Operations research and Information systems in the South African tourism industry

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Submitted in partial fulfilment of the requirements for the degree of

BACHELORS OF INDUSTRIAL ENGINEERING

In the

FACULTY OF ENGINEERING, BUILT ENVIRONMENT AND INFORMATION TECHNOLOGY

UNIVERSITY OF PRETORIA

OCTOBER 2010

Executive summary

Sunset Safaris and Tours is an inbound tour operator in South Africa that offers escorted and self drive tours of South Africa and also safaris further afield in Botswana Namibia, Tanzania and Kenya.

There are however many variables associated with such escorted tours and to evaluate and optimize these variables can save money, hence can the tours be conducted for less and this can give the company the competitive edge. Some of these variables are: 1) logistics management (collection of tourist, transport and destination of tourist); 2) the optimal collection and destination strategy (route planning) to be followed to minimize travel time of the tours and optimize vehicle usage; 3) proper information system to manage all tours in operation.

The main objective of the project is to minimize the cost associated with travelling between destinations by using logistical methods, operations research and also better management of information associated with tours conducted by the company. There are currently none of these systems in place to optimize the company's operations. This presents immense opportunities for improvement by implementing industrial engineering methods, theory and techniques.

This project aims to identify the methods of Industrial Engineering applicable in the tourism industry and how to implement them in the right way.

The methods used in this project require extensive research on how to apply them optimally in the tourism industry. These methods and techniques are identified and studied to better apply them in the design phase of the project (Appendixes). In this way the requirements of the company will be best achieved.

The design segment of the project will consist of an information system and a route planning formulation. This will be done to minimize logistics cost associated with a company of this nature.

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Chapter 1

Project proposal

Introduction

Tourism is a blossoming part of South Africa's economy and constitutes 3% of the country's Gross Domestic Product (GDP). The Soccer World Cup in 2010 have further increased South Africa's popularity with international visitors. The local market for local tours is also a very profitable part of a travel company's income. It is however a highly competitive market and to ensure a company's survival it should offer the best experience at the best price.

To offer these tours at the best price, it is cost that should be minimized in order to conduct the same quality of tour, but at a better price. In the case of Sunset Safaris and Tours their costs mainly consists of hiring transport and accommodation cost.

The company makes exclusive use of outsourced transport and accommodation. Because of this fact, the price of these outsourced companies is out of Sunset Safaris control and it is the cost that is not dependant on the suppliers that should be concentrated on.

The costs that can be controlled by the company are: optimally hiring transport and using the accommodation that is best suited for the tour. This is why route planning and logistics are important in the case of hiring transport and accommodation.

The study of these fields will be used to solve the problems presented in the project, and hence reduce costs associated with the tours.

Problem definition

Different modes of transport namely air, road and railway make the route planning and logistics difficult. Other variables include: destination, current location of tourists, transportation needs at location and luxury levels. All of these desire different modes of transportation. In this case the different luxury and standard levels of touring namely, cost cutter, standard and grandeur, also the three types of tours the company conduct namely Escorted, Self drive and South African specials can be considered as an independent but equivalent problem.

In addition, the total number of tourists on Sunset Safaris and Tours, the cost of hiring transportation and the cost and feasibility of tour guide hire need to be taken into account.

The motto at Sunset Safaris and Tours is "Customer Service Excellence". From the first moment the client contacts the company, until they are bid farewell on their journey back home, they will appreciate how Sunset Safaris and Tours have fully catered for all their needs and requirements.

The key to the company's customer service lies in the skill, commitment and experience of their staff and the use of outside service providers with the same level of professionalism. This project will help ensure that this promise is kept at a lower cost and without dropping any standards of the company.

Application of methods

Several ideas and modelling approaches for the determination of optimal routes can be applicable in this problem, these include: Transportation and Transhipment problems, Network models (shortest path problem), Integer programming, Travelling salesman problem, and Deterministic dynamic programming (network problem, resource allocation problem and knapsack problem).

