Transport Routing and Scheduling Systems
An Investigation into why Companies Implement Computerised Vehicle Routing and Scheduling Systems - an Australian Study Based upon research conducted between 1999 and 2005

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I hereby declare that the work in this thesis is that of the candidate alone, except where indicated in the text, and as described.

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Abstract

The field of transport logistics and supply chain management has changed dramatically over the last few decades as new technologies have been introduced to improve productivity and efficiency. One example is the use of computer software designed to enhance vehicle routing and scheduling. While there are many proprietary versions of this software they are generically labelled a Computerised Vehicle Routing and Scheduling Systems.

As with most new technology, not all organisations tend to adopt them at the same rate. Indeed, some do not adopt them at all. Given anecdotal evidence that this has been the case with the Computerised Vehicle Routing Scheduling Systems, the primary focus of this research became: what factors drive a company to implement Computerised Vehicle Routing and Scheduling Systems (CVRSS) and what benefits do they derive from it?

The research design adopted to address this problem utilised mixed data collection methodologies. In order to determine what was happening in the industry as a whole, a specially designed survey was conducted utilising both web-based and traditional paper-based instruments. This provided valuable quantitative data about the rate of uptake, types of companies and so on. To complement this, a focus group of selected representatives within the industry was conducted to delve more deeply into motivations behind the decision to adopt the technology and the perceived benefits derived from it.

The research concludes that companies implement CVRSS to realise operational savings. Additionally the results indicate that smaller companies implement CVRSS to ensure they maintain an effective place in the market without developing a larger workforce. Future research should concentrate on why companies do not adopt CVRSS and the impact of lower technology costs on transport operations.


1. Introduction

1.1 Background to the Research

The notion of efficiently and effectively moving goods from one given point to another has been considered since the days of the Roman Empire. With the advent of modern transport concepts and technology the idea of efficiency and effectiveness has become increasingly important. Modern transport organisations which run on low operating margins and are governed by extreme market pressures must, as a normal part of business, drive costs down utilising a range of processes and/or technological means. In addition, current trends to reduce the impact on the environment require that more efficient use of all transport types be found. Indeed the notion of reducing resources is a key driver.

This is all in an industry that makes a substantial contribution to the national economy. Indeed, according to the Australian Bureau of Statistics the transport and storage sector makes a 5.4% contribution to Gross Domestic Product (GDP). Other studies suggest that it is even higher at 15% of GDP and 14% of Gross State Product (GSP) (Parsons, personal communication, August 24, 2006).

Given the overriding pressure to improve, the transport sector uses a field of technology that has evolved within science and mathematics to logically interpret data and recommend gains in efficiency and effectiveness. Broadly categorised as Decision Support Systems (DSS) the field covers three key elements of efficient transportation, viz. route planning, load planning and scheduling. From a mathematical perspective
this field addresses various problem areas including, amongst others, the Travelling
Salesman Problem, the Chinese Postman Problem and the Travelling Salesman with
Time Windows Problem. From a commercial perspective the number of products that
service these problems is increasing both in volume and complexity.
Because of the range of mathematical solutions and technologies available it is
necessary to define a number of key phrases and words which will be used in this
thesis. Of these the most general is that of Vehicle Routing (VR). In his work on
routing and scheduling in the North of England Peter Eibl defined this as planning the
delivery and/or collection of goods using one or more road vehicles (Eibl, 1996). In
their work titled the “Logic of Logistics” Bramel and Simchi-Levi (1997) define the VR
in terms of the “Vehicle Routing Problem” (VRP) and a subset of this, the Capacitated
Vehicle Routing Problem (CVRP). The generally accepted definition of the Vehicle
Routing Problem in a general sense is:

    “a set of customers has to be served by a fleet of vehicles of limited capacity. The vehicles are initially located at a given depot. The objective is to find a set of routes for the vehicles of minimal total length. Each route begins at the depot, visits a subset of the customers and returns to the depot without violating the capacity constraint” (Bramel & Simchi-Levi, 1997).

Vehicle Routing and Scheduling (VRS) as defined by Eibl is when vehicle routing takes
on the dimension of time in terms of “Time Windows”. Specifically he defines vehicle
routing and scheduling as: when time constraints are incorporated (into the vehicle
routing problem) the ideal being to create a number of minimum cost routes for each
vehicle (Eibl, 1996). Eibl (1996) then goes on to define the computerised solution to
vehicle routing and scheduling as the Computerised Basic Routing System (CBRS).
Specifically he defines this term as: systems that determine the shortest route between
two locations within a road network. These types of systems are considered to deal with the Travelling Salesman Problem (Eibl, 1996). Eibl (1996) further breaks the Computerised Basic Routing Systems down into the computerised Order Allocation Systems (OAS). While not integral to the solution of the Vehicle Routing Problem it is never-the-less, a key component to the modern vehicle scheduling and routing software that is commercially available today. Practically, without this component the computerised routing and scheduling systems that we see today would not offer the advantages required by the end user. In summary it can be defined as: a system which allocates orders to routes or vehicles (Eibl, 1996).

Williams (2000) defines routing as allocating orders to a run, allocating the run to a driver and the driver to a vehicle. Williams contends that the routing component of a fleet can in fact remain a manual process but can be assisted with the use of technology. However the scheduling of vehicles is one which remains a task which can only be completed by a computer. He sees the task of scheduling broken down into key components all related to a driver's time (Williams, 2000). The tasks can be identified as waiting to load, loading, on the road, waiting to unload, unloading and administration and rest breaks. In a systems world, he argues the routing system would perform its task only in relation to the constraints placed upon it by the scheduling component. The result is two independent modules combining to produce a Routing and Scheduling outcome (Williams, 2000).

While there are many different companies offering proprietary software solutions to these problems, for the purpose of this thesis the generic term Computerised Vehicle
Routing and Scheduling Systems (CVRSS) will be adopted. This is in line with most of the academic literature currently available. The definition therefore of a CVRSS is as follows:

systems that are usually commercially available, highly sophisticated, interactive, based on complex mathematical programming, graphics displays and effective user interfaces. These systems are suitable for complex delivery constraints such as time windows and limited access customer premises (Eibl, 1996).

### 1.2 Research Question

Despite the obvious advantages of this new technology, an initial review of industry practise in Australia indicated that not all logistics companies adopt it. This raised an interesting question that became the primary focus of this research: **what factors drive a company to implement Computerised Vehicle Routing and Scheduling Systems (CVRSS) and what benefits do they derive from it?**

In order to address this question adequately, a number of sub-questions arise:

- What is the proportion of all both “own use” and “for hire” transport companies that adopt this technology?
- Are those which have adopted the new technology of a particular type?
- What benefits do companies believe they derive from the adoption of this technology?

The inclusion of all types of transport was significant because the researcher anecdotally understood that many “own use” service based organisations both in Australia and overseas had adopted CVRSS technology. Additionally “for hire” companies were perceived as the typical CVRSS user.
As a subset of these questions, four research hypotheses have been developed to provide even further focus for the research. These have been developed as part of a broad analysis of available literature. They are outlined in Chapter 2.

These questions became the focus of the research outlined in this thesis. As can be seen, these questions ensure that there is a broad but comprehensive approach to the particularly important primary research question. As it was anticipated that many companies would explain their adoption decision in terms of a list of benefits to be derived, it was important to ensure that broader cultural issues could be captured if they were relevant. That is, while post-hoc explanations will generally concentrate on quantitative benefits it is important to uncover why some companies are able to identify these benefits and move towards their adoption while others do not.

1.3 Justification for the Research

In the development of the research it became clear that there was a vast body of knowledge related to the mathematical concepts associated with CVRSS. It was decided however that the “industry” would appreciate a more practical approach. This was based upon the researchers experience and that research into VRP was a separate body of work. Regardless an overview of the mathematical approach was completed. In an academic sense, CVRSS systems have been developed to solve a number of well-known mathematical problems. These include the Travelling Salesman Problem, the Vehicle Routing Problem, the Chinese Postman Problem, and the Rural Postman
Problem. Of these, the Travelling Salesman Problem (TSP) is most often cited as being closely related to CVRSS.

Several authors have attempted to define the problem, including Eibl (1996). He defines it as the determination of a minimum cost cycle that passes through each node in each graph exactly once (Eibl, 1996). Others, however, have defined the problem differently. In his work on dynamic vehicle control and scheduling of a multi-depot physical distribution system Chwen-Tzeng Su (1999) discusses various algorithms that solve the Travelling Salesman Problem (TSP). The problem can be formulated into a mathematical model to establish the least-cost vehicle routes starting and ending at the depot and satisfying the requirement that every vertex only be visited exactly once (Chwen-Tzeng Su, 1999). Likewise, other authors such as Bramel, et al. (1997) have defined the problem in mathematical terms with a general description closely following that of both Eibl (1996) and Chwen-Tzeng Su (1999).

Indeed a number of variations of the TSP exist. These include:

- TSP with soft windows- delivery schedules that deal with ill-defined or “open” delivery times;
- TSP with semi soft windows- delivery schedules that deal with broadly defined time windows i.e. morning or afternoon and
- TSP with hard windows- delivery schedules that provide a narrow and defined delivery time frame i.e. 7 minutes per stop.

While TSP is a well-known problem within academic circles it is not well understood within the larger logistics industry. Likewise, even in the academic literature the focus
is on the nature of the problem and associated mathematical issues rather than its potential advantages to the industry.

Given the potential savings that adoption of this technology can create, understanding the drivers of company adoption can potentially benefit the whole transport and logistics sector as well as the broader society within which it operates. As defined, the transport and storage sector contribute approximately 15% to GDP. This contribution can be measured in a number of ways including economic, financial and societal. Road transport represents 70% to all freight transported in Australia as well as 34% of all kilometres travelled. Savings in this area have great potential to contribute to the well-being of society by reducing the end cost of products, road utilisation and congestion and unnecessary use of scarce fuel resources.

Many software vendors and some statutory authorities define a range of benefits that can be achieved through adoption of CVRSS. Indeed a range of reports have been completed that similarly identify the relative benefits of CVRSS.

A good example of the latter is the United Kingdom Department for Transport which summarises many of the benefits claimed by software vendors as follows:

*CVRSS rapidly process information concerning customer locations and requirements, and types and quantities of goods to be delivered and/or collected, and match these to available vehicle capacity, to produce the most economical routes and achievable schedules:*

*By so doing, CVRS systems can help to:*
  * Improve the utilisation of transport resources*
  * Reduce journey times*
• Minimise vehicle mileage
• Reduce operating costs
• Improve the reliability of delivery schedules (Department for Transport 2006)

Given the potential benefits, a number of authors such as Eibl (1996) identified questions that they believed warrant further research. The most germane of these was:

• What are the cost benefits of using CVRSS technology?; and
• How do cultures affect the way in which organisations select CVRSS technology? (Eibl, 1996)

It is the purpose of this research project to address aspects of these issues through the research questions outlined above, which seek to identify why Australian companies adopt CVRSS and to quantify the benefits associated with the adoption of CVRSS in an Australian context.

1.4 Methodology

This research adopted a mixed methodological approach. The primary approach involved the use of a survey aimed at getting information from a representative sample of the population. This was designed to address both the primary research question and some of the supplementary research questions that concern the way the sector as a whole operates. The identified population consisted of transport and logistics providers within Victoria, Australia. The second approach involved the use of a focus group. This was chosen as a means of obtaining a more detailed understanding of the attitudes of those in the industry. This mixed methodological approach resulted in
greater understandings of both behaviour and attitude than would have been the case using only one.

As stated above, the survey was designed to capture responses from a representative sample of the target population. It took two forms: an internet based survey and a paper based survey. In both formats it consisted of 6 sections and approximately 40 questions. The survey was broken into two parts: those that had adopted CVRSS and those that had not. Survey Respondents were identified through industry associations, networking groups and the Victorian Yellow Pages.

The survey attracted 85 respondents from within the transport and logistics sector. Data analysis consisted of direct interpretation of the data as well as the use of Chi Square to test statistical relationships. This analysis allowed for a number of conclusions to be drawn. These include comments on the relationship between the size of the company and the uptake of CVRSS, as well as other factors that distinguish between those that have adopted CVRSS and those that have not.

This survey was followed by the use of a focus group to collect further information. A selected group of senior industry executives participated in a focus group aimed at gaining a greater understanding of industry perceptions regarding the introduction and use of CVRSS. This was introduced to complement the data collected through the survey and to provide an opportunity to delve into specific issues in more depth. The results of this helped greatly in the interpretation of the survey data.
1.5 Definitions

For the purpose of this thesis many terms will be used. In an attempt to approach the discussion uniformly the following terms and their definitions will remain constant. The reasoning for this is that within the transport industry, and particularly the land transport industry, various phrases can have various meanings. This is particularly true across continents where the Vehicle Routing Problem (VRP), one of the primary foci of the research, can have several meanings. Therefore for the purpose of consistency, if a meaning has been defined in an academic text and there appears to be consistency with this definition then that meaning will be used in this thesis.

The word route is one which has differing meanings according to which continent the word is used. In the United States route (pronounced rowt) denotes the course or progress something follows (Golob & Regan, 2002). In Australia the word route can also denote a regular journey that includes a number of set stops in an ordered sequence (The Australian Concise Oxford Dictionary, 1987). For the purpose of this thesis the word route (pronounced rowt) will be defined as follows: the course or way taken in getting from starting-point to a destination or to send, forward, direct to be sent by a certain route (The Australian Concise Oxford Dictionary, 1987). Associated with the word route in the context of this thesis is the word load. Similarly for the purpose of this thesis the word load will be defined as: to put something on or aboard [person, vehicle, ship etc] (The Australian Concise Oxford Dictionary, 1987).
Another key word is *schedule*. Schedule can be defined as a tabulated statement of details, inventory etc., especially as an appendix or annex to a principal document; list of events, rates etc.; timetable; time started timetable or plan (The Australian Concise Oxford Dictionary, 1987) or a temporally organized plan for matters to be attended to.

A particularly important term to clarify is that of *efficiency*. Commercial providers of CVRSS define efficiency as optimising a number of key factors which include driver hours, vehicle operating costs, distance travelled and time, to name but a few. The technical definition of efficiency differs somewhat from the general understanding of efficiency. One of the more refined mathematical definitions is related to Pareto Efficiency. Efficiency occurs when, given a set of alternative allocations and a set of individuals, a movement from one allocation to another can make at least one individual better off, without making any other individual worse off (Osborne, 1997). The more general view of efficiency can be defined as: a state or quality of being efficient; ratio of useful work done to total energy expended (The Australian Concise Oxford Dictionary, 1987). This contrasts with the often substituted term *effective* which can be defined as “having an effect; powerful in effect; striking, remarkable; coming into operation...actually usable” (The Australian Concise Oxford Dictionary, 1987).

By far the most common term or phrase that will appear in this thesis will be Computerised Vehicle Routing and Scheduling (CVRS) and Computerised Vehicle Routing and Scheduling Systems (CVRSS). Three key types of software systems have been identified by Eibl (1996) as being components of the CVRSS, *viz.*, Computerised Order Allocation Systems, Computerised Basic Routing Systems and Computerised
Vehicle Routing and Scheduling Systems. However, to avoid confusion the more
generic term CVRSS will be the main focus of the thesis and for that purpose will be
defined as:

*systems that are usually commercially available, highly
sophisticated, interactive, based on complex mathematical
programming, graphics displays and effective user interfaces.
These systems are suitable for complex delivery constraints such as
time windows and limited access customer premises* (Eibl, 1996).

A number of Organisations track the development and promulgation of commercial
CVRSS and define these systems somewhat more succinctly. Hall (2006), for example,
referred to states while applications differ according to their target market, special
features and integration, these systems have a common set of basic capabilities:

- **geocoding addresses, i.e., locating the latitude and longitude by
  matching the address against data contained in a digital map
database;**
- **determining the best paths through street networks between
  pairs of geocoded points; solving vehicle routing problems,
  entailing an assignment of stops to routes and terminals,
  sequencing stops and routing vehicles between pairs of stops;**
  and
- **displaying the results in both graphical and tabular forms in such
  a way that dispatchers can guide the solution process and
  communicate results to drivers, loaders and other personnel.**

The Department for Transport (2006) in the United Kingdom is very proactive in
promoting CVRSS in transport operations and has outlined a number of key benefits
that potentially can be achieved through its adoption. When describing what a CVRSS
is the Department defines it this way:

*CVRSS(S) take large numbers of customer orders and calculate the
most effective way of meeting them. They calculate the time and
resources required to complete the work, using collection and
delivery information and observing the pre-determined parameter
settings that control the way in which the transport operation is
run. Parameters include road speeds, load size, customer opening
times and driver hours.

1.6 Delimitations of Scope and Key Assumptions

It is important to acknowledge that any research has a number of limitations and is
generally based on a range of assumptions. These put boundaries around the
conclusions that can be drawn and reduce the possibility of exaggerated claims.

The primary limitation is the lack of a clear understanding and definition of the
logistics, supply chain and transport sector. This creates problems at the sampling and
data collection stage and limits the extent to which acceptable generalisations can be
drawn from the results. Road transport generally works within the supply chain or
logistics chain. In turn, these chains generally operate across a number of industry
sectors including manufacturing, agricultural production and many others. Because of
this it was difficult to identify one key group that was the archetypal ‘transport and
logistics’ company to respond to the survey.

Even within different industry sectors transport and logistics companies operate in a
number of different ways. In particular, transport operations can occur at regional,
national and local levels. They also operate a number of different fleet vehicles,
ranging from multi-axle vehicles through to small utility vehicles and delivery vans.
Finally, transport companies operate at a number of different levels, ranging from one-
man courier operations through to multibillion-dollar businesses. This again affects the identification of the archetypal ‘transport and logistics’ company.

While the CVRSS generally operates at the regional level supporting the metropolitan distribution of product, very few organisations in Australia merely operate metropolitan distribution fleets.

To address these issues respondents were chosen from a known number of different industry sectors. An attempt was made to also ensure representation from companies with a range of different operating styles and sizes. However, while this can be justified from a sampling perspective (and is in Chapter 3), it creates limitations in so far as drawing conclusions and implications for the industry as a whole. This “industry limitation” led to a constriction in the data collected. Indeed this constriction was further compounded by the “snap shot” in time which all survey instruments are bound by.

Finally, it is important to acknowledge that the conclusions drawn are based on the assumption that respondents interpret the motivation behind their company’s behaviour appropriately. While this problem is faced by most researchers interested in company behaviour, it must be acknowledged that respondent interpretation of events cannot be avoided (Lincoln and Guba, 1985).
1.7 Outline of this Thesis

This thesis consists of five chapters plus appendices. The first chapter is the introduction and provides an outline of the overall thesis. The second chapter provides a conceptual framework for the research issues. It identifies the previous work undertaken and outlines the context within which the research was conducted. This was used to develop a number of research hypotheses to maintain a specific focus for the research. The third chapter outlines and justifies the methodology adopted to answer the research questions posed. It outlines the survey structure and statistical models that were used.

The fourth chapter provides an analysis of data and highlights relevant relationships that have been found within the data in relation to the research questions and/or the hypotheses.

The final chapter outlines conclusions and implications derived from the research. Conclusions are drawn from the research in a manner that will enable the reader to better understand the adoption and use of CVRSS technology in the Australian transport industry. In addition, it outlines the theoretical and practical implications of the research and makes suggestions for further work that has arisen as a result of the current work.
1.8 Conclusion

This chapter has provided a firm foundation for the thesis. It has defined the research question as well as outlining the justification for the research. This chapter has also highlighted a range of definitions as well as a number of limitations associated with the research. On this basis the thesis will now proceed to review previous research that has been done in the area with a view to positioning the current work in its academic and practical context and to establish four research hypotheses to help provide a focus.
2. Literature Review

2.1 Introduction

The purpose of this literature review is to investigate what research has been undertaken to help our understanding of the adoption of CVRSS in the logistics industry. It is not designed to review all the literature available on the TSP and the VRP, especially that which focuses on technical developments and specifications. While it is important to maintain a current perspective on all literature relevant to the field, it is not the objective of this thesis to be simply a review of all VRP or TSP algorithms. Rather, the review of the software information is to provide context for the academic works associated with it.

The chapter is split into discrete sections. The first section deals with the genesis of the modern CVRSS while subsequent sections deal with logistics and supply chain definitions, statistical review, technical review and survey review. The chapter addresses this previous work with a view to identifying gaps in the literature that became the drivers for the research question and subsequent hypotheses.

2.2 The Genesis of CVRSS

The pedigree of the modern commercially available routing and scheduling package is based in the Management Information Systems (MIS) of the early to late 60's in which companies began to automate processes such as stock control, accounts and payroll.
It is therefore appropriate to discuss (in brief) the history of MIS and a product of MIS, Decision Support Systems (DSS), as a background to any detailed discussion of CVRSS.

Power (2004) highlights the link between early MIS and DSS and the computing systems found in the 21st century. Convergence of a range of computing methods in the late 1960’s has led to the adoption of a number of technologies in the 21st century. These include expert systems, multidimensional analysis, query and reporting tools, OLAP, Business Intelligence, Group DSS, and Executive Information Systems (Power, 2004).

One of the earliest texts related to DSS was Michael Scott-Morton’s ground breaking book titled Management Decision Systems: Computer-Based Support for Decision Making published in 1966. This book outlined early experiments with a DSS and included an analysis of the interaction between managers and the DSS used.

Early computerisation within the business world was collectively known as Management Information Systems (MIS). In 1974 Davis defined a MIS as an integrated man/machine system for providing information to support the operations, management and decision-making functions in an organisation (Arnott & O'Donnell, 1994). The key defining characteristic of these early systems was that they had little to do with management and a lot to do with solving large-scale repetitive clerical problems (Arnott & O'Donnell, 1994). Hence, despite their collective name, the early MIS were clearly not capable of providing the type of decision support being sought by managers. Keen and Wagner (1983) suggest that this failure to perform as a management support
mechanism was largely due to the lack of understanding exhibited by computer professionals about the role of management and the type of information required within an organisation.

