to medium enterprises in South Australia could be improved by educating their managers about approaches to logistics principles and about how to choose among the available software packages
   a. The study suggests an effort to provide managers of small to medium enterprises with an understanding of key logistics principles.
3. By providing a generic data set for logistical analyses, the South Australian Government could encourage and improve the quality of distribution decisions taken by small to medium businesses in the State. This would contribute to the competitiveness of the State.
   a. The team recommends designing and making available a generic logistics data set for use by small to medium enterprises in South Australia
4. An awareness program should include presentation of principles and case studies that provide specific examples of the application of these principles.

Sustainable logistics improvement will only be achieved when logistics principles are incorporated in the culture of the business. Critical to ensuring sustainable improvement is the establishment of monitoring systems and forums that regularly review the lessons learnt from the implementation of the logistics principles.

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