Logistical methods applicable in this project include: global business logistics, global transportation options, the role of transportation in logistics, the basic modes of transportation, intermodal transportation, transportation management strategies, bases for rates, transportation services, network design, major location determinants and modelling approaches (optimization and heuristic models).

An information system will be created using Microsoft Access to keep track of clients' personal information and tour itinerary whilst monitoring current and future tours.

Focus of the project

The focus of the project will be on the optimization of Sunset Safaris and Tours routes to lower costs associated with the transportation of tourists between destinations.

Currently the company has no such system and this will greatly enhance the services to their customers. The literature that is used covers logistics, operations research and information systems design. All these fields need to be integrated to form the basis of the project. The problem faced by each field has been identified earlier in the project proposal.

Aim of the project

The aim of the project, as mentioned earlier, is to reduce cost between destinations, in order to deliver the same product to the tourist but at a better price (reduce transportation cost through optimizing logistics and routes). Also improve the administration of the different tours (Escorted tours, Self drive tours and South African Specials) by designing an information system.

The optimal methods that can be used in route planning and information systems and literature on similar projects that have been done in the past, have been identified. Where these methods are applicable in this project and where they can be improved upon, all this with the major function of improving the companies logistics and reducing logistics cost.

Project scope

Sunset Safaris and Tours offer different tours with different itineraries. These tours take tourists to Cape Town, the Garden Route, Soweto, Zululand, the Greater Kruger National Park, the Okavango Delta and Victoria Falls, Kenya and Tanzania, depending on the tour of their choice.

Different tours have different logistical and route demands, for example: 1) tourists arrive at the OR Tambo airport in Johannesburg, 2) the Cape Town/Garden Route part of the tour needs a tour guide and coach, whereas in the safaris sections the lodges offer their own transportation and guides; this is included in their accommodation cost. Therefore no busses or guides are needed at the safari lodges. A big challenge is optimally hiring these coaches and guides so that these resources are never idle but always busy while on the clock.

Because Sunset Safaris and Tours is a relatively new company in the industry they are in the process of developing structures to give the company the competitive edge.

Deliverables

After the completion of the research project, the author will deliver a fully functional generic algorithm that can be used to determine the optimal route for the relevant tour. It will be generic as it can be applied to any tour by simply entering the relevant information. Another deliverable will be an information system in Microsoft Access.

The output of the algorithm will be an optimized tour route that will indicate to the company exactly what, when, where and how (what vehicle, at what time, at what destination) to schedule their resources.

The information system will give the company the opportunity to manage their information easier and more efficiently.

Chapter 2

Literature review

It is beyond doubt that the process of implementing a logistics system in the tourism sector requires advanced knowledge of transportation and information systems and also knowledge about your passengers.

The hospitality services market is a very modern and competitive market, high quality tenders is of great priority. However it is the cost rather than the price that is emphasized when making decisions. Therefore it is important to pay close attention to cost analysis in certain links in the supply chain in order to gain a strong position in the market, maintain it and leave the competition behind.

According to Kordel (2008) there are quite a few areas in the hospitalities service section where it is advisable to fall back on the science of logistics. Furthermore the efficiency and quality of hospitality services can be improved through effective logistics management in the following areas:

- Supply processes
- Service production services
- Distribution processes
- Storing and warehousing processes
- Information transmission processes

In this project the information and distribution processes is created and managed to reduce total logistics cost of the company and hereby enable them to reduce the price of their service to their guests.

The transportation system is the link that connects a company's costumer, suppliers of raw material, warehouses, plants, and members of the channel (fixed points in the logistical supply chain) (Coyle, Bardi & Langley, 2003)

The link of transportation bridges the buyer seller gap and allows goods the opportunity to flow between the various points in the system. The carrier that the company uses, determines

operating efficiency of the chain and might give the company that competitive edge (Coyle et al, 2003)

Transportation is the action that creates time and place utility. Distribution therefore enhances utility. Place utility is the utility from making the product available at the right place and time utility is means that the product is delivered when is it is needed. (De Villiers et al)