Based upon this, Keen and Wagner (1974) suggest that any decision support system for management should be defined as follows:

“Specifically a decision support system is a computer based systems that is used personally on an ongoing basis by managers and their immediate staff in direct support of managerial activities.”

Decision support in the context of the twenty-first century has developed in a number of ways. However, as Arnott and O'Donnell (1994) point out, the overarching philosophy of DSS has not changed. This philosophy, they argue, is that the primary aim of a DSS is not the computer based product itself but the use of computer technology to support management decision-making (Arnott & O'Donnell, 1994).

In their article Computer Assisted Decision Support Systems: their use in strategic decision-making Gerson et.al. (1992) put forward several views about what a DSS should do or indeed does do. They suggest that there are a number of different viewpoints ranging from their collective view that all software tools could in fact be a DSS (including spreadsheets) through to the more widely accepted view that a DSS is a particular grouping of software that assists in solving a problem. More precisely, Gerson, et.al. (1992) define a DSS as “. . . any application that helps the decision maker to identify and solve a problem”. “It is the decision maker’s use of the application rather than the technology itself which identifies a DSS” (Michael, et. al. 1992).
The perceived link between DSS and CVRSS became evident in the late 1970’s with the early use of spatial data in products such as Geodata (Power, 2004). It is therefore possible for a CVRSS to be conceptualised as a DSS that relates to data about space and movement. However, in line with the comment above, it is the use that is made of this technology that should be regarded as a distinguishing characteristic rather than the nature of the technology itself.

To further develop this aspect of a DSS it is necessary to distinguish between the roles of a manager as opposed to the role of operational staff.

The question that this begs is: if DSS is a management tool only, does a routing and scheduling tool fit within the parameters of a DSS, as their use generally remains at an operational level? And if a business can be defined as both tactical and strategic does a routing and scheduling product come under the banner of a tactical tool or a strategic tool? Mintzberg, Raisinghani and Theoret (1976) define this problem in the work titled *The Structure of “Unstructured” Decision Processes* in which they establish that strategic decisions are ones which are not structured and have high levels of unstructured thought.

In all early case studies it has been found that the decision process involving a CVRSS revolved around the highly structured set of decisions found at mid to lower levels of management. This in no way mirrored the philosophical goal of DSS and researchers set about assessing decisions made at higher levels of management which relied upon
unstructured and disparate thought processes. It is at this point that the question of “where does a commercially available routing and scheduling software package fit?” Is it a DSS or is it something else? This question, whilst having some relevance, is not one which is readily addressed in the texts.

It is within this context that the research project has been framed. Developing an understanding of not only what the technology is, but also how it is used in a transport company is an important precursor to undertaking empirical research into the perceived benefits to an organisation.

It is clear that commercially available routing and scheduling packages can be viewed by some as a form of DSS. This statement can be justified by the fact that that commercially available software packages support the transport decisions made at all levels within an organisation. Indeed some commercially available software packages very much see themselves as DSS products. This can be seen in some of the advertising claims made by service providers. An example of this is the claim made by Caps Logistics: “CAPS LOGISTICS is the leading provider of PC based decision based support software for transport and distribution” (www.caps.com, 2001). Similarly, a company in the United States known as Integrated Decision Support claims to not only be a decision support tool for the transport industry but also has the ability to “optimise” transport operations (Integrated Decision Support, 2007).

However, when reviewing the information available on the internet from companies such as these and others it appears that there is a reasonable gap between those
companies that claim to offer a DSS and those that were considered to offer a CVRSS solution. Further, organisations that did claim to offer a DSS were generally those that operate at a community or societal level as opposed to an organisational level. An example of this was the County of Chittenden, which utilises a DSS to help define the larger transportation planning issue within the Municipality (Chittenden County Metropolitan Planning Organisation, 2006).

It would appear that the literature post 2005 would support the differentiation between a DSS and CVRSS. Further, it seems that there is no common link between CVRSS and DSS at least in those companies and organisations reviewed by the researcher. This suggests that the analysis needs to only consider its value in operational terms rather than as part of the broader strategic management function. This has been reflected in the research design adopted.

2.3 Supply Chain and Logistics

The area now known as Supply Chain Management has had many guises over the past 30 years. For example, Johnson et.al. (1999) includes a range of disciplines under this rubric, including inbound logistics, materials management, outbound logistics and business logistics. It is therefore appropriate to clarify what Supply Chain Management really is and how it relates to the field of Logistics.

Blanchard (1998) describes Supply Chain Management as the management of the flow of materials as well as the relationships between channel intermediaries from the point of origin to the point of consumption. On the other hand, Bramel and Simchi-Levi
(1997) use the commonly defined Council of Logistics Management narrative to describe it as:

*the process of planning, implementing and controlling the efficient flow and storage of goods, services, and related information from the point of origin to the point of consumption for the purpose of conforming to customer requirements.*

![Diagram of supply chain and logistics](image)

**Figure 1: Logistics and Supply Chain Interaction**

The field of transportation planning is part of the larger logistical planning discipline. The literature covers a range of discrete disciplines within the larger logistics field. These included operations management, production management, general management, supply chain management and business logistics management. Further Bramel and Simchi-Levi (1997) refines these fields into macro groupings including strategic, tactical and operational levels.

While academic research can be found in all fields, it is in both the logistics and operations journals where the most current literature appears. Much of this
information is related to the development of algorithms that address the Travelling Salesman Problem or the Vehicle Scheduling Problem rather than issues surrounding the current performance of the software products in the market place. This identified gap in the literature became part of the stimulus for the current research. Although it is important to continue to develop better and better mathematical solutions to these problems, an analysis of their adoption and application in the marketplace is an equally significant issue to address. As noted above, this research attempts to address this issue and fill this gap in the literature within the context of the transport industry in Australia.

The activity of particular interest within the focal transport industry is transport planning which, for the purpose of this thesis, is considered to involve those activities associated with the acceptance of a customer order, the loading of the order onto a vehicle, the effective routing and scheduling of the vehicle and the delivery of the product to the customer. In broad terms this means vehicle fleet size, load planning, driver rostering, load building, delivery time windows, routing and driver costs. In the overall transport sector transport planning in some form occurs with every journey, planned or unplanned. It is therefore particularly significant when a product or piece of software claims that it can reduce transport costs by improving the process of transport planning. This claim is often made by the promoters of CVRSS.

There is a view that CVRSS can fall into two categories; strategic and operational. Examples of strategic use of CVRSS include Rubbish collections services that tender for fixed route tasks on an annual basis. Examples of operational use of CVRSS include
standard route type businesses such as beer delivery where routing could occur on a daily basis.

Recent work on “Whole of Supply Chain” approaches has recognised that there is an integral link between inventory and transportation routing. In particular Custodio and Olivira (2007) highlight the link between efficient transport routes and reduced levels of inventory.

### 2.4 Statistical Analysis of the Australian Transport Industry

To put the value of transportation into perspective within Australia it is worth considering the significant impact it has on the Gross Domestic Product (GDP) of Australia. Similarly, the transport industry has the following key impact on the larger Australian Economy. Statistical data available for the analysis of transport within Australia, particularly in the study period was exceptionally disparate. The main purpose for inclusion of this data was to paint a broad picture of the transport industry rather than its relevance to CVRSS or companies that adopt it.

Placed in context however the uptake of CVRSS in Australia will be limited to that segment of the industry where CVRSS is of use, namely non line haul (inter and intrastate and operations.)
Transport specific businesses contributed 5.3% or $31 billion to GDP in 1998–99. (Excludes transport activity performed by other businesses.)

- The “for hire” transport sector provided 454,000 jobs, or 4.6% of total employment in 2004-05 (excluding Internal retail, mining, defence, postal and agricultural logistics and their respective industries). The for hire transport sector includes freight forwarders and fleet operators that utilise both contract and subcontract transport operators.
- 2,343,894 tonnes of freight are transported around Australia each year.
- 610,925 tonnes of freight are exported from Australia each year.

*Figure 2: BTRE Industry Structure (BTRE, 2004)*
• Australians drive an estimated 199 billion kilometres each year (BTRE, 2006).

Further, the Bureau of Transport Economics provides the following road-transport specific data to demonstrate its significance to the economy:

<table>
<thead>
<tr>
<th>Year</th>
<th>GDP Road ($ millions)</th>
<th>Transport and Storage % of GDP (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>94-95</td>
<td>7901</td>
<td>5.4%</td>
</tr>
<tr>
<td>95-96</td>
<td>8681</td>
<td>5.5%</td>
</tr>
<tr>
<td>96-97</td>
<td>8855</td>
<td>5.5%</td>
</tr>
<tr>
<td>97-98</td>
<td>9321</td>
<td>5.4%</td>
</tr>
<tr>
<td>98-99</td>
<td>9906</td>
<td>5.3%</td>
</tr>
<tr>
<td>99-00</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>00-01</td>
<td>10613</td>
<td>4.2</td>
</tr>
<tr>
<td>01-02</td>
<td>11262</td>
<td>4.2</td>
</tr>
<tr>
<td>02-03</td>
<td>12019</td>
<td>4.4</td>
</tr>
<tr>
<td>03-04</td>
<td>12845</td>
<td>4.4</td>
</tr>
<tr>
<td>04-05</td>
<td>13691</td>
<td>4.5</td>
</tr>
</tbody>
</table>

Table 1: Transport and storage GDP 1994-95 to 1998-99 (BTRE, 2006)

The link between GDP, the transport sector and CVRSS is significant. Any reductions in the cost of transport operations could theoretically impact upon a regional or national GDP. Therefore if the implementation of a CVRSS led to actual reductions in operational transport costs it could have an impact on GDP.

<table>
<thead>
<tr>
<th>Year</th>
<th>Total Employment Road ('000)</th>
<th>Total Employment all Industries ('000)</th>
<th>Total Employment Road/Total Employment all Industries (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>94-95</td>
<td>186</td>
<td>8219</td>
<td>2.2%</td>
</tr>
<tr>
<td>95-96</td>
<td>186</td>
<td>8311</td>
<td>2.2%</td>
</tr>
<tr>
<td>96-97</td>
<td>196</td>
<td>8306</td>
<td>2.3%</td>
</tr>
<tr>
<td>97-98</td>
<td>193</td>
<td>8537</td>
<td>2.2%</td>
</tr>
<tr>
<td>98-99</td>
<td>208</td>
<td>8732</td>
<td>2.3%</td>
</tr>
<tr>
<td>99-00</td>
<td>NA</td>
<td>9057</td>
<td>NA</td>
</tr>
<tr>
<td>00-01</td>
<td>213</td>
<td>9168</td>
<td>2.3%</td>
</tr>
<tr>
<td>01-02</td>
<td>221</td>
<td>9395</td>
<td>2.4%</td>
</tr>
<tr>
<td>02-03</td>
<td>218</td>
<td>9560</td>
<td>2.4%</td>
</tr>
<tr>
<td>03-04</td>
<td>231</td>
<td>9845</td>
<td>2.1%</td>
</tr>
<tr>
<td>04-05</td>
<td>215</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 2: Employment levels (Road) (BTRE, 2006)

Total domestic Freight and Passenger tasks 2003-2004

<table>
<thead>
<tr>
<th>Year</th>
<th>Tonnes Carried</th>
<th>Travalled Kilometres (TKm)</th>
<th>Average Distance (Km)</th>
<th>Passengers Carried</th>
<th>Tonnes carried Road/All Tonnes Carried (%)</th>
<th>TKm/Total of all TKm (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1,696,000</td>
<td>157,668</td>
<td>93</td>
<td>N/A</td>
<td>71.46%</td>
<td>34.65%</td>
</tr>
</tbody>
</table>

Table 3: Total domestic freight and passenger tasks: 2003-2004 (BTRE, 2006)

* 1998-99 Figures- 2004-2005 are not available
Table 4 is significant in that it highlights the significance of “Freight Vehicles” (Light commercials, Freight Trucks and Other Trucks) in all totals including the total number of vehicles and the total kilometres travelled. CVRSS are claimed by their various vendors to impact upon the total distance travelled by companies that adopt them.

Hassall (2006) has sought to provide a detailed analysis of the Australian Transport Industry. A selection of his data is provided in Tables 5 and 6. As can be seen the industry is very diverse and is intertwined with other sectors of the economy in a very complex manner.

Table 5: Fleet Structure (Hassall, 2006)

Recent data collected by the Bureau of Infrastructure and Regional Economics indicate a number of key changes in the “freight task”.

<table>
<thead>
<tr>
<th>Industry Segment</th>
<th>Numbers of Vehicles in Fleet</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Transport Hire and Reward</td>
<td>21,762</td>
</tr>
<tr>
<td>Agriculture Fishing and Forestry</td>
<td>93,389</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>6,514</td>
</tr>
<tr>
<td>Building and Construction</td>
<td>13,069</td>
</tr>
<tr>
<td>Wholesale and Retail</td>
<td>16,419</td>
</tr>
<tr>
<td>Electricity, Gas, Water &amp; Communications</td>
<td>82</td>
</tr>
<tr>
<td>Totals</td>
<td>156,486</td>
</tr>
</tbody>
</table>
Critical to this is the increase in billion tonne KM per Rigid Truck and Articulated Truck from the period 1989-90 financial year to 2006-07 financial year. Both of these vehicle types anecdotally are within the “target market” for CVRSS vendors.

The statistics demonstrate that the Australian economy relies heavily on the transport sector to supply a key component of GDP to the overall economy. Despite the statistical analysis the industry is not this homogenous. As defined earlier the national transport fleet operates at a number of different levels. This includes regional national and even metropolitan levels. This is an important consideration in assessing the ABS figures.

### Table 6: Total Road Freight, by Vehicle Type (TT 4.5)

<table>
<thead>
<tr>
<th>Year</th>
<th>Light Commercial Vehicles</th>
<th>% Change</th>
<th>Rigid Trucks</th>
<th>% Change</th>
<th>Articulated trucks</th>
<th>% Change</th>
<th>Total</th>
<th>% Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>1989–90</td>
<td>3.8</td>
<td>0</td>
<td>20</td>
<td>0</td>
<td>57.8</td>
<td>0</td>
<td>81.6</td>
<td>0</td>
</tr>
<tr>
<td>1990–91</td>
<td>4</td>
<td>0.2</td>
<td>20.8</td>
<td>0.8</td>
<td>58.7</td>
<td>0.9</td>
<td>83.5</td>
<td>1.9</td>
</tr>
<tr>
<td>1991–92</td>
<td>4.2</td>
<td>0.2</td>
<td>21.1</td>
<td>0.3</td>
<td>64.3</td>
<td>5.6</td>
<td>89.6</td>
<td>6.1</td>
</tr>
<tr>
<td>1992–93</td>
<td>4.3</td>
<td>0.1</td>
<td>21.4</td>
<td>0.3</td>
<td>69.9</td>
<td>5.6</td>
<td>95.6</td>
<td>6</td>
</tr>
<tr>
<td>1993–94</td>
<td>4.4</td>
<td>0.1</td>
<td>21.7</td>
<td>0.3</td>
<td>75.5</td>
<td>5.6</td>
<td>101.6</td>
<td>6</td>
</tr>
<tr>
<td>1994–95</td>
<td>4.5</td>
<td>0.1</td>
<td>22</td>
<td>0.3</td>
<td>81.2</td>
<td>5.7</td>
<td>107.7</td>
<td>6.1</td>
</tr>
<tr>
<td>1995–96</td>
<td>4.6</td>
<td>0.1</td>
<td>22.4</td>
<td>0.4</td>
<td>86.2</td>
<td>5</td>
<td>113.2</td>
<td>5.5</td>
</tr>
<tr>
<td>1996–97</td>
<td>4.7</td>
<td>0.1</td>
<td>22.9</td>
<td>0.5</td>
<td>91.2</td>
<td>5</td>
<td>118.7</td>
<td>5.5</td>
</tr>
<tr>
<td>1997–98</td>
<td>4.7</td>
<td>0</td>
<td>23.4</td>
<td>0.5</td>
<td>96.2</td>
<td>5</td>
<td>124.3</td>
<td>5.6</td>
</tr>
<tr>
<td>1998–99</td>
<td>5</td>
<td>0.3</td>
<td>24.3</td>
<td>0.9</td>
<td>101.3</td>
<td>5.1</td>
<td>130.7</td>
<td>6.4</td>
</tr>
<tr>
<td>1999–00</td>
<td>5.3</td>
<td>0.3</td>
<td>25.6</td>
<td>1.3</td>
<td>104.3</td>
<td>3</td>
<td>135.2</td>
<td>4.5</td>
</tr>
<tr>
<td>2000–01</td>
<td>5.6</td>
<td>0.3</td>
<td>26.4</td>
<td>0.8</td>
<td>107.4</td>
<td>3.1</td>
<td>139.4</td>
<td>4.2</td>
</tr>
<tr>
<td>2001–02</td>
<td>5.9</td>
<td>0.3</td>
<td>27.3</td>
<td>0.9</td>
<td>112.9</td>
<td>5.5</td>
<td>146.2</td>
<td>6.8</td>
</tr>
<tr>
<td>2002–03</td>
<td>6.3</td>
<td>0.4</td>
<td>28.5</td>
<td>1.2</td>
<td>116.5</td>
<td>3.6</td>
<td>151.2</td>
<td>5</td>
</tr>
<tr>
<td>2003–04</td>
<td>6.6</td>
<td>0.3</td>
<td>29.6</td>
<td>1.1</td>
<td>120.8</td>
<td>4.3</td>
<td>157</td>
<td>5.8</td>
</tr>
<tr>
<td>2004–05</td>
<td>6.8</td>
<td>0.2</td>
<td>31</td>
<td>1.4</td>
<td>128.7</td>
<td>7.9</td>
<td>166.5</td>
<td>9.5</td>
</tr>
<tr>
<td>2005–06</td>
<td>7.1</td>
<td>0.3</td>
<td>32.5</td>
<td>1.5</td>
<td>133.8</td>
<td>5.1</td>
<td>173.3</td>
<td>6.8</td>
</tr>
<tr>
<td>2006–07</td>
<td>7.4</td>
<td>0.3</td>
<td>34</td>
<td>1.5</td>
<td>140.9</td>
<td>7.1</td>
<td>182.2</td>
<td>8.9</td>
</tr>
<tr>
<td>Avarage Change</td>
<td></td>
<td>0.20</td>
<td></td>
<td>0.78</td>
<td></td>
<td>4.62</td>
<td></td>
<td>5.59</td>
</tr>
</tbody>
</table>
Comparative mile evaluations in the United States indicate the following kilometre/mile conversion:

<table>
<thead>
<tr>
<th></th>
<th>2004</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total US Vehicle miles</td>
<td>2,962,513 (4,767,702.52 Kilometres)</td>
</tr>
</tbody>
</table>

*Table 7: US Vehicle Miles (Federal Highway Administration, 2004)*

There is a considerable difference between total kilometres travelled in the US and Australia. However, given the relative size of the population and economies of the two countries the size and complexity of the Australian industry is quite remarkable. Any technological development that can improve efficiency and reduce costs in such a large sector of the economy is of great significance. Hence research into the uptake of one example of such technology CVRSS is clearly of value.

### 2.5 Commercial CVRSS History

Having identified the importance of the transport sector to all modern economies and specifically the role it plays in the Australian economy, it is worth exploring the history of CVRSS in general so as to understand the potential impact that new technological developments can have.

The CVRSS had its initial heyday in the 1950's with IBM developing what was called the Vehicle Scheduling Problem (VSP) System. The results of this were somewhat disappointing and the project was extended to the Vehicle Scheduling Problem Extended (VSPX). Again the results were disappointing (Williams, 2000).

The VSPX was implemented in a number of companies including the Warner Lambert Company in Ireland. Nolan and Campbell (1978) defined the system as having two
components, which consisted of a Network analysis tool and a Schedule production output. Network analysis was the calculation of true distance (a physical route) versus a co-ordinate (a point on a map) and the use of a factorial, which was used to calculate route distance. The factorial was based upon the number of geographic impediments or congested regions that were encountered in a straight-line distance. This was limited to 40 geographic barriers and 10 congested areas per route. According to Nolan et al. (1978), the results were disappointing with a marginal decrease in cost and a significant increase in customer service. The overall disappointment was based upon a number of factors including poor computational power and high software costs (Nolan and Campbell, 1978).

During the 1970's and early 1980's systems were developed which were mainframe based and were written in such languages as FORTRAN. Uptake of these systems in Australia was limited to large multinationals that had the backing of an overseas parent company as local companies were unwilling to try an untested technology, especially one that required an expensive mainframe computer. The advent of the "minicomputer" or PC in the late 1980's and the development of MS DOS based programs allowed for the mass implementation of CVRSS in those businesses which had until that point chosen to wait. These systems consisted of both Australian based products and those that were imported from overseas (Williams, 2000).

The early to mid 1990's saw the implementation of on-screen mapping and the introduction of Raster-based maps. These maps differ to Vector based maps in the way they plot a position. Vector maps use mathematical co-ordinates to identify a
location whilst Raster based maps use a representation of the vectors that make up the map. The introduction of this initiative allowed users to see the location of delivery sites, depots and geographic impediments such as rivers, etc. (Williams, 2000). Raster and Vector based maps have become very common in a range of applications. Geographic Information Systems (GIS) are the tools used to manage the spatial information utilised in many of these applications. Lang (1999) states that all transport modes utilise geographic information and therefore would benefit from the use of a GIS (Lang, 1999). Indeed modern CVRSS (including hand held personal GPS systems) operate by utilising the information within a GIS. The spatial nature of a GIS is integral to the effective operation of a CVRSS.