The Transportation selection decision

Carrier selection is a process where the firm purchases the service of a carrier to provide a link between logistical destinations. The carrier affects the operation of the logistical system functions. It must also consider all the other costs that might occur when considering how the transport method affects the facility operation. Coyle, Bardi & Langley (2003)

Step 1

Modal choice

Basic mode

Intermodal

Step 2

Specific carrier

Legal type

Individual carrier

Transport provider
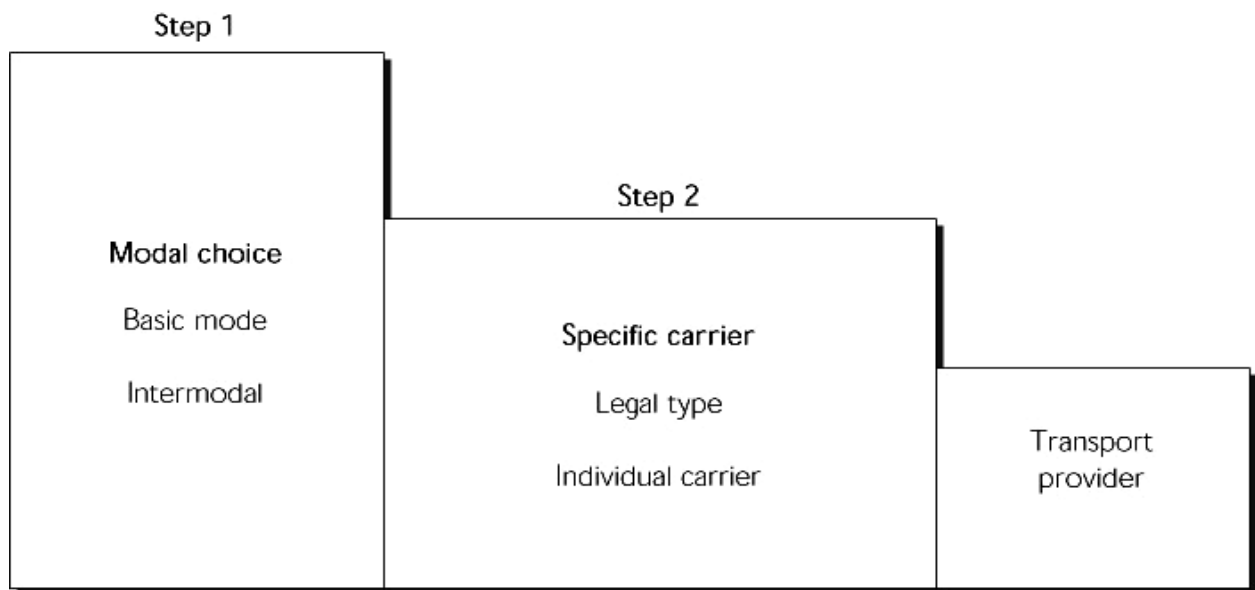
Fig 1 – The carrier selection decision making process. (Bardi et al, 2003)