Taylor *et.al.* (2000) point out that not only is GIS important to transportation but also plays a role in many larger societal issues including traffic engineering and the social sciences. Further, Taylor *et.al. (2000)* identify a link between GIS and CVRSS by stating:

*GIS packages have the capability to link different databases, where these refer to the same region (i.e. there are common attributes between the databases from the locational information that they contain). This is normally done by introducing a series of data layers in the GIS analysis, each layer referring to a different database.*

In the late 1990’s to early 2000’s companies began experimenting with internet-based applications. Companies such as Smarttrans in Australia have developed web-based applications that take the place of desktop systems (www.smarttrans.com.au, 2002). These systems rely on input from external, remote systems and or manual input. The method of output at this time was limited by the devices capable of receiving the data.
Further, the real time feedback from the “road” to the system is limited and therefore a potential constraint on this type of systems commercial effectiveness. This technology has yet to be proved and the question remains as to its long-term viability and its ability to compete against more advanced server and desktop-based systems.

In investigating the uptake of CVRSS an interviewed was conducted with a Principal from Oracle. The discussion identified that the uptake of CVRSS is <5% of companies that would benefit but could be as high as 10%. They also believe that with the advent of online shopping that this number would grow and indeed the question would be better if it related to “who should” take up CVRSS given that part of their market for CVRSS now related to service type organisations like power supply companies.

The advent of cheaper and readily available computing power added considerably to the ability of CVRSS to manage complex transport tasks. Many major transport companies and third party transport providers have now adopted these tools at an enterprise level. Examples include Toll Transport (multiple business units tendering to adopt the same package) and Patrick Automotive. While information on the sales of commercial CVRSS is not collected in any formalised manner, anecdotally vendors state that business is “good”. However, very little is understood about the reasons why individual companies actually adopt this technology.

A review of the commercial literature suggests that these reasons primarily revolve around cost savings in various forms (reduced labour costs, reduced travel costs, etc).
In the absence of any contrary evidence, the current research adopts the following hypothesis as it seeks to determine the veracity of this claim:

**H1:** *Companies that install a commercially available Vehicle Routing and Scheduling software packages do so to attain savings in their transport operation.*

### 2.6 Technical Review

In looking at the acceptance and effectiveness of CVRSS in the transport industry one cannot avoid exploring the mathematical theory behind today’s modern systems. This section covers in depth the technical elements associated how a CVRSS operates. It is provided as a background and is not referenced elsewhere within the paper. VRP deals with the real world problems of a given set of customers, vehicles with a known or limited capacity and associated with a depot, the objective being to create a set of routes with a minimal length (Bramel and Simchi-Levi, 1997). Indeed the process that many software systems utilise is based upon the allocation of a fixed number of resources to a known or semi-defined number of deliveries. Constraints including vehicle size, driver hours, delivery hours and geographical limitations such as one way streets are considered. Further solutions to the “problem” may in fact never be complete with constant reprocessing resulting and a better solution to the previous solution rather than a “final and correct solution”. Regardless the systems in general work in a similar way; deliveries, delivery times, vehicle and delivery constraints all balanced against a “solution” (Woodford, personal communication, December 21, 2012).
Bramel and Simchi-Levi (1997) however break the VRP into a number of sub problems. These include the Capacitated VRP with Equal Demands, the Capacitated VRP with Unequal Demands and the VRP with Time Window Constraints.

The current technical literature on VRP is very much linked to an area of mathematics known as Metaheuristics. Many authors provide a definition of metaheuristics in the literature however, none is clearer than Thompson (2000). As he explains, *heuristics will find a good solution to the problem with a minimalisation of computing time however this may not be the exact solution* (Thompson, 2000). Within the metaheuristics field, a number of different algorithms exist. Amongst others, Gendreau *et al.* (1999) is able to define several heuristic techniques including Simulated Annealing, Tabu Search, Genetic Algorithms and Artificial Neural Networks (Gendreau, Guertin and Potvin, 1999). However, Thompson (2000) is best able to illustrate a number of applications where metaheuristics are engaged to solve the Travelling Salesman Problem (TSP).

A related algorithm known as the Nearest Neighbour Random (NNR) is used to calculate a “set” of costs to a “set” of “fringe customers” which have as yet not been visited (Thompson, 2000). The failure of this algorithm to produce a viable solution is because it has no memory of past iterations and therefore could keep producing the same outcome. Genetic Algorithms on the other hand offer, as the name suggests, a series of evolutionary calculations. Thompson (2000) defines the process of calculation as maintaining a set of solutions from which the next set of solutions is produced using a number of operators. Selection of the next generation is based upon the fitness of
the solution according to the operators in place guiding the solution (Thompson, 2000).

The effectiveness of this algorithm has only recently been tested, on both the TSP and VRP. Tabu Search is a recent addition to the modern methods of solving the TSP. This method involves the searching of the current “neighbourhood” of solutions with selection of the next set of solutions based upon moves which are Tabu. As the calculations occur the set of operators are changed based upon the evolving Tabu list. This occurs until the stopping criterion is achieved (Thompson, 2000).

The final algorithms considered to be part of the modern era and assessed by Thompson (2000) is that of Simulated Annealing. This algorithm is based upon the theory of metal cooling in a liquid with the solution not becoming involved within its own neighbourhood but rather allowing it to look at an adjacent neighbourhood, which may have a higher optimal solution (Thompson, 2000).

Bramel and Simchi-Levi (1997) present a number of different but more general types of algorithm, in particular those suited to solving the TSP. Specifically three types of algorithms can be defined. The Minimum Spanning Tree Based Heuristic, a Nearest Insertion Heuristic and The Christofides Heuristics (Bramel and Simchi-Levi, 1997). The Minimum Spanning Tree-based Heuristic works on the basis that in the first instance a “depth first search” is performed which produces a solution, but not the optimum solution. All iterations from this point are based upon working towards the best final solution via small changes to the intermediate solutions.
Bramel et al. (1997) believe that the Nearest Insertion Heuristic is a viable solution to the problems suffered by the nearest neighbour algorithm (NNR) defined by Thompson (2000). They believe that the “Greedy” nature of the NNR algorithm has no bounded worst case performance and its use of arcs as a means of connecting vertices can lead to longer arcs towards the end of the calculation. The best definition of a Worst Case Performance Analysis is that it is the greatest distance generated between the worst case and the actual solution (Bramel and Simchi-Levi, 1997). As defined, the Nearest Insertion Heuristic inserts a new vertex between two vertices which are part of the standard Hamiltonian Cycle. The Christofides Heuristic similarly starts with a minimum tree length but uses Eulerian Tours to traverse the bounds of a graph only once. An Eulerian path in a graph is a path that travels along every edge of the graph exactly once. An Eulerian path might pass through individual vertices of the graph more than
once. An Eulerian path which begins and ends in the same place is called an Eulerian circuit or an Eulerian cycle (www.c3.lanl.gov, 2002).

The analysis of the TSP differs somewhat to the VRP in terms of the problems that the modern routing and scheduling algorithm attempts to solve. Bramel et al. (1997) define several scenarios for the solving of the VRP problem including the VRP with Equal Demands, the VRP with Unequal Demands and the VRP with Time Constraints (Bramel and Simchi-Levi, 1997). Bramel is able to define both VPR and the TSP in terms of a heuristic, which is able to partition itself to individual regions. However, they are at length to point out that recent research indicated that tying the regions to a Euclidian plain is pointless unless the Euclidian plain is geographically based. The research on regional heuristics, as defined by Hamovich and Rinnooy Kan (1985) defines 3 major types:

- Rectangular Regional Partitioning (RRP);
- Polar Region Partitioning (PRP); and
- Circular Region Partitioning (CRP).

Defined as the Capacitated VRP with Unequal Demands (UCVRP) it can be split into four separate heuristics:

- Constructive methods;
- Route First-Cluster Second Methods;
- Cluster First-Route Second Method; and
- Incomplete Optimisation Method.
The Route First-Cluster Second Method takes the standard TSP and incorporates it into the creation of a partitioned route and schedule which satisfies all the demands of the customer with no regard to demand. Bramel and Simchi-Levi, (1997) defines this heuristic in a more precise form:

A heuristic is Rout First-Cluster Second heuristic if it first orders the customer according to their location, disregarding demand size, and then partitions this ordering to produce feasible clusters. These clusters consist of sets of customers that are consecutive in the initial order. Customers are then routed within their specific cluster according to the heuristic within the cluster.

Again within this group of UCVRP there are several variations to the algorithm used within the cluster including the Optimal Partitioning Heuristic and the Sweep Algorithm (Bramel and Simchi-Levi, 1997). The Cluster First-Route Second Method is considered to be technically advanced with the clustering calculation occurring first and the routing second. Mathematically advanced programming takes the customers and creates clusters which can be serviced by one vehicle followed by the routing of that vehicle to service the customer. As stated, this method is considered to be technically advanced and includes heuristics such as:

- The Two Phase Method;
- The Generalized Assignment Heuristic; and
- The Location-Based Heuristic.

The last of the methods used in the UCVRP is that of the Incomplete Optimisation Method. This method is defined as computationally restrictive and therefore is generally terminated prematurely. Examples of this method include the following heuristics:

- Cutting Plane Method; and
• Minimum K-Tree Method.

Pre-dating all of these methods is the constructive method is also known as the Savings Algorithm. The best known and the simplest of this form of heuristics is the Clarke Wright Algorithm. The Clarke Wright Algorithm is recognised as the earliest of this class of algorithm and was included in many of the earliest commercial CVRSS. The saving formula can be written as follows: \(2 \sum_{i=1}^{n} d_i\)

![Figure 4: The Clarke Wright Algorithm. (Ballou, 1999)](image)

The VRP with Time Window Constraints (VRPTW) is a common problem in the commercial world. As defined, it is a constraint that is placed upon a delivery, which includes not only a quantity but also the time at which it is to be delivered at the same time optimising the route for that vehicle. Clearly, this problem is the most studied within the literature and many operational articles are directed to assessing and
qualifying various algorithms. As far back as 1984, Solomon (1986) explored The Vehicle Routing and Scheduling Problem with Time Window Constraints (VRSPTW). He was able to define the problem as a VRP with both temporal and spatial aspects (Solomon 1986) and also defined the two basic methods at that point that appeared to be precursors to any later work. The problem can be broken into two basic solution types, viz., that of the sequential solution and the parallel solution. Solomon (1986) believed that the parallel type solution showed the greatest potential. As defined, the parallel solution allowed for a number of routes to be constructed simultaneously (Solomon, 1986). Yvan et.al. (1990) defines a generalised version of the problem known as The Pickup and Delivery Problem with Time Windows (PDPTW) but agrees that the VRPTW is the accepted terminology. While Yvan et.al. (1990) go into great detail to define an optimal solution via a complex algorithm they are able to define yet another variation to the VRPTW, that of The Dial a Ride Problem (DARP). Simply put Yvan et.al. (1990) defines it as the TSP with constraints.

Jaw et.al. (1986) also define the DARP problem but do so in terms of what they call the Advanced Dial a Ride with Time Windows (ADARTW). This problem defines the dial a ride TSP and presents a possible solution to it. Specifically they define the problem as a many to many solution in that a vehicle can have one customer with many destinations. Further, the problem is constrained by quality of service issues which specify that “ride times” will not exceed a predetermined limit and that the specified pick up or delivery times are not exceeded by a pre-constrained limit (Jaw et al., 1986).
In a general overview of the VRP Laporte (1992) defines the VRP in terms of the constraints that are placed upon it. He defines two clear constraints within his article on the VRP, viz., the VRP which is capacity constrained (CVRP) and the distance constrained VRP (DVRP). The DVRP is considered to be a temporal restriction based upon total time. Laporte (1992) also defines the nature of exact algorithms which include the following:

- direct tree search method;
- dynamic programming; and
- integer linear programming

Laporte (1992) is also able to define the Clarke Wright algorithm from 1964, the Sweep algorithm, the Christofides-Mingozzi-Toth phase algorithm and the TABU search algorithm. However as they are defined as heuristics and not lower bound and branch bound techniques they were not within the scope of his research (Laporte, 1992).

In 1986 Baker, et.al. (1986) looked at the future and defined what they believed would be the direction of VRSPTW. In their article ‘Solution Improvement Heuristics for the Vehicle Routing and Scheduling Problem with Time Window Constraints’, they define two key areas that the VRSPTW could be used fully. These areas specifically include the VRP, which will require verification for payment and vehicles carrying a time dependent inventory (Baker and Schaffer, 1986).

In a more recent work on the VRP Kilby et.al. (1997) define it in terms of a number of constraints. These additional constraints include capacity, type, vehicle dimensions,
vehicle route length (due to fuel constraints) and a limit on the route time (hours that
can be worked) (Kilby, Prosser and Shaw, 1997). Chwen-Tzeng Su (1999) from the
University of Technology in Taiwan adds further complexity to the problem when he
defines the standard VRP with constraints of late penalties and loading, but with the use
of the Multi-Depot Model. He claims that this model allows for a more complete
solution. However this is set off against the relatively high computational costs
associated with such a solution. In defining the problem, Chwen-Tzeng Su (1999) is
able to relate the VRP to the modern commercial environment where a multiple depot
environment is the norm and vehicles operate from one or all of the depots within a
given region. Control of these vehicles can occur from a central location or indeed
anywhere within the Value Added Network (VAN). Similarly, orders can come randomly
from disparate centres with varying due dates and generation times (Chwen-Tzeng
Su, 1999).

Taking a slightly different perspective Horn et.al. (2000) defines the problem in terms of
the Australian environment and Taxi fleet performance. Using a software tool known as
LITRES-2 he manages demand information from a demand generation module. The
scheduling constraints include:

- time ordered pickup and set-down points;
- shift changeovers; and
- vehicle trajectories in time and space.

Horn et.al. (2000) were able to conclude a number of points which favoured the
use of an optimised model to remove inefficiencies from the taxi industry. The
findings were defined as: for much of the time a taxi fleet is larger than it actually needs to meet demand;
- service levels for customers will decline as demand increases and
- the size of a taxi fleet is measured by peak demand therefore as peak demand is only reached on occasion then much of the fleet will remain idle.

Recent areas of research include methods such as ant colony optimisation, mixed integer programming and constraint programming. Each of these areas offers an incremental improvement of solution generation.
- Ant colony optimisation - utilises the foraging techniques associated with ants and other foraging animals. This type of optimisation utilises ants using pheromones to highlight a path or route to other members of the colony.
- Mixed integer and constraint programming - This area of research utilises the marginal and or incremental cost of completing a particular task. This area of research is particularly valid in areas within the supply chain related to production planning (Dorigo and Blum, 2005).

Nagy and Sahli (2006) were able to distil what they defined as the “Location Routing Problem” (LRP) with special attention to vehicle routing problem into a chronological order. It can be thought of as a set of problems within location theory ...however they preferred to treat LRP as an approach to modelling and solving locational problems. Table 8 outlines the history of the “problem as Nagy and Sahil (2006) were able to define it.
Kritikos and Ioannou (2009) take the VRP with time window to another level arguing that current VPR solutions only deal with approximately 100 Orders. They argue that a better approach is to define the problem in a different way. The problem they argue is better defined as: “balanced cargo vehicle routing problem with time windows (BCVRPTW).”

Kritikos and Ioannou’s (2009) approach takes three steps, some of which are common to the VRP with time windows:

1. The cost of the vehicle whilst is engaged in a route (in between leaving and returning to a depot);
2. the set-up of a vehicle including the acquisition cost; and
3. the contribution of the “load imbalance” to the solution for the problem.
Others including Marinakis and Marinaki (2008) have adopted a different approach choosing to investigate the application of Bilevel Genetic Algorithms in solving the Location Routing Problem. They argue that the current problems and solutions ignore key “real world elements” such as:

- How many Facilities;
- where the facilities should be;
- what depot to assign to which customer;
- which customers to be assigned to which routes; and;
- what order customers should be served in.)

Given the importance placed on optimization by software developers, the question of whether this is understood by those involved in their adoption and use is a significant issue that needs to be addressed as part of the current research. In the absence of any contrary evidence, the following hypothesis was adopted:

**H2:** Commercial organisations understand the relevance of the term “optimisation” in the mathematical sense rather than the commercial context CVRSS vendors use and understand the part it plays in selection of CVRSS.

### 2.7 Commercial Implications

In an earlier published work on VR and VRS Eibl et al. (1994) analysed the VRP in terms of the specific impact on the commercial world. Working on the Northern British Brewing Industry Eibl et al. (1994) were able to distinguish the impact of an effective CVRSS on the logistics process within a business.
More recent literature highlights an acceptance of the Vehicle Routing Problem (VRP) as a generic and operational problem that has impacts in a range of sectors within the transport industry. Indeed Goel and Gruhn (2008) studied the air freight industry in Europe and were able to define a more specific problem defined as “The General Vehicle Routing Problem (GVRP)”. This work concentrated on the real world problems associated with multiple vehicles working from multiple depots and dealing with pickup and delivery “problems. (Goel and Gruhn, 2008)

It is in this area that the remainder of this literature review will concentrate. This review will focus on the role of commercially available software on a range of businesses in relation to the impact that it has had in reducing the costs of the transport
operation. In particular it will attempt to clarify the exact nature of the savings claimed.

Figure 5: The Benefits of Adopting a CVRSS (Department for Transport, 2006)

To do this it is appropriate to assess the published offering of a cross section of commercially available CVRSS software products. Information on all software products was obtained via the World Wide Web and is therefore considered by the author to be in the public domain. Where claims by software vendors are made directly about savings to potential purchasers this will be acknowledged. However, if the claims are
made via a testimonial from a client then this will also be acknowledged and considered indicative of savings achieved by the implementation of the software.

A total of thirty-one published offerings were assessed (Appendix 1). These offerings were viewed via the internet and via traditionally published brochures. In a general sense, the offer of each vendor was simply assessed based upon the savings that were claimed as part of the implementation of the specified package. In a more specific sense, the claims were assessed based upon whether it was made as a direct claim by the vendor or if it was done as part of a published case study attached to the web site/brochure. In very general terms, these savings were claimed in the areas of increased vehicle utilisation, fleet reduction, minimised road time and distance, decreased fuel usage and reductions in administrative costs.

With the exception of three, all software products were developed in the United States, Europe or the United Kingdom. Of the two that were developed in Australia one ostensibly relied on technology developed in the United States. Of all CVRSS products available in the Australian market place, only one Australian developed product (Transit Computer Systems) claimed high levels of cost savings. Products such as LITRE2, Trapeze and Raptour were considered commercially young and not included in the research. Other well-known products such as Sidewinder Real Time Optimisation and Smart Trans (both Australian developed) did not state savings nor offer a high level of information on their products at the time of the investigation.

Work completed by Hollis, Forbes and Douglas (2005) on Vehicle routing and crew scheduling for metropolitan mail distribution at Australia Post comes close to creating a
commercial context for VRP. Indeed the Limited Depots Approach (LDA) was able to define a potential solution to the vehicle routing problem as well as the crewing scheduling problems and the multiple depot problem. These solutions whilst developed essentially for a mail delivery business (Australia Post) demonstrate that saving could indeed be generated. CVRSS vendors talk about these saving as “direct saving”. (Hollis, Forbes and Douglas, 2005)

These direct savings as stated by CVRSS vendors could be categorised into a number of general areas. These included:

- Improved customer service;
- Direct cost savings;
- Productivity improvements;
- Reduction in mileage (UK and US);
- Reduction in hours; and
- Reduction in vehicles required.

Some providers such as Descartes Systems offered similar saving scenarios. However, due to the increased breadth of the system it extended its saving to areas such as inventory reductions. Similarly, the product known as TruckStops offered by Micro-analytics not only claimed that it can produce savings but that it routinely offers results 3-10% better than competing products. Companies such as InterGis offered savings in areas such as matching the right driver to the right run and the matching of customer requirements to resources. In the same vein as Micro-analytics, Stratagen Systems claims that it will not only save money but that it is 15% better at producing more efficient routes than its competitors.
Much of the information that was contained in these documents could be considered marketing hyperbole. However, this could still have an effect on the decision to adopt CVRSS. Given that the focus of this thesis is to understand why some companies have adopted this new technology, the nature of the savings is particularly important. If the claims made by the proponents are all cost related (whether backed by empirical evidence or not), then were only cost benefits important drivers in the decision? In order to address this issue systematically the following hypothesis was established.

**H3:** The benefits companies achieve from the installation of CVRSS are all cost related.

### 2.8 Human Factors

The human factors associated with this research fall into two main categories, *viz.* human factors associated with completing surveys and human factors associated with the adoption of CVRSS. The human factors associated with completing surveys will be covered in Chapter 5. Those associated with the adoption of CVRSS are covered here.

Any discussion on the adoption or uptake of CVRSS needs to include the factors associated with human acceptance of the systems. With CVRSS this can occur at a number of levels. These include the people that complete the routing and scheduling, (that is those who take an order from a customer and turn it into a pickup or drop off) and the vehicle drivers that are at the behest of the CVRSS.
The field of behavioural operations has outlined a number of behavioural and cognitive issues that can impede improvement. Gino et.al. (2005) states that the assumption that humans are rational beings and, therefore can become part of the improvement to operations should be challenged. This is largely due to their ability to learn and process information (Gino and Pisano, 2005).

This element has been well recognised in the work by Eibl (1994), albeit without reference to behavioural operations. Specifically Eibl (1996) refers to the development of individual worker’s conviction to the process and the development of this conviction at all levels within the user group. Eibl (1996) extends this specifically to include drivers, stating that CVRSS only works well when drivers adopt the routes that have been proposed by the CVRSS.