Motor carriers

This transport method consists of for-hire or private carriers. For-hire carriers are classified as regulated, contract or exempt.
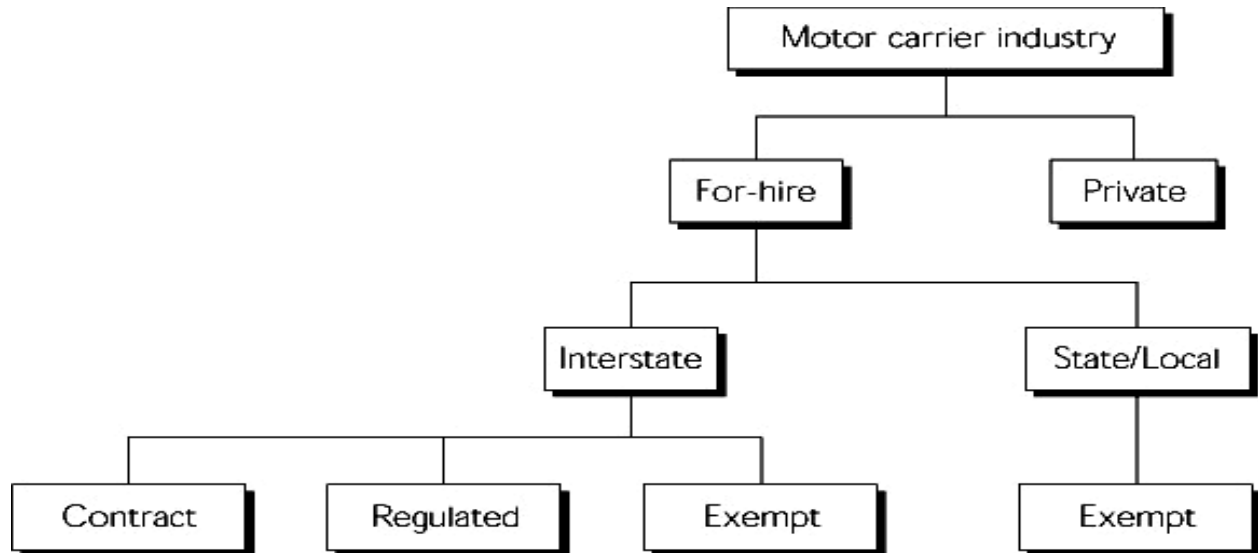
Fig 2 – Motor carrier decision making structure. (Bardi et al, 2003)

High variable cost and low fixed cost characterizes the cost structure of motor transport, it does not require extensive terminal and equipment cost, and availability is high. One of the biggest advantages is that it can provide service to any location.

Motor carriers however has got a higher long distance transit time than air carriers. Another disadvantage is that variables like traffic and weather conditions can affect transit time reliability. Coyle et al (2003)

Air carriers

The air carrier industry has a limited number of carriers and the cost is highly variable in proportion to fixed costs. The major advantage is speed; it affords low transit times over very long distances while the major disadvantage is cost (higher than motor carriers). Accessibility is somewhat limited and land carriers must be used to move customers to and from the airport. Due to flight delays reliability is also a problem. Coyle et al (2003)

- Intermodal

  Intermodal transportation refers to the use of two or more carriers in the movement of a shipment. The basic reasons for using intermodal transportation are various mode service characteristics and costs. By using this method of transport the company can maximize a certain modes advantages and minimize its disadvantages. Birdyback combines the accessibility of motor and the speed of air carriers. Coyle et al (2003)

- Number of carriers

  Reducing the number of carriers, negotiating with carriers and contracting with carriers can reduce transportation cost and make evaluation of carriers easier.

Carrier: _____ Time period: _____

Maximum Rating	Evaluation Criteria	Carrier Rating	Comments
	Meets pick-up schedules		
	Meets delivery		
	Transit time		
	Overall		
	Consistency		
	Claims		
	Frequency		
	Timely settlement		
	Equipment		
	Availability		
	Condition		
	Driver		
	Customer acceptance		
	Courtesy		
	Attitude		
	Scope of operations		
	Operating authority		
	Computer		
	Electronic billing		
	Billing		
	Errors		
	Timeliness		
	Tracing capabilities		
	Problem solving		
	Innovativeness		
	Management		
	Attitude		
	Trustworthiness		
	Financial		
	Operating ratio		
	Cash flow		
	Profitability		
	Rates		
	Accessorial charges		
	Handles rush shipments		
100	Total weighted rating		

Evaluator: _____ Date: _____

Fig 3 – Evaluation form for carriers. (Coyle et al, 2003)

Information systems

The following areas are relevant for this study:

1. Information system concepts.
2. Methods for system development.
3. System analysis and process modelling.

- Information is a key resource of an organization. It is important that an organization must use information strategically as a resource in order to achieve competitiveness. (Kendal et al, 1995)

- Information systems introduction

  Information systems in organizations receive and manage data to get useful information that helps an organization, employees, customers, suppliers and partners. (Bentley et al, 2007)
  Information systems can encompass among others computer and manual application and is instrumental to a company's day to day business. (Brookes et al, 1982)

- Information systems packages

  Existing information system packages that exist are among others, PSD: client manager and NFS rendezvous.
  Four criteria have been identified when deciding what information systems packages should be used namely:

  1. Operational feasibility. An in depth study has not yet been done that makes it difficult to analyze whether proposed system will meet requirements. A flexible system is needed that offer a variety of solutions.