Whilst not analysed in specific detail, a number of authors refer to the union issue associated with the adoption of CVRSS. More specifically, they refer to opposition to the adoption of CVRSS by organisations representing employees. Eibl (1996) refers to this in passing via the survey instrument he utilised when surveying. This would, however, seem to be a subset of driver adoption. Although no specific details were provided, a report in a national newspaper indicated that the adoption of CVSS in Victoria was challenged by the Transport Workers Union (TWU). With what is known of the case, the issue appeared to be related to the adoption of CVRSS in concert with GPS, which would identify the location of the vehicle at all times via the GPS network. Union representatives claimed that this was a breach of the Privacy Act and sought an injunction to halt the implementation.
No other information is available regarding this issue. In light of the limited work available, the following hypothesis was established to provide a focus for the research.

**H4:** *Companies adopting CVRSS will face some internal (from within the company) opposition to its introduction from either operational or driver staff.*

### 2.9 Conclusion

This chapter has looked at the literature available and its relevance to the research work undertaken. The review covered academic, commercial and other relevant information. In addition this chapter covered the academic areas associated with development of computerised vehicle routing and scheduling. This review was used to establish four Research Hypotheses that became the focus of the empirical research outlined below. It is to the design of this research that the next chapter turns.
3. Methodology

3.1 Introduction

This chapter seeks to outline and justify the research methodology used to address the research question and the associated hypotheses. In particular, it will outline the following aspects:

- The nature of the research design used;
- why a survey approach was used;
- source and type of subjects surveyed;
- the type and appropriateness of the research instrument;
- a chronological order of the study development including instrument appropriateness; and
- a description of the data analysis.

3.2 Research Design

A number of options were investigated when selecting the appropriateness of the research design. Of the competing methods, an extended case study was considered. Previous work such as that conducted by Eibl (1996) suggested that a case study could effectively provide suitable answer(s). Others have used surveys to take a broader perspective.

During the early stages of the design the question of utilising the CVRSS vendors as a source was considered. This however was discounted even though it would have been
a simpler research option. This was based by and large on the fact that the research 
question was related to why companies chose not to adopt a CVRSS as opposed to why 
the sales process for a CVRSS failed. Whilst this might seem to be a subtle difference it 
is clear that the two different approaches would have fundamentally yielded different 
results. For example a company may have rejected a CVRSS installation because the 
return on investment was not clear whilst the CVRSS vendor might see the same failed 
sale as a poor fit with the CVRSS product.

Much of the survey work completed on CVRSS or associated subject matters, is related 
to the measurement of existing optimisation models and the elements associated with 
them. This includes work by Cordeau et.al. (1998) that looked at a range of 
optimisation models associated with routing and scheduling of trains (Cordeau, 1998) 
or Qui et.al. (2002) who surveyed the performance of Automated Guided Vehicles 
(AGV) and the type and use of algorithms (Qiu et.al., 2002). The other work of note is 
Hall (2002, 2006) which compares many of the known commercial CVRSS on a range 
of levels. Whilst this work is good for comparison it is predominantly based upon 
United States’ CVRSS Packages with some European CVRSS. It has no reference to 
Australian based or developed products.

While case studies would have proved effective in outlining the experiences of a few 
companies, it was the view of the researcher that given the sparseness of information 
available in Australia a major survey covering many companies would prove helpful to 
the transport and logistics sector. With this in mind it was decided that a survey 
instrument capable of capturing this information should be adopted. However, to
compensate for the survey's potential lack of specific detail regarding the decision-making surrounding adoption it was decided to complement this with a focus group. This would provide an opportunity to delve more deeply into the process of adoption and the factors that affected it. The use of this mixed approach would achieve some of the advantages of an extended case study while at the same time provide the type of quantitative data required to address the research questions.

The next section of this chapter outlines the sampling design utilised while the following section focuses on the development of the survey instrument itself. As will be seen, two different delivery mechanisms were used to capture the target sample.

The work of Hall (2002) in combination with that completed by Eibl (1996) influenced the design of the survey instrument used. This instrument was delivered in both a paper-based and Hypertext Mark-up Language (html) version on a predefined website with respondents given the option to fill out either type. The two survey instruments were identical in all respects. The dual method of delivery was selected because it was considered to be the most convenient and appropriate method for industry representatives to respond to the questions asked. Bearing in mind the geographic distribution and complexity of the potential population, using an internet-based tool has obvious efficiency advantages. However, discussions with both supervisors and involved academics suggested that the use of only an internet-based survey could create unnecessary bias that potential respondents may have to one “type” or another. The use of both an internet-based instrument and paper-based instrument was
designed to remove any such bias. It also removed any potential bias created by the fact that at the time of the survey not all respondents had access to the internet.

Limitations of the internet based instrument included the amount of time and testing required to make it functional and the method of attracting respondents to complete the survey. Benefits of the method included instant data collection and allocation, the predefinition of queries and the capacity to monitor response rates. Limitations associated with the paper based survey included the costs and the time associated with the development and distribution of the instrument. Benefits included a more recognised method of responding and a clearer understanding of the overall purpose of the survey. Although discussed later, the results of the internet-based instrument proved to be richer than those of the paper-based survey.

The questions included on the instrument were both quantitative and qualitative. Quantitative questions were used to define the company type, turnover and other “framing” type information. Qualitative measures were used to identify the respondent’s view on a range of issues which involved opinion and non-quantifiable answers. The development of the instrument used is described in more detail in Section 3.4 below.
3.3 Sampling Design

The target population was considered to be all road transport companies in Victoria, Australia. However, companies with only one vehicle were excluded based upon:

- the researcher’s experience: this indicated that their place in the sector was generally limited to subcontract work for courier companies or similar;
- CVRSS Vendors view: that companies deploying less than 10 vehicles were not commercially viable from a CVRSS installation perspective; and
- Previous researchers findings including Eibl (1996) and Hall (2005).

To ensure a suitable sample from this population potential respondents were initially defined as members of Chartered Institute of Transport (CIT) now the Chartered Institute of Logistics and Transport (CILTA), an international body with representation in all states within Australia, and the Logistics Association of Australia (LAA) now the Supply Chain and Logistics Association of Australia (SCLAA) similarly represented in all states but with no recognised international affiliations. The target group within these respective populations was specifically those that participated in the road transport and distribution sectors. A sector is defined as a group of participants which may work on a common set of tasks or processes within different industries. For example, the transport industry, the food industry and the paper industry all operate, in part within the “Logistics and Transport” sector. This sector is variously recognised in Australia as the Transport and Logistics Sector (T and L) or the Transport, Distribution and Logistics Sector (TDL). The road transport sector was purposely targeted due to the specific nature of research questions. Both the CILTA and LAA represented the freight and
logistics sector with approximately 400 and 700 members respectively in Victoria. In February 2002 official letters were sent to both organisations requesting permission to utilise their membership databases. In both instances permission was granted.

The two respective groups represented a large section of the sector with high levels of exclusivity. Members of the CILTA came from a range of backgrounds including road, rail and air transportation as well as from the logistics sector. Members of the SCLAA similarly had a diverse range of backgrounds with membership including consultants, managers, logistics managers and transport professionals. Both organisations were member-based and operated as not-for-profit. Both offer a range of services to members including networking events, site tours, conferences and newsletters.

The CILTA (2004) mission is as follows:

“Providing leadership in research, policy and professional development and supporting continuous improvement in the Transport and Logistics Industry. Our aim is to raise the standard of performance in the industry.”

The SCLAA has a similar charter as reflected in the following:

“VISION: To serve and advance the Logistics and Supply Chain profession in Australia.
MISSION: To be the Australian professional organisation to which people associated with logistics and supply chain belong, by ensuring that we:
• Create value for members and stakeholders;
• develop the profession by facilitating the exchange of knowledge and experience;
• encourage, recognise and reward achievements and excellence within the profession and;
• collaborate responsibly with relevant organisations.” (LAA, 2004)
A range of privacy issues became evident following the initial agreement established with both associations. The Privacy Act, 1998 was amended in December 2001 to prohibit these types of associations from releasing data that could identify individual members (Privacy Act, 1998). Access to the survey sample became restricted as the amended Act meant that the researcher could not access the membership database directly. All access had to be “dumb” in that any communication with the potential sample group had to occur “en masse”. This creates problems with regard to identifying a specific target group.

This legislative change created a number of major sampling issues, including the need to ensure that there was only one respondent from each company and that members of both associations were not approached twice (that is, some could potentially be a member of both CIT and LAA). To avoid duplication it was necessary to capture only one individual from each company or to ensure that if two respondents from the same organisation did respond that they would be easily identified regardless of the respondents preferred response method.

During this period an additional complication arose as the CILTA went through a major structural change which included a name change to the Chartered Institute of Logistics and Transport (Australia) [CILTA]. As part of this change, those that granted permission to utilise the membership subsequently withdrew their permission. This necessitated an unexpected change in sampling design.
After discussion with both supervisors and respected researchers it was decided to select a different sample group from the same population. Although the sample group would come from the same sectors represented by the CILTA and the SCLAA, they would be accessed differently. The sample therefore became members of the transport and logistics sector selected from the Victorian “Yellow Pages”. The Yellow Pages is owned by Telstra, and entries are voluntary and open to all businesses. The service offered by the Yellow pages can be defined as follows:

Yellowpages.com.au is an Australian business directory with over 1.7 million business listings. You can search Yellowpages.com.au to find out about and contact these businesses. The site offers phone and fax numbers, addresses, product and services information, opening hours, payment methods, maps, links to websites and e-forms to help you find what you are looking for. (Telstra, 2004)

The “Yellow Pages©” was therefore used to identify the potential population of appropriate respondents. This proved to be a very reliable listing of all transport companies. All entries listed as “Transport Services” in the Victorian section were approached. However, given the limitation outlined above, respondents were screened initially by telephone to ensure that their company had more than one vehicle. A total of 426 entries were identified in July 2003 with phone contact made to all in order to assess their suitability and willingness to complete the survey as well as a contact name within the business to address all correspondence. This process proved very successful at removing companies that did not see the value of the research and therefore had no intention of filling out the survey or those that were inappropriate for the survey. These included individual companies that:

- had no vehicles;
- provided only a sales function; or
was only an office for a national business headquartered elsewhere.

Table 9 illustrates the characteristics of particular companies deemed inappropriate:

<table>
<thead>
<tr>
<th>Reason for Exclusion</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Had no vehicles</td>
<td>These businesses include freight brokers that did not own or control a fleet of vehicles.</td>
</tr>
<tr>
<td>Was a sales business</td>
<td>These businesses are sales based businesses that sell transport related products including vehicles and associated products</td>
</tr>
<tr>
<td>Was part of a national organization</td>
<td>These were organizations identified as either multinational or trans-national with decision making powers located in places other than the sample group e.g. Victoria. This was due to the sample set coming specifically from a Victorian base only.</td>
</tr>
</tbody>
</table>

Table 9: Reasons for Exclusion

A number of complexities were highlighted during this phase of the sampling process. These included:

- several companies with offices in Melbourne and transport fleets located in places other than Victoria;
- transport companies operating both “Metropolitan Fleets” and “Line Haul Fleets”; and
- transport companies exclusively designated as interstate or long-haul road businesses.

In order to help the subsequent analysis transport fleets were further defined into groups based upon their identified their purpose. These groups are defined in Table 10 below. This served to help remove bias towards a particular grouping. The research identified that there were very few “Own Fleet” companies that would have the scale or capacity to implement a CVRSS. On the other hand and “Third Party Provider would consider the adoption as “core business”.

<table>
<thead>
<tr>
<th>Transport Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Own Fleet</td>
<td>Transport fleets that are used for the purpose of providing transport related services for a company's own use.</td>
</tr>
</tbody>
</table>
| Third Party Provider (Combined)             | Transport fleets that are used for the
Within some large distribution organisations such as Toll, K and S and Linfox, a number of significant independent divisions were identified. With this in mind the initial requirement that survey participants from independent divisions operated autonomously when it came to the selection of software was changed to an assurance that there would be only one response from the identified division. Appropriate groups in this category were defined as fully owned operating divisions separate from other divisions headquartered in Victoria and operating separate transport (non-shared) fleets.

Utilising the Yellow Pages category of ‘Transport Services Group’ had an additional advantage. It allowed for the identification of a number of different transport types. The ability to categorise respondent companies by type provided a number of potential advantages in terms of analysis. For example, it could be that different transport company types may have different reasons for taking up the use of the CVRSS.

The first of these groups included those transport providers that serviced either their own requirements or manufacturing processes or “Own Fleet” transport providers. That is, businesses that would not necessarily be considered as transport providers in a third party sense but rather those that provided transport as part of their general

| Third Party Provider | Transport fleets that are used for the purpose of providing transport related services exclusively for third party or external companies and individuals. |

Table 10 : Transport Company Type
service offering. Examples of these types include manufacturers, retailers and wholesalers.

Another group identified included those companies engaged in transport for their own purposes (ie. as part of their normal business) as well as providing transport services to other third party customers.

The final group that was identified was the purely third party transport provider. This type of transport operator either provided full transport contract services for companies or completed transport transactions where the third party had insufficient volumes to warrant a transport fleet. Examples of full contract transport services included services provided to grocery chains or brewery businesses where transport services in the past had been provided “in house” and were now contracted out to a third party following some form of tender or negotiation process. Examples of the other type of third party provider (ie. those contracting out due to insufficient volumes) included small businesses that moved product on a regular or semi-regular basis to either intra or interstate destinations without sufficient scale to warrant deploying their own fleet.

On the basis of this analysis, the population size was defined as a possible 426 qualified respondent companies. With a confidence level of 90% and an error rate of 5% a sample of 80 respondents would be required to generate statistically valid results (Veal, 2005).
Aside from the demographic questions asked of the respondents when initial phone contact was made they were also asked if they would prefer to complete the survey in a web format (html) or paper based format. The answers were varied and indicated that it would be necessary to use both formats in order to ensure an adequate response rate.

The disadvantages of this sample identification process were all related to time and cost. The time associated with contacting and ensuring inclusion exceeded 4 months on a part time basis. The benefits however were considerable, including knowledge that the survey population met the fairly stringent qualification requirements, including the fact that all respondents were part of a group that did or could potentially utilise CVRSS software, and that the identified respondents were prepared to complete the survey. This highlighted the benefit of developing an independent survey population (through the Yellow Pages) as opposed to the use of a proprietary database population which had caveats attached. This would have been the case with both the CILTA and LAA membership data bases where direct contact, other than via a survey instrument and selection of appropriate respondents, was not permitted.

### 3.4 Research instrument

As previously stated, initially the survey instrument was designed purely as a web based tool with no supporting paper based instrument. However, this changed following advice from both supervisors and those experienced in survey design. The concern from a design perspective was that an html or web-based survey was naturally
biased towards those that had access to the internet. It was therefore decided that the survey instrument would exist in both a web-based html document and a paper based document. Further the feedback obtained during the sample screening process indicated that utilising both methods of delivery would ensure a good response rate. Additionally it would allow for the comparison of data and response rates between the two types.

Initially the tool was designed in a proprietary software product know as Microsoft FrontPage©. This product had interoperability between other well known software products including the Microsoft Office Suite. The original design phase lasted until July 2002 and covered a range of issues and research areas including traditional survey design as well as web survey design.

Following the initial design phase a range of technical issues arose to hinder further development. The most prominent of these was lack of support provided by a range of Internet Service Providers (ISP's) to the Microsoft FrontPage© product. Specifically Microsoft FrontPage© required the use of proprietary server extensions that enabled the collection of data as well as the reliable running of the product. Added to this was the disproportional size of the file that was generated using the Microsoft FrontPage© scripting tool.

In July 2002 a change was made to both the platform for the web based survey and the ISP. This caused a considerable disruption to the development process and effectively required the researcher to go back to the initial design phase. In this time a
web site was registered as the address for the future survey. The site was www.trc-survey.org. It was paid for by the researcher and was an abbreviation for Transport Research Centre a unit of RMIT University that offered some support during development.

<table>
<thead>
<tr>
<th>Country Codes</th>
<th>The html version allowed for a range of countries to be viewed and one selected. The paper based version required the respondent to fill out the country.</th>
</tr>
</thead>
<tbody>
<tr>
<td>ANZIC Codes</td>
<td>The html version allowed for the selection of one or more Australian and New Zealand Industry Codes (ANZIC). The paper based survey required the respondent to write the ANZIC code without a predefined list.</td>
</tr>
</tbody>
</table>

Table 11: Survey variation - paper based vs. html

As mentioned earlier the change of platform and ISP added to the development time. It also added considerably to the complexity of the undertaking and required the services of a website developer. This did, however, produce a testable product capable of demonstrating the capability of the survey instrument.

In parallel, the researcher developed the paper based equivalent of the web based survey. In many respects this was a simple task in that a copy of the web-based survey could be used as the paper based model. However some alterations were required. The differences therefore were centred upon the areas listed in Table 11.

The largest difference between the web based survey and its paper based equivalent was that the former provided the opportunity to channel respondents to specific sets of questions based upon the answers to key questions. In comparison, the paper based survey relied upon the ability of the respondent to follow detailed instructions to determine which areas of the survey to complete.
Design in Web surveys is of greater importance than in other modes of surveying because of the visual emphasis of the Web and the way the survey appears in different browsers and on different computer screens (Couper, 2000). Couper (2000) believed that the audience and the purpose of the survey should affect the design, and that the design of a Web-based survey for teenagers and one for seniors might be designed quite differently. "The notion of a one-size-fits-all approach to Web survey design is premature" [7]. Solomon (2001) noted that Web-based survey development is still in its early stages, and, since HTML forms have their own unique design concerns, it is yet to be seen how knowledge from other surveying techniques will be transferred to this new mode of surveying (Gunn, 2006).

A major difference between the HTML and paper-based instrument was the speed with which a respondent could complete the survey in the html format as opposed to the paper based format. Similarly, the web based format added to the richness of the response in that respondents were required to completed sections of the survey before proceeding to the next stage. This ensured completed responses in all sections.

During the initial design phase a number of key criteria were defined that were considered to be critical success factors. These are outlined in Table 12.

<table>
<thead>
<tr>
<th>Ease of Use</th>
<th>The survey needed to be comprehensive yet easy to use. It needed to reflect the sample groups understanding of the subject matter.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Speed of completion</td>
<td>As many of the respondents within the target sample were commercially employed it was critical that they be able to complete the survey instrument in a minimum amount of time whilst simultaneously attaining the maximum amount of information.</td>
</tr>
<tr>
<td>Relevance</td>
<td>The information required needed to demonstrate relevance within the domain and to a larger extent within the sector.</td>
</tr>
</tbody>
</table>
The research instrument utilised a range of quantitative and qualitative question types. These ranged from questions confirming business turnover through to perceptions of events.

Much of the research literature on web-based surveying relates to companies that either produce surveys of web sites themselves or are specifically related to the use of a particular program i.e. Microsoft Front Page™. Some sites, however, were very specific in their presentation of information. Websurveyor© from the US (www.websurveyor.com 2000) were very detailed in their structuring recommending that the form of the survey specifically be cognisant of the following criteria:

- **Have a clear understanding of the target audience.** “Audience + Purpose = Design”.
- **Ensure that the survey is short.**
- **Keep Questions clear and concise.** “Wordy and complex questions can confuse and put off respondents”.
- **Ensure that respondents are capable of technically answering the questions, this may include ensuring that the entire survey is confidential.**
- **Avoid the use of technical jargon which includes acronyms.** (www.websurveyor.com, 2000)

The Websurveyor website argued that the one mistake made constantly in survey design is to put the demographic questions first, before the questions that really need to be answered. Research completed by Websurveyor© into the placement of the
demographic question sets reveals that the placement has a large impact on the successful completion of the survey by respondents.

Similarly Websurveyor© suggested that pilot testing of the survey should be extensive to eliminate any poor wording or technical jargon. Equally important is the ability to test the statistical validity of the questions. Websurveyor© suggested that the purpose of this analysis is to individually test each question in terms of its reliability and probable response. Websurveyor© (www.websurveyor.com, 2000) was able to point to issues of bias which can take several forms including

- **Biased Questions** which open with an opinion “Given the failure of…” which result in respondents providing an answer that was led by the question.
- **Neutral Bias** where the respondents are presented with a number of responses ranging from strongly disagree through to strongly agree, with the neutral position being the centre position i.e. neutral.
- **Agreement Bias** where respondents are asked to answer an opinion based question. The answer in most instances will be that the respondent will agree with the question.

Other effects which were taken into consideration in the design included conditions known as the **Halo Effect**. The halo effect occurs when a question is linked to a particular person or group of people. Websurveyor© uses the following example of the Halo Effect: “Do you agree with President Bush that the Tobacco Companies are waging war on our Children?” (www.websurveyor.com, 2000). This question can have two responses depending on the perspective of the respondent. For example, if a respondent is against President Bush he could answer no rather than actually addressing the question which is related to the issue of tobacco and children.
One of the key benefits of using a web-based survey is the ability to collect information directly into a defined database. Several web-based articles exist on the development of internet-based surveys with particular attention being paid to the development of the storage of information collected. In his article, “Creating a Survey Data Base” for the “Washingtonian” Chernoff (2001) states that:

*users should be able to enter questions directly into the data base without programming, and it should allow for an unlimited number of responses to all questions.*

In his traditional work on research methods Jackson (1998) outline a number of key points that can lead to the success of a traditional survey. Traditional can mean many things however for the purpose of this research it was defined as;

- *Phone Survey*
- *Mailed Survey*
- *Group Administered Survey*
- *Interview (Winston 1998)*

Several key points become clear throughout the research and all relate to the concept of not burdening the respondent with an arduous task which is unclear and difficult to fill out. Winston (1998) defines this as follows

“A well designed questionnaire does not impose on the patience of the respondent. It should be possible to move through the questionnaire rapidly, without becoming bored, and without having reread the question through ambiguity. An easy to complete questionnaire is more likely to be properly filled out.”

Other considerations in the development of a clear instrument, is that it needs to be introduced well. From this perspective the introduction for the CVRSS web-based
questionnaire outlined what a CVRSS was, how it operated and the purpose of the research. Various texts point to further introductory information including confidentiality agreements and directions for the honest filling out of the questionnaire.

Length was considered important in designing the questionnaire. Several reasons were outlined for this including the importance of taking into consideration the respondents’ available time and the level of additional work required for the input of data. At least one of these elements, that of data entry, can be discounted due to the development of a web-based application which, as mentioned above, uses a database to automatically store all the data entered onto the website. The problem of “respondent fatigue” however was carefully considered before the development of the web based CVRSS survey. Moreover Winston’s (1998) general rule for the development of surveys in terms of the number of questions that should be asked given the guidelines were adopted (See Table 13).

<table>
<thead>
<tr>
<th>Type of Survey</th>
<th>Maximum Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phone Survey</td>
<td>20 Questions</td>
</tr>
<tr>
<td>Mailed Survey</td>
<td>60 Questions</td>
</tr>
<tr>
<td>Group Administered Survey</td>
<td>100 Questions</td>
</tr>
<tr>
<td>Interview (Winston 1988)</td>
<td>80 Questions</td>
</tr>
</tbody>
</table>

*Table 13: Questionnaire Type (Winston, 1998)*

From a layout perspective both the proponents of web based surveys and traditional surveys are at one in terms of the order of questions. The issue of easing a respondent into the questionnaire is paramount with the asking of personal questions restricted at the beginning to reduce initial recalcitrance. To be more specific the first
questions should be simple and only take a minimal amount of time to complete, giving the impression to the respondent that the entire survey will only take a couple of minutes to complete. Further to this, if the questionnaire requires what is regarded as highly personal information these questions are best placed at the end so that the actual questions are more likely to be filled out even if the personal questions are not.

With the consistency of format goes the placement of key variable questions. Winston (1998) suggests that key variable questions i.e. those that require answering and are key to the research project should appear approximately one third of the way through the survey. Similarly open ended questions which can be defined as those that require some opinion to be formed should be kept to a minimum and if they are to be used should only be done so in conjunction with “coded” or preset category answers.

Under the general category of design several other issues are raised by a number of authors. These include those listed in Table 14 below.

<table>
<thead>
<tr>
<th>Grouping of questions by type</th>
<th>Questions should be grouped according to the type of question that they are</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clearly Indicate Branching</td>
<td>Branching is defined as a set of questions within the one questionnaire that should be filled out by a subset of respondents. This is generally signified by statements such as “if answer is Yes to Question # then go to Question #”</td>
</tr>
<tr>
<td>Achieve precise measurement</td>
<td>This can be defined in terms of any empirical form of measurement for example, age height, dollar values or occupations.</td>
</tr>
<tr>
<td>Give the questionnaire a distinctive look</td>
<td>Ensure that the questionnaire is different to look at and that it attracts the interest of the respondents.</td>
</tr>
<tr>
<td>Do not over crowd the page</td>
<td>Presenting an uncluttered look on the page that allows respondents to proceed quickly will give them the idea that they are moving rapidly and that it is not an impost on their time.</td>
</tr>
</tbody>
</table>

*Table 14: Good design guide*
Other minor points raised by authors include that fact that all words must be understood and that wording should err on the side of simplicity for the sake of making a question clear. Similarly the word “and” produces one-dimensional answers (Winston, 1998). Variability of the wording is pointed to as a key to producing variability in the answers thus creating variability in the analysis of the data. In the same vein authors point to a number of key remaining issues. These include avoiding complexity, the use of existing words for comparative analysis and asking respondents to speculate.

The CVRSS Survey did not use any open ended questions. This was mainly because most answers could be pre-coded without the need for respondents to type an answer. Previous reasoning for the use of open ended questions in surveys can be discounted with the advent of computer based surveys and their effective use of drop down listings. It was previously argued that open ended questions could be used in situations where an answer has too many permutations (e.g. age). Clearly in the case of a paper based survey if the response was to include all possible responses it would need to list all possible numbers between 0 and 120. This is not required with pull-down menus.

On the other hand, one of the key advantages researchers have had in the past when they used open ended questions was the ability to include some of the responses as quotes in the final analysis.
Several other types of questions were considered in the development of the questionnaire and were generally discounted. The reasoning for the discounting was that the web based format of the questionnaire allowed for a more precise way of capturing data as well as offering a very quick way for respondents to complete the task. While not all types of questions were discounted those that were included:

- Presence Absence Questions;
- Rank Ordering Questions;
- Likert Type Questions; and
- Semantic Differential Questions.

A variation of the Magnitude Estimation Question was, however, used extensively allowing respondents to define within a specified range a given response.

Donald Orlich in his work on Designing Sensible Surveys (Orlich, 1978) suggests that the major reason for surveying is to assist in the decision making process. Orlich (1978) claims that it should aid in:

- planning of new programs, revising or improving current programs or deleting obsolete programs;
- Determining the feelings, opinions, or attitudes of groups of individuals; and
- testing of a research hypothesis.

Orlich (1978) was able to define the general advantages and disadvantages of printed or written questionnaires. Amongst the strongest points he makes for the advantages are:

- many individuals contacted concurrently;
- a cost effective method of delivery;
- identical questions to all respondents;
- ease of tabulation of results;
• convenience to respondents; and
• interviewer bias avoided. (Orlich, 1978)

The disadvantages as defined by Orlich (1978) include:

• motivation for the respondent answering the way he/she does is unclear;
• respondents remain limited in expression of responses due to instrument design;
• data collection from those that cannot read or are vision impaired is limited;
• response rates can vary;
• poor return rates remain as an unknown due to lack of direct respondent contact;
• name and address details are often spurious; and
• questions can mean different things to different people.

Under the heading of ‘Semantics of Construction’, Orlich (1978) talks about the detail of the question being asked. For example if a question asks for an opinion on a subject in general this is very different to asking for a personal opinion on the same subject.

While this is a fine point, it is important to note that the respondent could answer each question differently based upon the addition of two or three words. To illustrate, the question that simply asks the question “to what extent are reference materials in the library satisfactory?” would elicit a different response to the question “to what extent do you think that the reference material available in the library is satisfactory?” (Orlich, 1978). One question asks for a purely personal view the other allows the respondent to take into account the views of others.

Within the same vein the question of impersonal versus personal questioning should be explored. Authors claim that well-constructed logical yet impersonal questions allow
for the production of logical inferences. However as Orlich puts it “the responses may be more projective than they are explicit” (Orlich, 1978).

The CVRSS survey used what Orlich (1978) described as “Forced Response Techniques”. By this Orlich (1978) stated that respondents are forced to make a response to one category. This method requires vigorous research into all the possible responses and the listing of them. Where this does not allow for the capturing of all responses the use of “other please specify” can be considered. In the case of the CVRSS survey the use of “other please specify” was removed after initial consideration. The removal of the ability to answer in this way was done for two main reasons, viz. firstly, from a technical perspective it was difficult to achieve and secondly, the use of this answer rather than a defined response could have led to respondent failure to complete the question due to the need to type a response.

Within the “Forced Response” category of questions the issue of scaling of the response is important. Nominal or Naming scales are non-numerical in their relationship and are usually designed to gather factual or objective information and identify rather than measure. An example of this is the question include: are you a (1) Male or (2) Female (Orlich, 1978). By comparison an Ordinal Scale is used to gather both factual information and respondent opinion (Orlich, 1978). Such questions offer the researcher the ability to scale responses which have some mathematical relationship but not one which is precisely defined. A Likert Scale is a form of Ordinal Scale (Named after Rensis Likert). The final form of scale is that known as the interval scale. The interval scale differentiates itself from the ordinal scale by having a rank
order relationship which has equidistant relationships. The instrument used only the first three types of scales.

### 3.5 Validity and Reliability

Ensuring the validity and reliability of the questions and the instrument on a whole is a paramount consideration in the design phase of the research instrument. The questions at all times need to measure what we think they are measuring and must remain meaningful to survey respondents. To this end questions that did not relate to transport were uncommon and questions that seemingly had no relevance to the subject such as ANZIC were utilised sparingly.

A number of works define reliability and validity however one of the more complete definition came from Peter Eibl (1996):

- **the reliability of measurement refers to the measure's ability to provide consistent results over time; and**
- **the validity of measurement refers to the measure's ability to quantify what is actually intended to measure** *(Eibl, 1996).*

A number of tests are recognised to measure reliability, including:

- Test-retest method.
- Parallel test method.
- Internal consistency testing *(Veal, 2005).*
Hussey and Hussey (1997) define tests associated with validity and reliability in a slightly different way. They argue that reliability can be tested in the following ways:

- **Test and Retest:** Questions are asked of the same people on two separate occasions with the correlation of the two sets of data computed to test the co-efficiency.

- **Split Halves Method:** Responses are placed into two separate piles and assessed separately with the correlation co-efficiency tested between the two piles.

- **Internal Consistency Method:** This method utilises the correlation between every item in the sample group and produces an index of reliability. This method is popular and relies upon the use of questions as the method of data collection and the use of software that utilises algorithms known as Kuder Richardson (KR20) (Hussey and Hussey, 1997).

According to Hussey and Hussey (1997), testing of validity is confined to the extent to which the research findings are consistent with the situation that is being in studied. However, validity can itself be divided into the following three types:

- **Face Validity:** A weak form of measurement which tests if the data “looks like” it is measuring what is supposed to be measured.

- **Content Validity:** Measures the content from a representational adequacy perspective ensuring that both dimensions and sub-dimensions are measured.
• **Construct Validity:** Also referred to as convergent validity meaning that information from two or more sources indicate the same or similar meanings within the construct.

Issues of reliability and validity of the instrument were addressed in a number of ways. One of the key elements in the design of an instrument is the use of previously validated and reliable instruments. In his work on Computerised Vehicle Routing and Scheduling Eibl (1996) deployed a survey instrument that utilised a range of questions designed to understand the uptake of CVRSS in the Brewing Industry in the north of England. Questions in general areas such as education, computer literacy, management satisfaction, driver acceptance and performance were copied directly into the instrument design. Although the purpose of the research instruments differed in all respects, many of the questions in the current research instrument could be tested for reliability against this work.

### 3.6 Data Collection Timelines

As previously defined data was collected via two different methods, *viz.* a paper based survey and an internet based survey. The chronology of the development, release and subsequent analysis is detailed in figure 6.
The research was begun in 2000. This involved a detailed literature review which was substantially completed in a year but continued throughout the length of the research project. As part of the literature review a number of research questions and associated hypotheses were identified and finally formulated. This then led to the creation of a prototype data collection methodology designed to take into account a range of considerations.

The designation of the tool and to a lesser extent the practical development of the instrument was then begun. This process took the greatest amount of time within the overall research project. A number of reasons exist for this including:

- Development of a data base.
- Development of a web site.
- Selection of an ISP.
- Peer review.
- Paper based instrument development.
- Final review.

The development of the database and the development of the web interface in practical terms occurred at the same time. As questions were developed and the tool designed the data base was built to accommodate the answers. The database was
constructed in Standard Query Language (SQL) on a computer located in a secure data centre. The SQL database was supported by the researcher's employer and was part of a secure corporate environment.

The web site was developed initially by the researcher and was designed to quickly and accurately move respondents from one section of the web site to another. Specifically it was designed to identify those respondents that were using CVRSS and those that weren't.

The location of the web-based survey was moved from a commercial provider to the secure corporate environment provided by the researcher's employer. The web site similarly underwent a change with the adoption of direct HTML coding as opposed to Microsoft Front Page® code generation to reduce the relative file sizes and to also improve efficiency. A paid developer was used to develop this and over a period of six months converted the entire survey to a more efficient and logical tool.

The survey itself was then sent out for peer review by both well regarded academics and key figures with the transport industry. A number of responses were achieved from both academic and industry sources. The suggested changes provided by both groups of reviewers fell into two categories, viz. commercial and academic.

The changes categorised as commercial included areas such as:

- Commercial validation of revenues by respondent;
- Coding of respondents via Australia New Zealand Industry Codes (ANZIC);
- Commercial vehicle loading weights.
The changes categorised as academic were largely provided by the researcher's supervisor, Dr David Wilson and a number of other key academics including Peter Dapiran of Monash University and Ian Sadler of Victoria University. A number of criticisms were identified and suggestions made. These included:

- Simplifying the survey;
- Ensuring identification of all potential user groups;
- Restricting the sample to a smaller geographical area; and
- Effective coding of all answers.

Most of the recommendations were incorporated into the final design of the web based survey and again tested. Final testing was conducted to identify a subset of the entire sample. A research assistant then conducted face to face interviews with the subjects to ascertain usability and ease of use. A number of comments were received via this process and incorporated into the final design.

Upon completion of this process the paper-based survey was completed to emulate the web based survey in all respects with the exception of those areas identified previously. The survey was converted into a booklet (Appendix 1) and published. Final approval of both the web based and paper based surveys was sought in March 2004 and the survey was posted and released in June 2004.

The web-based survey remained on the www.trc-survey.org web site for 1 month and all paper based surveys were received within this period.
<table>
<thead>
<tr>
<th>Date</th>
<th>Activity Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>17/6/2003</td>
<td>Research at ARRB on topics such as scheduling and routing problem, theoretical solutions, current market solutions, case studies etc.</td>
</tr>
<tr>
<td>27/7/2003</td>
<td>Created listing of transport and non-transport companies from Yellow Pages online that will constitute the sample size.</td>
</tr>
<tr>
<td>12/8/2003 to 20/9/2003</td>
<td>Contacted transport and non-transport companies to register interest in participating in research survey.</td>
</tr>
<tr>
<td>5/12/2003</td>
<td>Survey approved by Dr David Wilson. Compared online survey and hardcopy version. Documented inconsistencies and necessary amendments so both versions are exact duplicates.</td>
</tr>
<tr>
<td>12/12/2003</td>
<td>Recommended additional validation and functionality on online survey so survey respondents are re-directed to answer relevant questions based on user selections. Tested website amendments.</td>
</tr>
<tr>
<td>17/12/2003</td>
<td>Conducted first peer review testing with Luke Bourchier at BP Australia.</td>
</tr>
<tr>
<td>18/12/2003</td>
<td>Conducted second website testing at Sidewinder AP with Dave Woodford.</td>
</tr>
<tr>
<td>20/12/2003</td>
<td>Documented feedback from peer review testing sessions.</td>
</tr>
<tr>
<td>8/1/2003</td>
<td>Restructured online survey based on Dave Woodford’s recommendations. Sent revised survey to Mark Helding for approval.</td>
</tr>
<tr>
<td>15/12/2003</td>
<td>Liaised with Research and Development unit to organize materials for survey mail out.</td>
</tr>
<tr>
<td>25/12/2003</td>
<td>Tested website’s ‘Back’ functionality. Users were able to click on the back button on the browser but the previous page did not retain the input values. This was a limitation of the website design.</td>
</tr>
<tr>
<td>19/01/2003</td>
<td>Contacted Paul Harbun for final user acceptance testing. Sent instructions on accessing website and attached feedback form for completion after website testing.</td>
</tr>
<tr>
<td>1/2/2004</td>
<td>Performed final website testing before sending out surveys.</td>
</tr>
<tr>
<td>2/2/2004 to 3/2/2004</td>
<td>Surveys were printed and stapled into booklets and envelopes labelled for survey mail out. A total of 280 surveys were sent out to transport and non-transport companies.</td>
</tr>
<tr>
<td>25/2/2004</td>
<td>Drafted letter advising survey recipients of closing date.</td>
</tr>
<tr>
<td>26/2/2004</td>
<td>Sent out letters to survey recipients.</td>
</tr>
</tbody>
</table>

*Table 15 Research Activity Diary*
3.7 Conclusion

This chapter outlined research design adopted and the data collection methodology associated with the identification and development of the survey instrument. It also covered the piloting, the execution and the timelines associated with the project. In addition the chapter related the methodology to previous work undertaken as well outlining regional specific issues that needed to be addressed.

This chapter also highlighted a number of shortcomings with the research instrument in particular the access to specific populations as well as the relative complexity within these population groups.
4. Results

4.1 Introduction
This chapter outlines the results that were uncovered following the administration of the survey instrument and the findings that arose from the focus group. In terms of the survey, the questions were broken down into separate sections covering personal details, company profile, transportation type and use of CVRSS. Whilst the majority of questions were generic (eg. company size and transport application), a split occurred at the CVRSS usage stage. For those companies that utilised a CVRSS the questions were related to the perceived benefits achieved from utilising the software. For those companies not using the CVRSS the questions sought to find out why they had chosen not to adopt a CVRSS and the level of understanding the respondents had of these systems in general.

The outcomes of the follow-up focus group are presented as a series of conclusions drawn directly from the discussions that arose. In line with standard protocols, these are outlined as both observations and direct quotations.

4.2 Survey Results

4.2.1 Descriptive Population Data
The total number of companies that gave a manual or web answer to the survey is 62 (31 paper based and 31 HTML). As this response was considered to be suboptimal, companies that supplied no response were approached directly. In general respondents in this group were apologetic pointing to work pressures as well as
misplacement of the information and accompanying instrument. A further 23 responses were attained through this contact, taking the total sample to 85.

Both forms of the survey presented rich yet diverse responses. Very few surveys were complete in every aspect and with few exceptions respondents did not want further information from the researcher relating to the survey outcome. This was not surprising given the nature of the workforce within the defined sector and the general interest shown in the research by respondents.

Charting of data as opposed to frequency or other methods of tabular presentation were considered the best method of detailing the findings. This was based upon a number of factors mainly related to the codification of respondent answers and indeed the branching and complexity of the data. However some basic frequencies have been defined:

<table>
<thead>
<tr>
<th>Do you use a CVRSS in your business?</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>23</td>
</tr>
<tr>
<td>No</td>
<td>28</td>
</tr>
<tr>
<td>No response</td>
<td>34</td>
</tr>
<tr>
<td><strong>Grand Total</strong></td>
<td><strong>53</strong></td>
</tr>
</tbody>
</table>

*Table 16: Frequency of CVRSS usage*

In general a number of observations can be made about the respondents. The vast majority (80%) were transport providers to other parties aside from their own company. Only 15% were not transport providers to other parties and 5% did not respond to the relevant question.
Some Companies may operate in several groups

Table 17: Participant Groupings

Of interest was the type of freight that respondents carried. Understanding the difference between a general freight carrier and different type of carriers may indicate a correlation between CVRSS uptake and freight type. The respondents were therefore broken into the categories shown in Figure 7. Over one third (37%) were general freight carriers. Manufactured Goods (14%), Dry Food (14%) and Frozen Food (11%) were the next largest groupings.

<table>
<thead>
<tr>
<th>Freight by Type</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distribution</td>
<td>21%</td>
</tr>
<tr>
<td>Courier</td>
<td>8%</td>
</tr>
<tr>
<td>Third Party Logistics</td>
<td>13%</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>3%</td>
</tr>
<tr>
<td>Total</td>
<td>100%</td>
</tr>
</tbody>
</table>

* Some Companies may operate in several groups

Figure 7: Respondent Companies by Freight Type

The companies varied greatly in size (measured by employee numbers). The majority had 20 or less employees. The detailed distribution is as follows: 42% have 1-10 employees, 16% have 11-20 employees, 15% have 21-50 employees and 13% have
greater than 50 employees. This appears to be in line with the size distribution of the industry as a whole. Although 15% of respondents provided no answer, it is possible to claim that, based on size at least; the sample was a fair representation of the population.

4.2.2 Actions of Respondent Companies

One of the initial purposes of the survey was to establish how many companies within the sample group operated a CVRSS. The responses indicated that the majority of respondents did not operate a CVRSS within their business. Only 45% (28 companies) within the respondent group operated a CVRSS whilst 50% (31 companies) did not and 5% (3 companies) failed to provide an answer. Hence, at the time of the survey the majority of respondents had not adopted CVRSS technology.

Of particular interest is whether those that have adopted the technology are of more likely to be of a particular type. The variables that may be of relevance here are size, turnover and road transport costs.

The size of the company (measured by the number of employees) has been identified above as being possibly related to CVRSS adoption. When reviewed in the groups that do and do not have CVRSS the results shown in Figures 8 and 9 were obtained. A visual inspection of the data indicates that adoption of the technology is much more likely amongst smaller companies. A Pearson Chi-Square analysis was not possible because the data transgressed the ‘Expected Frequencies Rule’.
Another variable predicted to be related to adoption of the CVRSS technology was turnover. Within the entire sample group 23% have a revenue of less than $1,000,000, 35% have revenue greater than $1,000,000 but less than $5,000,000, 11% have revenue greater than $5,000,000 but less than $10,000,000 and 14% have revenue greater than $10,000,000 but less than $50,000,000. No companies had revenues greater than $50,000,000 but less than $100,000,000. However 5% of respondents had revenue greater than $100,000,000. Approximately 12% of respondents provided no answer. When reviewed in the groups that do and do not have CVRSS the following results were found. A visual inspection of the data reveals that adoption is much more likely to occur amongst those companies with a smaller
turnover, especially a turnover of less that $1,000,000. Once again a Pearson Chi-Square analysis was not possible because the data transgressed the ‘Expected Frequencies Rule’.