2. Cultural feasibility. Installation of the new information system is accompanied by training for system users and therefore the users feel comfortable with its use.

3. Technical feasibility. Very expensive and out of budget for the company and will not be technically feasible.

4. Economic feasibility. The benefit of such system does not justify its cost and is therefore not economically feasible.

It can be seen that these packages will not be feasible for this project mainly because of its considerable cost. Bentley et al (2007)

- Methodology for system development

For the development of information system methodology is needed to ensure every aspect of the system is covered and shortcut risks are reduced. Various development and system development methodologies are used. (Bentley et al, 2007)

For this project the design process of Pisacane and Moore (1994) will be applied for the developing of an information system. The reason why this is effective is that it can be adapted to fit any project.
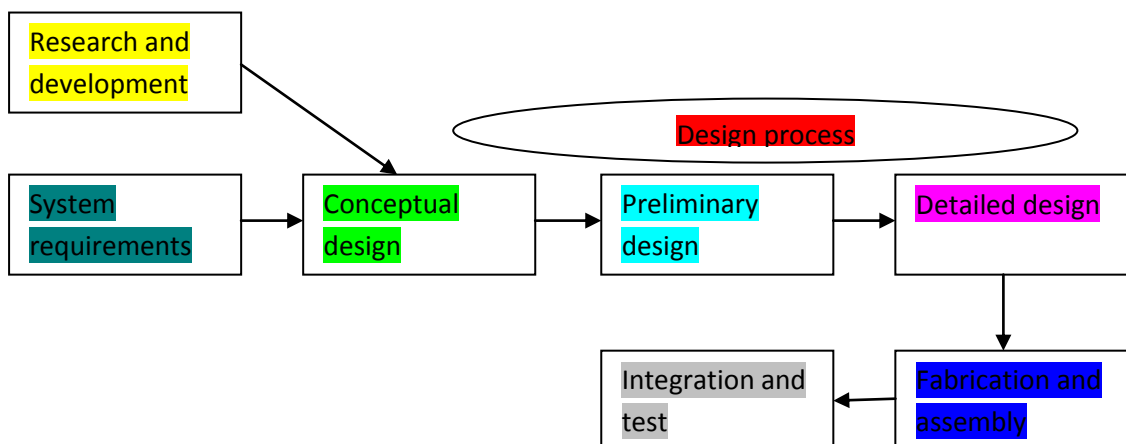
Fig 4 – View of the design process.

- Analysis approach

  The following categories should be analyzed according to Tesone (2006)

     1. System needs
     2. Products
     3. Activities
     4. Information needs
     5. Capabilities
     6. End users

  PIECES (performance, information, economics, control, efficiency and service) identify areas of problems as well as opportunities.

- Microsoft Access

  Because Sunset Safaris and Tours is a small company MS Access is the best option database software because of the following reasons:

     1. Cost effective.
     2. Supports up to 50 users.
     3. Supports up to 2GB of data.

  The above reasons are all sufficient for Sunset Safaris and Tours requirements.

- Construction

  Bentley et al (2007) states the following aims and tasks for construction and implementation of an information system:

     1. Network building and testing
     2. Database building and testing
     3. New software and programs installed and tested
     4. Development and testing of a functional system
     5. Interfaces between new and existing systems

Operations research

The travelling salesman problem is based on the fact that a travelling salesman must visit a certain amount of destinations before returning to the same point where he started from. Hereby one can find the optimal sequence of destinations that will minimize the distance of the total trip (Winston, Venkataramanan, 2003)

- According to Winston & Venkataramanan (2003) a travelling salesman can be formulated as follows:

Destinations 1, 2, 3, 4,......, N. for $i \neq j$ let c_{ij} be the distance from destination i to destination j and let $t_{ii} = M$, where M is a very large number. This ensures the correct sequence of destination (not repeating).