![Figure 10: Companies using CVRSS by Revenue](image)

![Figure 11: Companies not using CVRSS by Revenue](image)

Transport costs are another point of differentiation between companies. Of the companies that responded to the survey:
• 19% had road transportation costs less than $100,000;
• 32% had road transportation costs greater than $100,000 but less than $500,000;
• 7% had road transportation costs greater than $500,000 but less than $1,000,000;
• 11% had road transportation costs greater than $1,000,000 but less than $5,000,000;
• 11% had road transportation costs greater than $5,000,000 but less than $10,000,000; and
• 5% had road transportation costs greater than $10,000,000 but less than $50,000,000.

None of the companies surveyed had road transportation costs greater than $50,000,000. Only 5% of respondents provided no answer to this question. When reviewed in groups that do and do not have CVRSS the results shown in Figures 10 and 11 were identified. Once again a visual inspection of the data suggests that those companies with smaller transport costs are more likely to adopt the technology. Once again a Pearson Chi-Square analysis was not possible because the data transgressed the ‘Expected Frequencies Rule’.
Despite the fact that the Chi-Square test could not be applied it does appear from visual inspection that the adoption of the CVRSS technology is related to the size,
turnover and transport costs of the sample companies. In each case the smaller the metric, the greater the chance that it would be adopted.

45% (28 companies) reported that they operate a CVRSS. Specific questions were targeted at this group to find out why they had done so and what their experience had been when using the technology.

The decision to adopt the technology can be made at a number of levels within a company. As can be seen in Figure 12, 50% of the companies who responded indicated that the decision had been made at the Executive Management level and 30% said that it went as high as the Board of Management. None reported that the decision was made by Middle Management.

<table>
<thead>
<tr>
<th>At what level was the decision to purchase an CVRSS made?</th>
<th>Middle Management</th>
<th>Executive Management</th>
<th>Board of Directors Level</th>
<th>IT Manager</th>
<th>don't know</th>
<th>Grand Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td>10</td>
<td>6</td>
<td>3</td>
<td>1</td>
<td>20</td>
</tr>
</tbody>
</table>

*Table 18: Frequency of Decision Makers within the CVRSS purchasing process*
When asked why their company had decided to adopt CVRSS technology respondents were given a number of alternative pre-coded responses to choose from. These included the following:

- Price;
- Functionality;
- Price and Functionality;
- Part of a larger Business System;
- After market Support;
- Technical Support;
- Country of Origin;
- Cost Savings; and
- Other

This question had a high level of “no responses” with possible reasons discussed in following chapters. The reasons behind why companies purchased CVRSS were therefore identified as follows. As can be seen, price and functionality are by far the
most important reasons advanced. It appears that those making the decision were influenced by the relatively cheap price and its perceived functions. No respondents referred directly to an expectation of potential savings being the driver.

![Figure 15: Reasons for purchasing a CVRSS](image)

<table>
<thead>
<tr>
<th>Reason</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Price</td>
<td>50%</td>
</tr>
<tr>
<td>Functionality</td>
<td>30%</td>
</tr>
<tr>
<td>The need to Manage a Larger Fleet</td>
<td>10%</td>
</tr>
<tr>
<td>After Market Service</td>
<td>0%</td>
</tr>
<tr>
<td>Savings</td>
<td>0%</td>
</tr>
<tr>
<td>Other</td>
<td>0%</td>
</tr>
<tr>
<td>Grand Total</td>
<td>19</td>
</tr>
</tbody>
</table>

Table 19: Frequency of Reasons behind the purchase of a CVRSS

This was particularly interesting as 43% of the companies that had adopted CVRSS technology received a guarantee of a direct saving on transport costs by the software provider. Only 30% didn’t receive this guarantee and just less than one quarter (23%) of respondents provided no answer to this question.

Despite the fact that the prospect of potential savings does not appear to have been important in the decision, a key question was whether there were any actual savings
created by the software once it was operational. One fifth (21%) of the companies that installed the CVRSS claimed that they had achieved savings in under 6 months, whilst 36% stated that they achieved such savings in under 12 months. Interestingly, 11% of respondents stated that savings are not yet evident. Despite the latter, the responses suggest that over half (57%) of those who adopted the technology reported savings within a 12 month period. However, only 39% of the companies claim to have paid for the software through the savings generated. Almost one third (32%) of respondents provided no answer to the latter question. When this data is placed alongside the fact that the prospect of potential savings was not an important motivator, it is interesting to see that almost a third of companies did not even know whether such savings eventuated.

A particularly interesting question is how the perceived savings were achieved. For 43% of the companies there was a reduction in the amount of overtime having to be paid. Slightly fewer companies (39%) stated that there was a reduction in the number of kilometres travelled. Furthermore, 36% of the companies found that there was a reduction in operating costs overall. For a very small number of companies (4%) there was a reduction in the number of vehicles with a similar number (4%) stating that there was a reduction in the number of drivers. No companies reported a drop in the number of administration staff required.

Other benefits that could be derived from the introduction of the software include the percentage of on-time deliveries. For 14% of companies the software didn’t improve the deliveries in full on time. A similar number (14%) of the companies experienced a
small improvement while 29% of companies found an overall improvement. This means that less than half (43%) found any improvement at all. A small minority of companies (7%) don’t measure on time deliveries hence they did not know the impact. It must be noted that this data needs to be treated with caution as over one third (36%) didn’t give an answer. Again this could reflect a low level of interest in the benefits derived from the investment in their CVRSS.

The introduction of new technology can be problematic. This appears to be the case with some companies surveyed, but the nature of the difficulties differed. For 50% of the companies the major difficulty in implementing the software was lack of skilled staff. Over one third (36%) of those surveyed faced driver opposition to the implementation of the new software. This primarily concerned issues of computer knowledge rather than a fear of changes to employment conditions. Just under one fifth (18%) noted that there was a lack of support from the software provider.

4.3 Focus Group Results

4.3.1 Introduction

It was recognised that the data collected in the survey may not provide a definitive answer to the research questions and indeed based upon the changes in technology dated very quickly. This required a different approach that would complement the survey output and be able to delve in depth into the factors influencing decision-making. Indeed the production of a report in 2006 by the UK Government (Figure 5) highlighted the potential to ask a range of questions in line with value beyond the overall cost saving potential.
The approach chosen adopted a phenomenological methodology utilising a focus group (Hussey and Hussey, 1997). The reasons for this change included:

a) the research subject was limited to very few companies and indeed very few individuals within these companies;
b) few companies had completed a detailed cost benefit analysis in the research area;
c) few companies in Australia had the need for the type of Routing and Scheduling being researched;
d) the surveying of CVRSS vendors was considered inappropriate as the purpose of the research was to establish the customers reason for take up of CVRSS; and
e) the proliferation of Routing and Scheduling engines within Portable Global Positioning Devices including Navigation.

Phenomenology is concerned with the meaning behind an action or phenomenon. It does not result in quantitative data. A key feature of this approach is the attempt by researchers to “scruptinize at short range, to place themselves in close contact with . . . the world of those being studied” (Gubrium and Holstein, 1977). Researchers focus on what the subjects are experiencing, how they interpret this and how they structure their world (Bogdan and Bliken, 1992). A focus group data collection strategy is an ideal way of gathering data to operationalise this approach.

4.3.2 Focus Group Format and Composition

The Focus Group consisted of seven individuals from the Transport, Logistics and Supply Chain Sectors. Participation within the focus group by all members was only guaranteed once the researcher agreed that they would remain anonymous. However individuals represented the express air freight sector, the line haul minerals sector, the retail sector and the third part logistics sector. All individuals represented a separate organisation or company. All individuals had or utilised large transportation fleets
which ranged from small vehicles through two large heavy articulated combination vehicles. Some organisations only operated local metropolitan fleets, whilst others operated both intra-and inter State vehicle fleet.

All individuals were considered to be decision-makers within their businesses. All individuals have at some point, been involved in transport operations, including routing and scheduling. They all had at some point in their career been exposed to transport routing and scheduling systems. It was clear, however, that only a few focus group participants had worked with or overseen transport routing and scheduling systems.

All participants were Melbourne based with operations in Melbourne as well as interstate and intrastate.

The focus group was conducted by the researcher in a private room and recorded for later analysis. The focus group was initially introduced to the concept of transport routing and scheduling and its place in the supply chain and transport industries to ensure consistency of understanding. The participants were also introduced to the initial research findings. It was also explained that the research findings in the first study were not definitive and the focus group purpose was to further investigate transport rating and scheduling within an Australian context.

4.3.3 Focus Group Outcomes
To begin the discussion, the question was posed: “Do transport routing and scheduling engines produce financial or economic savings for those companies that implement them?”
This discussion point, successfully introduced a number of participants into the discussion. A number of participants had never been exposed to transport routing and scheduling software and therefore needed further guidance. At this point, a number of other participants were able to guide those that hadn't been exposed to transport routing and scheduling systems through their operation and potential use.

Interestingly, this discussion led immediately to the cost associated with purchasing and implementing these systems. Some participants quoted figures in the range of $100,000-$200,000 for the purchase and implementation of such systems, whilst others quoted figures ranging between $500,000 and $1 million. The varying costs associated with these systems the group concluded was associated with the size of the organisation and complexity of the transport task. This discussion introduced a healthy degree of scepticism within the focus group by some members. Some found it difficult to believe that a system that automatically routes and schedules transport operations would be of any benefit to their specific business.

The group was effectively polarised. Five of the active participants believe that the use of transport routing and scheduling software had provided a positive benefit to their organisation or organisations. Two others, however, believe that transport routing and scheduling software would not be able to provide any benefit to either their organisation or any other.
This then led to the group that believed transport routing and scheduling provided a financial and economic benefit trying to convince those that could not see the benefit of the relative merits of the software. At this point, the researcher tried to delve further into the relative operations of both groups. It became clear from these discussions that the group that could not see the relative benefits of transport routing and scheduling software, had operations that would anecdotally gain much benefit from the use of the software. These businesses operated large line-haul fleets. These fleets, operated on an inter- and intra-state basis. The majority of the fleet was on a fixed contract basis, which means that vehicles were permanently attached to a bulk freight contract, operating through permanent pickup and drop-off locations. The participants in the focus group that operated this type of business were more interested in fleet utilisation within the bounds of a fixed contract that had fixed pickup and drop-off points and fixed costs to find revenue streams.

Those participants within the focus group who supported the use of CVRSS technology operated completely different transport fleets. These fleets are as numerous and varied as the clients that they service. Some fleets operate small pickup and delivery type vehicles (less than 1 tonne), whilst others operate large line haul fleets at both a metropolitan, intra-state and inter-state level. Manual routing systems for these businesses varied from computer generated messages (no routing but rather a list of jobs queued and forwarded to the driver) through to manually filled in cards placed into slots by drivers run that are radioed through.
It is therefore very clear that the views regarding the potential benefits of those that had the large fixed term fixed price contracts for transport were fundamentally different to those that had large variable contract and customer bases.

Participants who utilised transport routing and scheduling software were asked how many individuals were utilised in the respective transport operations to manage the routing and scheduling within their businesses. Those that didn't have transport routing and scheduling software had no single individual, at a centralised location or function, managing the day today transport operation. Those that did have the software had one or more individuals responsible for the day-to-day, scheduling and operation of the transport fleet.

The focus group then rationalized that the type of contract or operations performed by the fleet dictated not only the organisational structure associated with that business but also the type of day-to-day management required to maintain an effective operation. Companies that had long term fixed contracts with defined pickup points and drop-off points utilising defined transport vehicles had little or no need for centralised transport management on a day to day basis. Those businesses that had high levels of randomness associated with the transport operation required high levels of management input. This factor appeared to be more important than costs in the decision-making process.

Further to this, those that had variable contracts and randomness within their pickup and drop-off locations on a day-to-day basis required much more management, and
indeed saw transport routing and scheduling software as a way to limit the amount of labour required to manage this task. Additionally, these businesses saw the use of transport routing and scheduling software as a way to improve efficiencies on the road. These efficiencies gained operate at a number of different levels. These included a reduction in the following three aspects of their operations:

- the number of fleet vehicles required to complete the transport task;
- the cost associated with running their transport fleet; and
- the labour associated with managing the transport routing and scheduling on the day to day basis.

The focus group addressed the question of cost savings associated with transport routing and scheduling software. No member of the focus group was able to identify the exact cost savings associated with using routing and scheduling software. Indeed, no member of the focus group was able to identify if a business case had been completed to identify the cost benefits of implementing transport routing and scheduling software. It appears that individuals or organisations that use this software take it as a given that without this software their operating costs would be considerably higher.

The discussion also focused on the types of software being utilised. Most participants who utilised transport routing and scheduling software could identify the type of software they used, but were unfamiliar with its exact operation or the method of calculation for the production of routes and/or schedules. On top of this, many of the focus group participants could not identify whether the software acted in real time or in
batch mode. Batch mode was identified to the participants as the method in which orders can be moved from an ERP or Order entry system into the VRP.

In order to explore the level of participant knowledge about the types of routing and scheduling software and the mode in which that they operate an explanation was given of real time, routing and scheduling, versus batched routing and scheduling. This explanation allowed participants to identify how their particular software operated. It was clear that the majority of software applications utilised were, in fact, operating in batch mode. However, the nature of the discussion demonstrated a very real limit on the knowledge base about this technology, even amongst those who use it. Focus group members were only able to outline how they utilise their software on a day-to-day basis, while only one could identify how the application of batched mode routing worked.

The participants then discussed the application of new and emerging technologies. These included GPS devices and portable navigation devices. The focus group agreed that in the past five years this technology had moved ahead significantly but all noted that this technology had yet to gain a foothold within their business. The industry term turn-by-turn was foreign to participants. It was explained that this level of technology was in fact how portable navigation devices operated. Most participants within the focus group doubted that turn-by-turn technology would further improve efficiencies in their transport operation or fleet. All agree, however, that there was a significant difference between batched mode, scheduling and a real-time scheduling. On this
point, most agreed that this level of technology, would add considerably to the potential savings within their transport and fleet operations.

When pressed on the potential implementation of such software. Most agreed that it wouldn't happen in the medium or long-term. Most believed that there would be a significant cost to implement this infrastructure and because of this most believed that the benefit would exceed the cost of the software. This was of particular interest, given that most participants had demonstrated only a very rudimentary understanding of the costs of real-time transport routing and scheduling software.

The final discussion centered on the use of maps in transport routing and scheduling software. Most participants utilise maps as a reference rather than as a tool to support the transport routing and scheduling operation. Further to this, a number of the participants believe that the use of maps really only served a purpose when it comes to showing customers the extent of their technology.

The findings that were derived from the focus group can be summarized as follows:

- transport routing and scheduling software falls into two categories; batched mode transport routing and scheduling and real-time transport routing and scheduling;
- Organisations that had large fixed term fixed fleet contracts had little or no need of complex transport routing and scheduling software;
• organisations that had multiple contracts, which required high levels of day to day management input utilised transport routing and scheduling software extensively;

• focus group members believed that real-time routing and scheduling would in fact add some further functionality to their day to day transport operation;

• focus group members also believed that the cost of the software would not be met by the savings that it generated;

• most, although not all focus group participants; believe that the use of maps within the transport routing and scheduling software was of little benefit on a day to day basis; and

• all focus group participants believed that the introduction of portable navigation devices was a significant step forward in the personal use of transport routing and scheduling software, but that so far it had had little or no impact upon their day-to-day transport operations. Further they were unsure where the internet would take the technology, specifically the addition of new levels of maps and indeed the associated information that can be added to these maps.

4.4 Hypothesis Testing

As noted in Chapter 2, a number of Research Hypotheses were established to focus the research within the broad framework of the research question. This section of the thesis specifically addresses each of these in turn.
**H1:** *Companies that install a commercially available Vehicle Routing and Scheduling software packages do so to attain cost savings in their transport operation.*

The question of why companies deployed routing and scheduling systems was addressed in a series of questions within the survey and through the focus group discussion. The survey questions included levels within the business at which the decisions were made to select the software, the type of savings promised by the software vendor and if in fact the benefits had been achieved. It appears that knowledge about costs and associated savings is very limited, even amongst those who have utilised CVRSS packages. While there was a general belief that there would be cost savings, those surveyed or who participated in the focus group did not have specific knowledge about this nor did they see it as a major driver for the decision. Of particular interest was the fact that they did not undertake subsequent analysis to determine whether their investment had led to any cost savings. Cost may be a driver, but it is almost seen as a given and does not play an active part in the decision. Moreover, it could be said that it is the perception of cost-savings rather than the reality that is important.

**H2:** *Commercial organisations understand the relevance of the term “optimisation” in the mathematical sense rather than the commercial context CVRSS vendors use and understand the part it plays in selection of CVRSS.*

A direct question related to optimisation was part of the survey and there was ample discussion about this topic amongst focus group participants. Whilst the relevance of
optimisation is directly related to the field of mathematics the researcher had found that optimisation was “sold” in the marketplace as a key benefit of the system. It appears, however, that knowledge of the actual operation of the CVRSS technology is limited. Most participants did not really understand how the algorithms work and the advantages and disadvantages of different approaches utilised by different software products was not known. The industry appears to equate “optimisation” with cost minimization which in practical terms equates to “resource” minimisation

**H3:** The benefits companies achieve from the installation of CVRSS are all cost related.

This question referred to the specific benefits achieved from the installation of a CVRSS. These benefits were promoted in a range of different ways to such things as reduction in distance travelled and reduction in the hours worked but stopped short of offering a specific reason for the savings in these or other categories.

As noted above, the perception of cost savings was an important driver in those companies that have decided to utilise CVRSS. However, it appears that the benefits, both expected and derived, extended beyond costs. As many of the companies that adopted the technology were small, cost savings, although important, were not sufficient. They also wanted to demonstrate flexibility and innovation, especially amongst those that had a high level of randomness in their delivery pattern. This flexibility and innovation gave them a point of difference from their larger competitors.
**H4:** *Companies adopting CVRSS will face some internal (from within the company) opposition to its introduction from either operational or driver staff.*

The results indicate that, like the introduction of many new technologies, the introduction of the CVRSS did face opposition from some staff within the company. However, this does not appear to have been severe and largely revolved around a lack of knowledge and consequent concern about having to learn something new, rather than it being seen as a threat to employee conditions and employment. The results also indicated that the reaction to this software being introduced varied according to the age of the employees. Younger, computer savvy employees have less concerns than their older colleagues who have not had a lot of previous experience with computer packages.
5. Analysis and Discussion

5.1 Introduction

The history of CVRSS is one which is linked to both the development of the computer and the development of the mathematical methods that deal with complex problems. Additionally the link between these issues and the commercialisation of CVRSS are complex and indeed detailed. The researcher has attempted to create a link between these areas but made a conscious decision to concentrate on the purpose of the research which was to define a link between CVRSS and cost reductions. As such the researcher acknowledges that the historical development of CVRSS and the larger area of Decision Support Systems was not covered in depth but rather simply to create some “historical background”.

The survey and subsequent focus group provided a reasonable insight into the research questions relating to the effectiveness and uptake of CVRSS in the larger transport and distribution sector in Victoria. Before discussing these in detail it is necessary to acknowledge that there were some issues with both the survey and the process which need to be considered when analysing the results. These are outlined in the next section.

5.2 Limitations

A number of external factors created some limitations in the research design as it evolved. These are outlined in this section.

A key issue was the disparate nature of the transport and distribution sector and the difficulties associated with obtaining a sample that is representative of it. Companies that operate in this sector include those that are primary contractors, third party contractors, and own users. The use of any CVRSS therefore can occur at any level within this group and the nature of its use and benefits at each level is quite disparate. An example of this is a major brewer who contracts all transport to a third party
transport provider. While the third party transport provider may utilise a CVRSS the brewing company could believe that the transport contractor may not be utilising the software correctly and therefore is considering utilising another CVRSS.

A second issue was the nature of the research instrument used. Due to the preference of the researcher a web based survey was chosen during the initial design phase. Investigations and consequential testing proved that many potential respondents would not utilise the web base research instrument. The reasons for this included lack of user acceptance and access to the internet. Given the complex structure of the sector it was important that this problem would not adversely affect the representativeness of the sample. Hence, as stated above, two different survey instruments were developed and used.

Thirdly, during the survey instrument development and refinement process both forms of the survey became long-winded and remained, to some extent, this way. This may have adversely affected the response rate. There was a range of questions that needed to be asked for framing purposes and a number that needed to be asked to establish active use of CVRSS. Unfortunately nothing could be done to reduce its size and complexity. Added to this was the complexity of a transport operation. Transport companies can operate at a number of levels including locally, regionally and interstate. These companies could conceivably operate a CVRSS for all parts of a business or just for a localised metropolitan transport operation. Similarly a CVRSS could be operated in another state yet be categorised as a local transport operation. Accounting for this in a single survey of limited length was problematic.

A preliminary review of the target population suggested that a broad approach to attracting survey participation was not going to be successful for all of the reasons detailed above. Consequently a pre-identification process was undertaken. Individuals within the targeted organisations were identified and surveys addressed specifically to them. This contributed to the relatively high response rate achieved, despite the issues outlined above.
An interesting opportunity arose as a consequence of utilising both a paper-based and web-based surveys. During the redesign process discussions with other researchers and academics suggested the possibility of testing the different response rates from web-based surveys versus paper-based surveys. While this became a distraction to the main purpose of the research which was to investigate the uptake of CVRSS, some observations can be made.

Release of the survey took place and results were measured separately for the web-based response and paper-based formats. After 2 months all results were collated and the web-based survey shut down. In total 62 responses were received out of 200 invites to participate. The results received proved valuable and did represent a reasonable opportunity to compare the use of both survey formats. According to the literature the use of web-based surveys have a number of advantages.

Advantages of Web surveys are a faster response rate; easier to send reminders to participants; easier to process data, since responses could be downloaded to a spreadsheet, data analysis package, or a database; dynamic error checking capability; option of putting questions in random order; the ability to make complex skip pattern questions easier to follow; the inclusion of pop-up instructions for selected questions; and, the use of drop-down boxes. These are possibilities that cannot be included in paper surveys (Gunn, 2006).

The responses were divided into 29 paper based surveys and 33 internet based surveys. There was no discernible difference in the “richness” of information received from either type of survey. The same number of questions was answered in either type of survey and the information was complete. Similarly there was no discernable relationship between those respondents who utilised a CVRSS and the method of survey format that they chose. Other researchers have found similar results. “There was no significant difference between the proportion of respondents who switched from the mail to the internet group and those who switched from the internet to the mail group” (Pam-Leece et al., 2006). However:
It is interesting to note that despite many of these advantages of Web surveys, Dillman, Tortora, et al. (1998) found that the response rate was greater for plain rather than fancy surveys that employed tables, graphics, and different colours (Gunn, 2006).

Further to this Gunn (2006) identified that different forms and types of web based surveys can lead to different responses. Gunn (2006) stated that web-based surveys are quite unlike other survey methods of data collection in their execution, and this difference can lead to participants acting differently when responding to Web-based surveys. Parackal (2005) claims that the best response to surveys of any type is a combination. “The best overall response rate was obtained for the approach that offered both mail and telephone survey options” (Parackal, 2005).

These issues were not well known at the time of survey development nor were the methods of web-based delivery well understood. Both surveys were exceptionally long and proved difficult to refine. Of greatest difficulty was the need to accommodate the unknown factor associated with respondents that did or did not utilise a CVRSS. In addition, the questions asked of a company that utilised a CVRSS were ostensibly different to those asked of a company that did not utilise a CVRSS. In general the questions associated with companies that operated a CVRSS were related to the decision to purchase, the benefits achieved and difficulties associated with implementation. Questions directed to those without a CVRSS were related to why they had not chosen to adopt a CVRSS and the possible reasons.

The framing or demographic questions again proved difficult to complete in a cogent and easily understood way. This is ostensibly related to the nature of the transport and distribution sector. That is, companies can operate either from one depot in one state or from many depots in many regions and/or states. Added to this is the configuration of vehicles that exist within a given fleet. They can range from small “utility” type vehicles through to large “B Double” combination heavy vehicles. Hence there is a huge variation in company type within the sector.
A final level of complication was the use of contractors. In a transport environment the term contractor generally refers to a vehicle and driver combination. It was postulated that companies with high numbers of contractors may not utilise a CVRSS on this basis.

These factors had a considerable impact on the overall direction of the survey and in many ways proved to over complicate the finished survey tool. With the benefit of hindsight the survey instrument tried to achieve too much. The overall project would have been better served by focusing on either a smaller number of companies or alternately on either companies with CVRSS or without CVRSS but not both.

Further to this, the adoption of one-on-one interviews with companies/users may have achieved a far more focused and expedient result. This would have allowed for a more in-depth review of the each respondent and provided timely feedback into the survey process on elements that did work and elements that did not.

Overall there were many limitations associated with identifying who would use a CVRSS and who is using a CVRSS. In interviewing a vendor for the final component of the research they were unable to identify who their target market was. Indeed their target market had changed considerably in a short period of time to encompass service based CVRSS (the installation of water heaters) as opposed to the traditional CVRSS applications. Further the vendor, who in their own estimation (Oracle Systems) had a major share of the market could only claim one new CVRSS client every 18 months.

On the other hand, the decision to use a focus group to delve into the decision-making process proved to be valuable and overcame some of the issues just identified.

5.3 Discussion of Results

Despite these limitations the results offer some key insights. One of these is the predominant type of freight carried by “transport companies”. Over one third (37%) responded as General Freight Carriers. General Freight Carriers can be defined in a
number of ways however a recent report by IBIS World concluded that it was made up of 8 predominant market segments:

The market for road freight transport can be divided into eight main components and their relative usage of road freight services: Manufacturing (30 %), Wholesale Trade (15 %), Retail Trade (15 %), Agriculture (10 %), Mining (10 %), Construction (10 %), Finance and Insurance (5 %), and Health and Community Services (IBIS, 2006).

This in itself is significant because the road freight industry held an estimated 22.3 % market share of the Australian domestic freight task in terms of tonne-kilometres in 2002-03 and it is estimated that 70 % of the 2.15 million tonnes of domestic freight carried in Australia was moved by trucks. Key financial information that underlines the significance of the sector includes:

- In 2004-05, industry revenue was estimated to be $16252.7 million, up 7.1 % over 2003-04, and value added was $7846.0 million. During the same period it directly employed an estimated 94850 people (IBIS, 2006).

This analysis of General Freight could lead to a number of overlaps and analysis in this way could lead to misinterpretation. It was the author’s contention at survey inception that the segments that transport companies operated in would reflect the “type of freight that they carried as opposed to the market that they served”. An example of this is that markets served may include Agriculture however from a transport perspective the type of freight might be grain or indeed raw materials.

Of interest also was the relatively small number companies that indicated that they moved parcels. Initial analysis of the population group indicated that the predominant type of transport company represented in the sector was parcel or courier companies. In addition it was initially believed that these types of companies would be the predominant CVRSS user.
To further extend this, the type of company that responded to the survey was broken into a number of groups. The major representation within this analysis was that of transport companies. In many ways the 55% depiction is not surprising as this is the traditional market for the CVRSS. This was followed by distribution, which again is not surprising.

The number of employees within the respondent organisations was considered to be a key indicator in a company’s uptake of CVRSS. The results for this series of questions indicated that the majority of companies responding to the survey employed 1-10 employees. Further to this, companies that employed greater than 50 staff were relatively under-represented regardless of the use of CVRSS. There are a number of possibilities for this. These include an inadvertent bias towards smaller organisations in defining the sample group. Alternatively, larger companies may operate in smaller groups which were better able to deploy CVRSS. Alternatively it could be claimed that companies that deployed CVRSS were smaller companies by nature and it is this type of company that see the benefit of deploying the software.

Of interest within those that did utilise CVRSS and those that didn't utilise CVRSS was the predominant number of employees. Almost two thirds (61%) of all companies that utilise CVRSS in the sample group employed between 1-10 staff. Only 38% of those that did not utilises a CVRSS employed between 1-10 employees. This finding is at odds with both the researchers’ original view and the common view held within those that market and sell CVRSS.

To make sense of this another series of questions should be considered. The question of savings achieved from the CVRSS installation could only be answered by those that had installed a CVRSS. Over half (57%) of all those that responded to this series of questions stated that the CVRSS software had achieved savings in under 12 months. When asked to qualify the form of the savings 82% of respondents indicated that they were generated from a combination of reduced overtime and kilometres travelled. On this basis the claims made by many of the commercial CVRSS providers would appear to be supported by those that have installed it.
In addition the majority of respondents had revenues less than $10,000,000. Respondents were not asked about the purchase price of the CVRSS that they installed so any conclusion that may have been attained from a match between revenue, operating costs and CVRSS costs is not possible.

One conclusion that can therefore be drawn is that whilst the majority of companies that deployed CVRSS were smaller the reason that they did so was because they could achieve cost savings. Hence it could be argued that small companies are more focussed or aware of costs and are more likely to be looking at cost reduction strategies to remain competitive. Larger companies may see their competitive advantage in terms of size, network, reliability or other factors, rather than cost.

Interestingly, 80% of those surveyed stated that the decision to purchase a CVRSS was made by either the executive management team or by the board. As the majority of those that actually purchased the technology were small, this really means owner-managers rather that company executives. Related questions indicated that the reason over 50% of respondents made the decision that they did was based upon the price of the CVRSS followed by the CVRSS functionality. This could reflect the notion that the executive level within the company is only interested in the “pay-back” period whilst the “champion” is interested in medium term profit and loss benefits.

This would indicate that, in general, companies that purchased a CVRSS made the decision based upon the savings demonstrated by the CVRSS vendor and that a determining factor was the price of the CVRSS. Whilst not indicated in any of the surveys it would appear that a return of funds deployed to acquire the CVRSS was a critical determinant in the decision to buy.

*The Return on Investment (ROI) is the primary basis for evaluating the performance of a Manager on an investment centre. The ROI is considered to be superior to any other performance measurement.* (Kimmel, Weygandt and Kieso, 2005)
This is not surprising given the nature of business and the general processes followed by many businesses but what is surprising is that the majority of these businesses would be considered small. Although further investigations are warranted to substantiate this claim, it does appear that small businesses in many instances apply the same logic to major business decisions that those in large businesses but that their size makes them even more aware of the potential that cost savings would have on their sustainability.

Difficulties associated with implementing the CVRSS were well documented in the texts. Of these the greatest was opposition presented by the drivers. In the survey sample the greatest difficulty in implementing the software was staff-related but concerned a lack of skilled staff within the organisation. This response in many ways is not surprising. The transport and distribution industry, like many manual labour sectors suffers from a lack of younger people entering. The very nature of CVRSS requires a reasonable level of computer understanding. Manual routing and scheduling does not require high levels of computer interaction. The combination therefore of older staff with lower levels of computer literacy combined with the adoption of state of the art CVRSS would cause considerable problems during any implementation phase.

The issue of driver acceptance was also found to be significant, albeit not the primary staffing issue. Over one third (36%) of those surveyed stated that driver adoption was a significant factor in the implementation of the CVRSS. This is compounded with the combining of CVRSS and Global Position System technology (GPS) which allows for the vehicle to be tracked via orbiting satellites and relayed to the CVRSS user. This issue caused a significant impediment to a major Australian transport company (Patrick) when it endeavoured to implement both a CVRSS and GPS solution in its car carrying business (. Represented by the TWU, drivers were able to obtain an injunction citing privacy concerns stopping the implementation of a proposed CVRSS and GPS solution.

The delivery of products on time and in full is known in the transport sector as Delivery in Full on Time (DIFOT).
DIFOT is a percentage. It is found by looking at a particular set of orders, for example the set of orders placed by customers between 1st March and 31st May 2005, and finding out how many of these orders were delivered in full and on time. DIFOT is the number of orders in the set delivered in full and on time, as a percentage of the total number of orders in the set.

I think it is important to work with a set of orders, as I just described. If for example, one just tries to count how many orders between 1st March and 31st May 2005 were delivered in full and on time, and make this a percentage of the number of orders received in the same period, you might not get the right answer, particularly if dealing with long delivery times. This is because some of the orders delivered in that period would have been placed prior to the period, and some orders would not have been filled within the period, so if there were any "surges" either side of the period, these could distort the final figure.

My understanding is that DIFOT should not distinguish between what is in control versus what is out of control. Separate analysis breaking down what was NOT delivered in full and on time, and showing the causes, would be good (Boland, 2005).

Only 57% of those that responded to the survey stated that they achieved some improvement in DIFOT. This is surprising given the driving force behind many of the CVRSS available is the ability to achieve defined customer delivery time windows.

A final piece of information that was concluded from the survey concerned the guarantees provided by the CVRSS vendors and improvements in customer service. Anecdotal observations made by the researcher indicated that many, if not all, software vendors provide a guarantee about the savings that would be achieved upon installation of their CVRSS. What was not clear was a link between the savings that were achieved from the CVRSS and the promise provided by the CVRSS vendor. However, this was not substantiated in the research as less than half of those surveyed reported that a guarantee by the CVRSS vendor was provided.
5.4 **Future Work**

The transport and related sectors are exceptionally complex in their structure and location. In addition, the sectors that they serve are varied and similarly complex. One of the issues future research would need to consider is this complexity. This complexity can be considered in two ways; complexity related to the CVRSS systems and complexity (subtlety) related to the human/system interface. Indeed the human interface complexity is worthy of more in depth research.

One of the key features of this research project was the reliance on a paper and internet based survey instrument. The nature of the sector being surveyed necessitated the use of a complex research instrument. This combined with the disparate and, in some instances, itinerant nature of the workforce proved to be a difficult combination to work with. Any future research would need to find even better approaches to address this issue.

Further research in the area should include a range of new technological innovations in addition to the CVRSS, including GPS. This technology, not initially a consideration at the beginning of the project, has penetrated all levels of society and is now available in many forms including simple aftermarket packages for the general public. The commercially available products have also improved in terms of cost and user friendliness.

Pre-qualification of potential survey participants will remain an issue for any future work. There are a number of reasons for this, not the least of which is identifying and qualifying those that utilise the software but also qualifying if the software utilised is in fact a CVRSS in its own right. These are questions that would need to be answered before any research project was defined.

Adoption of a particular technology is often seen to reflect a company’s attitude towards change and innovation. Future research in this area could tie the specifics of adopting a particular piece of technology to the broader nature of management and its
propensity to innovate. It could be that the attitude of the company and its management towards innovative technology is a more important factor than the particularities of the technology itself. Further to this, research into the hurdle rates (financial measures) for the adoption of a CVRSS could link well to any technical reasoning for adoption of CVRSS.

Finally, it is acknowledged that this research has focussed entirely on Victoria. It would be appropriate for any future research to extend the coverage to include the whole of Australia. This would add to the complexity of the data collection, but it would provide tremendous opportunities to make interstate comparisons and to really understand the way the Australian Transport Industry is adopting new technology.

5.5 Conclusion

This final chapter has attempted to draw the research to a conclusion. It has acknowledged some of the limitations in the research design and identified ways that these may be addressed in future studies. It has also made reference to areas that may prove fruitful in any future research into this and related topics about the Australian Transport Industry.

Finally, this research, despite its acknowledged limitations, has provided a valuable insight into both the Transport Sector itself and the way it has addressed the use of CVRSS. It is clear that while all companies face substantial cost pressures, some are far more open to this particular technological solution than others. It appears that these are more likely to be companies that have smaller fleets, employees and turnover. In the research reported here, these could therefore be described as early adopters of technological innovation. It will be interesting to see whether others follow suit.

This work will hopefully highlight to the transport and now retail sectors the potential complexities associated with not only the selection of a CVRSS but how they operate. In particular it is hoped that readers will understand that the current iteration of CVRSS
or delivery schedules is by and large based upon all previous accumulated work. Many of the issues highlighted remain relevant today. These include; the return on investment, setting up/implementation, user engagement and any benefit claims made by CVRSS vendors.
6. References


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IBIS, W. (2006), Road Freight Transport in Australia IBIS.


7. Bibliography


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Optimisation


Power, D.J. (2004). *A Brief History of Decision Support Systems*, DSSResources.COM,


Woodford, D. (2012). *Personal Conversation*


8. Appendices
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<th>Product</th>
<th>Vendor</th>
<th>Address</th>
<th>Phone</th>
<th>Fax</th>
<th>email</th>
<th>Year Introduced</th>
<th>Has desire for security affected your product and customer requirements?</th>
<th>Number of companies using software/ percentage of companies that are private fleets</th>
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<tr>
<td>ArcLogistics Route 3</td>
<td>ESRI</td>
<td>160 New York St. Redlands, CA 92373</td>
<td>(909) 793-2853</td>
<td>(909) 793-5953</td>
<td><a href="mailto:spasquin@esri.com">spasquin@esri.com</a></td>
<td>1999</td>
<td>Enterprise version available</td>
<td>y</td>
<td>2,500/50%</td>
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<tr>
<td>Compass</td>
<td>RouteLogic</td>
<td>1041 Washington Cir. Boulder Creek Pkwy, CO 80301</td>
<td>(303) 651-7250</td>
<td>(303) 704-0056</td>
<td><a href="mailto:info@routeLogic.com">info@routeLogic.com</a></td>
<td>1999</td>
<td>Import/export ability to ASCII or dBase; EDI &amp; Adhoc report generator</td>
<td>y</td>
<td>10+2%</td>
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<tr>
<td>Direct Route</td>
<td>Appplan Logistics Software, Inc.</td>
<td>1651 Greenwich Rd. Suite J Oklahoma City, OK 73109</td>
<td>(909) 805-1250</td>
<td></td>
<td><a href="mailto:sales@appplanlogistics.com">sales@appplanlogistics.com</a></td>
<td>1999</td>
<td>Optimal resource scheduling, driver/powered units required</td>
<td>*</td>
<td>175/65%</td>
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<tr>
<td>Edgar Transportation Management System</td>
<td>Edgar Management Consultants, Inc.</td>
<td>132 Pine St. Suite 202 San Francisco, CA 94104</td>
<td>(415) 998-3456</td>
<td>(415) 998-3370</td>
<td><a href="mailto:edgarinc@edgar-consultants.com">edgarinc@edgar-consultants.com</a></td>
<td>1972</td>
<td>System tailored to client requests</td>
<td>y</td>
<td>20 companies/10%</td>
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<tr>
<td>Postnhke Enterprise Routing and Scheduling System</td>
<td>Descartes Systems Group</td>
<td>120 Randall Dr. Markham, Ontario Canada N2V 3C5</td>
<td>(519) 746-8110</td>
<td>(519) 747-7038</td>
<td><a href="mailto:info@descartes.com">info@descartes.com</a></td>
<td>1987</td>
<td>Integrated, route planning, dispatch and wireless communications, customer serviceability</td>
<td>*</td>
<td>1,500 customer divisions</td>
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<tr>
<td>LOG Dispatcher</td>
<td>LOG</td>
<td>1080 Linda Vista Ave. Mountain View, CA 94043</td>
<td>(800) 367-4566</td>
<td>(650) 567-8001</td>
<td><a href="mailto:info@log.com">info@log.com</a></td>
<td>1997</td>
<td>Handles pickup &amp; delivery, handles truck compartments, handles mixed Arc-Node routing</td>
<td>*</td>
<td>300+</td>
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<tr>
<td>Intertour/Interload</td>
<td>Intertour/Interload</td>
<td>Stumpflh. 1, 76133 Karlsruhe, Germany</td>
<td>(49) 7211 9651-0</td>
<td>(49) 7211 9651-699</td>
<td><a href="mailto:info@intertour.de">info@intertour.de</a></td>
<td>1983</td>
<td>Freight optimisation, strategic planning based on delivery, multi-modal transports</td>
<td>y</td>
<td>500</td>
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<tr>
<td>Manugistics Fleet Management</td>
<td>Manugistics, Inc.</td>
<td>2115 East Jefferson St. Rocklin, MD 20852</td>
<td>(301) 984-5000</td>
<td></td>
<td></td>
<td>1985</td>
<td>Rush hour, one-way streets, LTL, splitting, frequency deliveries, bid schedule development</td>
<td>*</td>
<td>1,000 installations</td>
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<tr>
<td>Optrak4</td>
<td>Optrak Distribution Software</td>
<td>69 S. Andrews St. Hartford, 5024 1HR, Great Britain</td>
<td>(0146) 0-1992 431200</td>
<td></td>
<td><a href="mailto:sales@optrak.co.uk">sales@optrak.co.uk</a></td>
<td>2001</td>
<td>Fully customizable solutions using scripts, multi-stage optimization, industry specific optimization</td>
<td>y</td>
<td>50</td>
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<tr>
<td>Prophesy Mileage &amp; Routing</td>
<td>Prophesy Transportation Solutions, Inc.</td>
<td>204-C West Newbury St., Bloomingdale, CT 06002</td>
<td>(800) 776-6786</td>
<td>(800) 243-2629</td>
<td><a href="mailto:sales@prophesy.com">sales@prophesy.com</a></td>
<td>1984</td>
<td>Street level mapping</td>
<td>*</td>
<td>25,000 installations</td>
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<tr>
<td>Prologos Planung und Beratung</td>
<td>Prologos Planung und Beratung</td>
<td>Tempelstrasse 4, 21079 Hamburg, Germany</td>
<td>(49) 0 40 790 123 10</td>
<td>(49) 0 40 790 123 19</td>
<td><a href="mailto:info@prologos.de">info@prologos.de</a></td>
<td>1994</td>
<td>Integrated territory optimization module</td>
<td>*</td>
<td>20/90%</td>
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<tr>
<td>RoadNet 5000</td>
<td>GPS Logistics Group</td>
<td>549 Farmour Ave. Baltimore, MD 21208</td>
<td>(410) 847-1869</td>
<td>(410) 847-6246</td>
<td><a href="mailto:sales@gpslogistics.com">sales@gpslogistics.com</a></td>
<td>1983</td>
<td></td>
<td>*</td>
<td>849/99%</td>
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<tr>
<td>Roadshow System</td>
<td>Descartes Systems Group</td>
<td>120 Randall Dr. Waterloo, Ontario Canada N2V 1G5</td>
<td>Phone: (519) 746-8110 Fax: (519) 747-7038</td>
<td>1987</td>
<td>Integrated, route planning, dispatch and wireless communications, customer service visibility</td>
<td>-</td>
<td>1,500 customer divisions</td>
<td>Coca-Cola, Aimable, FedEx, Air Ground Freight Services Division</td>
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<td>RoutePro</td>
<td>CAPS Logistics</td>
<td>2700 Cumberland Pkwy Atlanta, GA 30339</td>
<td>Phone: (770) 432-9555 Fax: (770) 432-3146</td>
<td>1997</td>
<td>Multi-compartment, zone creator, load balancing</td>
<td>-</td>
<td>300+75%</td>
<td>Demler Chrysler, Ford Motor, Excel Logistics, GA-Pacific, Fresh Express</td>
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<td>RouteSmart</td>
<td>RouteSmart Technologies, Inc.</td>
<td>8850 Stanford Blvd. Suite 2600 Columbia, MD 21045</td>
<td>Phone: (800) 977-7284 Fax: (410) 290-1334</td>
<td>1989</td>
<td>Designed for newspaper, postal, utility &amp; waste management industries</td>
<td>-</td>
<td>200+950%</td>
<td>FedEx home Delivery, USPS, New York Times, Conest, 50+ municipalities</td>
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<td>Routronic 2000</td>
<td>Carrier Logistics, Inc.</td>
<td>220 White Plains Rd. Tarrytown, NY 10591</td>
<td>Phone: (914) 332-0300 Fax: (914) 332-0949</td>
<td>1985</td>
<td>Total transportation package available from pick-up through delivery with billing, rating, invoicing</td>
<td>-</td>
<td>80 all common</td>
<td>Toll Holmes, Australia, Convey Transm Services U.S.</td>
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<td>SHORTREC product suite</td>
<td>ORTEC</td>
<td>3003 Sunset Pl. #190 Atlanta, GA 30329</td>
<td>Phone: (404) 460-5245 Fax: (404) 460-4070</td>
<td>1981</td>
<td>Integrated with other ORTEC solutions, like advanced load optimization, inventory Management, etc.</td>
<td>-</td>
<td>over 100 companies/80%</td>
<td>BP, Tesoro, TNT Logistics, Lufthange, Yellow Freight System</td>
<td></td>
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<td>STARS (Smart Track Assignment and Routing System)</td>
<td>M/A TECH, Inc.</td>
<td>1301 Highway 36 Harvest, NJ 07733</td>
<td>Phone: (732) 264-4700 Fax: (732) 264-6015</td>
<td>1995</td>
<td>Short vs. long haul, multiple depot loadings, multiregional routing and scheduling for LTL operation</td>
<td>-</td>
<td>20%70%</td>
<td>Nippon-Hitsuishi Oil Company (Japan)</td>
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<td>Territory Planner</td>
<td>UPS Logistics Group</td>
<td>849 Farmout Ave. Baltimore, MD 21286</td>
<td>Phone: (410) 847-1900 Fax: (410) 847-6246</td>
<td>1983</td>
<td>-</td>
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<td>Pepsi, Sysco, Anheuser-Busch</td>
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<td>tmsRouter</td>
<td>GeoComInc</td>
<td>1300 Hawthorne Ave Smyrna, GA 30080</td>
<td>Phone: (770) 883-0295 Fax: (253) 550-8116</td>
<td>2000</td>
<td>Genetic routing algorithm, client-server architecture, TCP/IP networking, enterprise RDBMS</td>
<td>-</td>
<td>contact</td>
<td>Carroll Independent Fuel, Southern Maryland Oil, Punisher, Multi-Marques</td>
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<tr>
<td>tmsZoneDesigner</td>
<td>GeoComInc</td>
<td>1300 Hawthorne Ave. Smyrna, GA 30080</td>
<td>Phone: (770) 883-0295 Fax: (253) 550-8116</td>
<td>2001</td>
<td>Genetic routing algorithm, client-server architecture, TCP/IP networking, enterprise RDBMS</td>
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<td>contact</td>
<td>Carroll Independent Fuel, Southern Maryland Oil, Punisher, Multi-Marques</td>
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<td>Trapeze</td>
<td>Trapeze Software Group, Inc.</td>
<td>14460 N. 87th St. Suite 120 Scottsdale, AZ 85260</td>
<td>Phone: (480) 627-8400 Fax: (480) 627-8411</td>
<td>1992</td>
<td>Schedules demand-responsive services, fixed route, flex route &amp; school</td>
<td>-</td>
<td>800 products installed</td>
<td>Dallas Area rapid Transit, Capital Metropolitan Trans. Authority (Austin, TX), Spokane Transit, Van Tran (Tucson, AZ)</td>
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<td>Translogix</td>
<td>Translogix</td>
<td>Level 9, 28 Clarke Street Ch Data New M0 2005 (02) 9467 9400</td>
<td>Phone: (02) 9467 9400</td>
<td>1982</td>
<td>-</td>
<td>-</td>
<td>Rulline, Home Depot, Simmons Mattress, UPS Worldwide, 7-Eleven, Dominoes, Nestle, Pepsi America, Miller Brewing, Chicago Tribune</td>
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<tr>
<td>TruckSTOPs Routing &amp; Scheduling for Windows</td>
<td>Micro Analytics, Inc.</td>
<td>2220 Clarenden Blvd. Suite 1002 Arlington, VA 22201</td>
<td>Phone: (703) 841-0414 Fax: (703) 527-1693</td>
<td>1984</td>
<td>Capacity planning, mixed pick-up &amp; delivery, multiple-day runs, multiple depot routing</td>
<td>-</td>
<td>2,400 systems sold</td>
<td>Rulline, Home Depot, Simmons Mattress, UPS Worldwide, 7-Eleven, Dominoes, Nestle, Pepsi America, Miller Brewing, Chicago Tribune</td>
<td></td>
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<tr>
<td>VersaTrans Routing &amp; Planning Software</td>
<td>VersaTrans Solutions, Inc.</td>
<td>6 Airport Park Blvd. Latham, NY 12110</td>
<td>Phone: (800) 433-5530 Fax: (518) 796-7778</td>
<td>1982</td>
<td>Comprehensive redistricting package includes automatic route building</td>
<td>-</td>
<td>-</td>
<td>Buffalo, NY; Davis City</td>
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</table>
*Developed from an initial concept by Lionheart Publishing.*
Appendix 2: The Survey

CVRSS SURVEY

This survey is part of a larger research project sanctioned under RMIT ethics guidelines. It is designed to gain an insight into the fleet management habits of companies that use or are involved in transport, specifically in Melbourne. You have been selected to participate in the survey because of your industry participation. The results will be available to all participants once the results have been collated and published.

The research student conducting this survey is a consultant active in the logistics industry as well a lecturer at RMIT. The aim of the research is to gain an effective understanding of fleet management within a defined region.

Plain English Statement
This survey is designed to collect information from industry on the use and prevalence of Computerised Vehicle Routing and Scheduling Systems (CVRSS) in the logistics industry. As a respondent you have been selected due to your position within the industry.

Replying to the survey is strictly voluntary however the information that is being collected will be used as part of a thesis being completed at RMIT University on the subject and will be published.

Two forms of response are available, this paper based survey which when completed should be placed in the envelop provided and returned to the researcher or via a web based version which is located at www.trc-survey.org Please do not complete both the web based survey and the paper based survey as it will skew the results.

If a respondent completes either the paper based survey or the web based survey and feels as though they would like to withdraw consequently please contact the researcher. Similarly if a respondent requires clarification they can also contact the researcher. The contact details for the principle researcher are as follows;

Mark Helding
PO Box 404 Bentleigh Victoria 3204
0411 641 413
cvrss_in_oz@bigpond.com.au

Privacy and Ethics

Protecting your privacy and your personal information is an important aspect of the way this survey is designed and used. The privacy policy supports and endorses the state and national privacy regimes.

We will only collect personal information from you with your prior knowledge and consent. You can access our website home page and browse our site without disclosing personal information.

We will only use personal information provided by you for the purposes for which it was collected. We ensure that your personal information will not be disclosed to State institutions and authorities except if required by law or other regulation.

We have implemented technology and security policies, rules and measures to protect the personal information that we have under our control from: unauthorised access, improper use, alteration,
unlawful or accidental destruction and accidental loss. We will remove personal information from our system where it is no longer required (except where archiving is required).

If any question of ethics in regards to this survey needs to be addressed please contact the Chair of the Business Ethics Sub Committee, Associate Dean (Research) Professor Robert Brooks at robert.brooks@rmit.edu.au or on +61 (3) 9925 5593.

The Survey
Please carefully read the instructions below. The survey can either be completed on this form or alternately on the website www.trc-survey.org. Please take care to only fill out one survey and not fill out both the web survey and this paper based survey. The map is designed to help you navigate the survey as there will be sections that you will not need to complete and sections that will need to be completed. If you would like a copy of the results please complete the section provided.

Computerised Vehicle Routing and Scheduling Systems
Computerised Vehicle Routing and Scheduling (CVRS) is the application of computer software and hardware to assist transport professionals in reducing costs. The purpose of this Web site is to discuss the provision of Computerised Vehicle Routing and Scheduling Systems (CVRSS) and their benefit to the transport professional in the Australian Environment. I can be contacted at cvrss_in_oz@bigpond.com.au

The purpose of this survey is to create a link to those with an interest in the area of study and to assist in the completion of a thesis on the subject. A survey is linked to this document for the purposes of understanding how transport professionals schedule and route both with and without complex software.

Suppliers of this software in general are based in either the United States, Canada or Europe. Only a small number of these CVRSS are developed and produced in Australia. The History of Computerised Transport Routing and Scheduling (CVRS) has its heyday in the 1950's with IBM developing what they called the Vehicle Scheduling Problem (VSP) System. The results of this were somewhat disappointing and the project was extended to the Vehicle Scheduling Problem Extended (VSPX) but again the results were disappointing.

During the 70's and early 80's systems were developed which were mainframe based and were written in such languages as Fortran. Uptake of these systems in Australia was limited to large multinationals that had the backing of an overseas parent company, local companies unwilling to try an untested technology.

The advent of the “minicomputer” or PC in the late 1980's and the development of MS DOS based programs allowed for the mass implementation of CVRSS in businesses which had until that point chosen to wait. These systems consisted of both Australian based products and those that were imported from overseas.

The early to mid 90's saw the implementation of on screen mapping and the introduction of RASTER or hand drawn maps. RASTER maps differ to vector maps in the way they plot a position, Vector maps for example use mathematical co-ordinates to identify a location whilst RASTER maps use a representation of the vectors that make up the map. (For more information on this subject see look up Geographic Information Systems on the World Wide Web) The introduction of this initiative allowed users to see the location of delivery sites, depots and geographic impediments such as rivers etc.

The future is at present unclear in terms of CVRSS however one thing that will play a part is the World Wide Web (WWW). Web based applications which reduce the cost of software and improve its reach will eventually appear.
Is your company a transport provider to other parties aside from your own company? (Please tick)

Yes □  No □

Do you operate a Computerised Vehicle Routing and Scheduling System?

Complete All Sections.

YES □  NO □

Complete Sections 1,2,3,4,6,7.

Section 1: Location

1.1 What country are you in?

1.2 If within Australia what state do you reside in?

Section 2: Business Type

Please indicate the particulars of the business that you work in. If you work in a multinational business please only select the responses for the country that you reside in.

2.1 Please identify the type of business that you operate (Please tick the box)

Transport □
Distribution □
Courier □
Warehousing □
Third Party Logistics □
Manufacturing □

Other
2.2 How many staff are employed in your business? (Please tick the box)

1-10 □
11-20 □
21-50 □
Greater than 50 □

Other □

2.3 What was the revenue of your company last financial year? (Please tick the box)

Greater than $1,000,000 □
Greater than $1,000,000 But less than $5,000,000 □
Greater than $5,000,000 But less than $10,000,000 □
Greater than $10,000,000 But less than $50,000,000 □
Greater than $50,000,000 But less than $100,000,000 □
Greater than $100,000,000 □

2.4 Keeping in mind the answer from question 2.3 please indicate approximately the road transportation costs that can be directly attributed to your business. (If your company is a transport company the answer should be the total cost). (Please tick the box)

Greater than $100,000 But less than $500,000 □
Greater than $500,000 But less than $1,000,000 □
Greater than $1,000,000 But less than $5,000,000 □
Greater than $5,000,000 But less than $10,000,000 □
Greater than $10,000,000 But less than $50,000,000 □
Greater than $50,000,000 But less than $100,000,000 □
Greater than $100,000,000 □
2.5 Please indicate the number of independent centres that schedule and route transportation in your business.


Section 3: Fleet Size and Operations

Section 3 is split into two parts. The first part deals with vehicle trips that only occur in a metropolitan or regional area on a sustained basis. These trips would typically not be classified as an interstate journey.

The second part deals with vehicles that do complete interstate journeys on a sustained basis. If you only operate in a metropolitan or regional centre then you should fill in part one only. Similarly if you only operate interstate transportation then fill out part two only. If however you operate in both areas please complete both part one and two.

3.1 Please indicate how many metropolitan or regional centres you operate independent Computerised Vehicle Routing and Scheduling System (CVRSS) in. Independent Computerised Vehicle Routing and Scheduling System (CVRSS) can be defined as centres/systems having separate staff and reporting requirements i.e. a capital city.

3.2 Please indicate how many vehicles are controlled in each location.

<table>
<thead>
<tr>
<th>Vehicle Numbers</th>
<th>Location</th>
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3.3 Keeping in mind question 3.1 please indicate the approximate percentage for each type of driver/vehicle within your fleet. Where usage may vary from day to day a daily average should be used. The total of all driver/vehicle types should add up to 100%.

- Permanent company vehicle
- Permanent contractor including vehicle (greater than 35 hours per week)
- Casual contractor including vehicle (less than 35 hours per week)

3.4 Please select from the list, the type of freight that your company deals with predominantly. (Greater than 90%)

- Bulk Liquid Freight
- General Freight (Mixed non Express Freight)
- Parcel Freight
- Frozen or Chilled Foodstuffs
- Dry Foodstuffs
- Manufactured Goods
- Work In Progress Goods
- Bulk Raw Materials
- Money
- Passengers
- Medical
- Bulk Processed Materials

Other

3.5 Predominantly what type of vehicles are contained within your fleet? (Greater than 90%) (Please tick)

- Car (2 axles)
- Utility or Van (2 axles)
- Light Rigid Truck (Less than 4.5t)[2 axles]
- Light Rigid Truck (Less than 4.5t)[3 axles]
- Heavy Rigid Truck (Greater than 4.5t but less than 14t)[2 axles]
Heavy Rigid Truck (Greater than 4.5t but less than 14t) [3 axels]
- Semi-Trailer (Less than 20t) [4 axles]
- Semi-Trailer (Less than 20t) [5 axles]
- Semi-Trailer (Greater than 20t) [6 axles]
- Semi-Trailer (Greater than 20t but less than 25t)
- Heavy Combination (Greater than 25t)

3.6 In terms of deliveries or pickups would you say that they predominantly occur (Please tick)

- On the same day as receipt of order/instruction.

Or

- Any time after the day of order/instruction receipt.

Interstate transport operations

Please indicate the particulars of the fleet that your company utilises in its normal operation. In the case of a multinational operation please indicate only responses indicative for the country that you reside in.

3.7 Please indicate how many vehicles you control within your interstate transport operations in each location.

<table>
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<tr>
<th>Vehicle Numbers</th>
<th>Location</th>
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3.8 Keeping in mind question 3.7 please indicate the approximate percentage for each type of driver/vehicle within your fleet. Where usage
may vary from day to day a daily average should be used. The total of all
driver/vehicle types should add up to 100%.

☐ Permanent company vehicle
☐ Permanent contractor including vehicle (greater than 35 hours per week)
☐ Casual contractor including vehicle (less than 35 hours per week)

3.9 Please select from the list, the type of freight that your company deals
with predominantly. (Greater than 90%)
☐ Bulk Liquid Freight
☐ General Freight (Mixed non Express Freight)
☐ Parcel Freight
☐ Frozen or Chilled Foodstuffs
☐ Dry Foodstuffs
☐ Manufactured Goods
☐ Work In Progress Goods
☐ Bulk Raw Materials
☐ Money
☐ Passengers
☐ Medical
☐ Bulk Processed Materials
☐ Other

3.10 Predominantly what type of vehicles are contained within your fleet?
(Greater than 90%) (Please tick)
☐ Car (2 axles)
☐ Utility or Van (2 axles)
☐ Light Rigid Truck (Less than 4.5t) [2 axles]
☐ Light Rigid Truck (Less than 4.5t) [3 axles]
☐ Heavy Rigid Truck (>4.5t but less than 14t) [2 axles]
☐ Heavy Rigid Truck (>4.5t but less than 14t) [3 axels]
☐ Semi-Trailer (<20t) [4 axles]
☐ Semi-Trailer (<20t) [5 axles]
☐ Semi-Trailer (<20t) [6 axles]
☐ Semi-Trailer (>20t <25t)
□ Heavy Combination (>25t)

3.11 In terms of deliveries or pickups would you say that they predominantly occur (Please tick)

□ On the same day as receipt of order/instruction.

Or

□ Any time after the day of order/instruction receipt

3.12 Please tick the box if you use a Computerised Vehicle Routing and Scheduling System to route and schedule your interstate transport movements.

□

Section 4: Staff

*Please indicate approximately the particulars of staff that are involved in the control of your transport fleet. In the case of a multinational operation please only indicate responses indicative for the country that you reside in.*

4.1 Please indicate in total for all regions how many staff are involved in the scheduling and routing of your transport fleet.

□ 0

□ 1-3

□ 4-7

□ 7-10

□ Greater than 10

4.2 What are the prerequisites for employment in the scheduling and routing of your transport fleet? (Please tick)
☐ No experience
☐ Industry Experience Only
☐ TAFE or Equivalent
☐ Undergraduate Degree

4.3 Is your workforce Predominantly Unionised? *(Please tick)*

☐ Yes ☐ No
Section 5: Computerised Vehicle Routing & Scheduling Software

Please indicate the particulars of the software that your company utilises in its normal operation. In the case of a multinational operation please only indicate responses indicative for the country that you reside in.

5.1 Please indicate the approximate date when the Computerise Vehicle Routing and Scheduling Software was first installed. (for multiple sites please use the date of the first installation)


5.2 Please indicate the name of the software that you use?


5.3 At what level within the organisation did the decision to purchase the Computerised Vehicle Routing and Scheduling System get made? (Please tick)

- [ ] Middle Management
- [ ] Executive Management
- [ ] Board of Directors Level
- [ ] IT Manager
- [ ] Don't Know
5.4 What was the driving force behind the decision to purchase this particular Computerised Vehicle Routing and Scheduling System software package? (Please Tick)

☐ Price
☐ Functionality
☐ Price and Functionality
☐ Part of a larger Business System
☐ After market Support
☐ Technical Support
☐ Country of Origin
☐ Cost Savings
☐ Other

5.5 If other selected please indicate the type below.

Comments

☐
☐
☐
☐
☐
☐
☐
☐

Comments
5.6 Does your Computerised Vehicle Routing and Scheduling System use actual road maps to calculate distance or to calculate the distance based upon a straight line? *(Please Tick)*

- Yes
- No
- Don’t know

5.7 Does the Computerised Vehicle Routing and Scheduling System utilise in vehicle GPS tracking? *(Please Tick)*

- Yes
- No
- Don’t know

5.8 Does the Computerised Vehicle Routing and Scheduling System utilise in-vehicle computers or data capture devices? *(Please tick)*

- Yes
- No
- Don’t know

5.9 Does the Computerised Vehicle Routing and Scheduling System utilise in vehicle data output devices such as computer screens and terminals?

- Yes
- No
- Don’t know
5.10 Please indicate approximately on a daily basis, how much time it takes to produce a computerised schedule for the deliveries/pickups that need to be completed. *(Please write time below)*


5.11 Please indicate if the software provider guaranteed a direct saving on transport costs by using their software. *(Please tick)*

☐ Yes ☐ No

5.12 Please indicate the magnitude of the saving in percentage terms that the software was anticipated to provide.


5.13 **Was the saving achieved?** *(Please tick)*

☐ In Under 6 months
☐ In Under 12 months
☐ In Under 2 years
☐ Not Yet Evident

*If you answered “Not Yet Evident” to question 5.13 then go to Question 5.20*

5.14 **Was the saving produced in any of the following areas** *(please tick as many areas as applicable)*?

☐ Reduction in the amount of overtime worked
☐ Reduction in the number of Kilometres travelled
☐ Operating costs i.e. fuel, tyres etc
☐ Reduction in the number of vehicles
☐ Reduction in the number of drivers
☐ Reduction in the number of administrative staff
5.15 Did the software provider use the term route *optimisation* as part of the benefit of the software? *(Please tick)*

☐ Yes  ☐ No

5.16 If yes to above, was the term explained by the software vendor? *(Please tick)*

☐ Yes  ☐ No  ☐ Don’t know

5.17 Was the annual percentage saving in the magnitude of: *(Please tick)*

☐ Greater than 0 but less than 5%
☐ Greater than 5% but less than 10%
☐ Greater than 10% but less than 15%
☐ Greater than 15%

5.18 Was the annualised AUD saving in the magnitude of? *(Please tick)*

☐ Less than $10,000
☐ Greater than $10,000 but less than $20,000
☐ Greater than $20,000 but less than $50,000
☐ Greater than $50,000 but less than $100,000
☐ Greater than $100,000

5.19 Would you say that your company has paid for the Computerised Vehicle Routing System through savings achieved from implementation? *(Please tick)*

☐ No  ☐ Yes  ☐ Unsure
5.20 Please indicate on a scale of 1 to 5 your overall satisfaction with the software, 1 Not satisfied at all, 3 being satisfied to some extent and 5 being very satisfied. (Please tick)

☐ 1
☐ 2
☐ 3
☐ 4
☐ 5

**Section 6: Customer Service**

6.1 Did the implementation of your Computerised Vehicle Routing and Scheduling System improve your Deliveries In Time? (Please tick)

☐ No not at all
☐ Yes to a small extent
☐ Yes
☐ We don’t measure on time deliveries

6.2 If you measure Deliveries In Time please indicate the percentage number in the space provided below.

%  

6.3 If you answered yes to question 6.2, what was the percentage prior to the installation of the Computerised Vehicle Routing and Scheduling System?

%
6.4 Please detail below other measures of customer service that you business offers.


6.5 Did the Computerised Vehicle Routing and Scheduling System provide for improved delivery of customer service?

☐ Yes
☐ No
☐ Unsure

6.6 What were the major difficulties in implementing the software?

☐ Lack of skilled staff within your organisation
☐ Driver opposition to the implementation
☐ Lack of help from the software provider

Other


Comments
### Section 7: Participation details (Optional)

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<tr>
<th>Company Name</th>
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<tr>
<td>Street number</td>
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