Also:

$X_{ij} = 1$ if salesman goes from destination i to destination j.

Solution:

$$\text{Min } z = \sum_i \sum_j c_{ij} x_{ij} \dots\dots\dots\dots\dots\dots\dots\dots (1)$$

Subject to:

$$\sum_{i=1}^{i=N} x(ij) = 1 \text{ (for } j = 1, 2, \dots, N)\dots\dots\dots(2)$$
$$\sum_{j=1}^{j=N} x(ij) = 1 \text{ (for } i = 1, 2, \dots,N)\dots\dots\dots(3)$$
$$u(i) - u(j) + Nx(ij) \leq N - 1 \text{ (for } i \neq j; i = 2, 3, 4, \dots, N) \dots\dots(4)$$
$$\text{All } x_{ij} = 0 \text{ or } 1, \text{ All } u_j \geq 0 \dots\dots\dots\dots\dots (5)$$

Objective function (1) is the total travel time between destinations.
Constraints (2) and (3) make sure that all destinations are visited.
Constraints (4) make sure that no double tours are made to relevant destinations also that results for x_{ij} are feasible, all uj values satisfies the constraints.

- To solve a travelling salesman problem the following information is needed:

1. A set of m pick up points where guests are collected. Each pick up point will receive a number of guests equal to s(i).
2. A set of n destination points where guests are visiting. Each destination point j can receive no more than d_j guests.
3. A variable expense c_{ij} incurred for a guest received at pick up point i and delivered to destination point j.

Let: x_{ij} = number of guests transported from pick up point i to destination point j.

Then the objective function for the problem is:

$$\text{Min } z = \sum_{i=1}^{i=m} \sum_{j=1}^{j=n} c(ij)x(ij)$$

subject to:

$$\sum_{j=1}^{j=n} x(ij) = s(i) \qquad (i = 1, 2, 3,\ldots,m) \ \text{(pick up constraint)}$$
$$\sum_{i=1}^{i=m} x(ij) \leq d(j) \qquad (j = 1, 2, 3,\ldots,n) \ \text{(destination constraint)}$$
$$X(ij) \geq 0 \qquad\qquad (i = 1, 2, 3,\ldots,m; j = 1, 2, 3,\ldots,n)$$

This seems efficient enough but there is a certain class of transportation problems for which this simplex is inefficient. These are called assignment problems (Winston, Venkataramanan, 2003)

- Supplementary method

Another method that can be used if this travelling salesperson turns out to be unfeasible is the Assignment problem.

An assignment problem is in general a balanced transportation problem where all demand and supplies are equal to one. Hence an assignment problem has the character that you have the knowledge of the cost of assigning each pick up point to each destination point. The cost of these problems is therefore its cost matrix. (Winston, 2003)

<u>Transportation management</u>

Typical examples of Freight management activities are (Litman, 2002)

- Improving routing and scheduling to minimize mileage and improve load factors, for example, avoiding empty back hauls.
- Organizing distribution systems to minimize vehicle trips to deliver cargo.
- Reducing freight transportation by decreasing volume sizes.
- Implementation of fleet management procedures that will minimize mileages, ensure the correct size vehicles, and ensure vehicles are maintained and run in ways that decrease external expenses such as congestion and crash risk etc.
- Improving operator instruction to ensure more efficient driving.

Chapter 3

Project analysis and design

In this project two industrial engineering methods (Operational research (route planning) and information systems design will be used to improve the logistical methods utilized by Sunset Safaris and Tours.

The design of the route planning function will be done in Lingo and the information system will be designed by utilizing Microsoft Access. The primary reasons for using these programs are amongst others their availability and low cost.

Some engineering functions will be completed before the final design can be done, which include: vehicle routing tool, procedure of transportation, use case diagram, an entity relationship diagram and performing a PIECES analysis to name a few. Throughout the project logistical considerations of transport are considered to save costs for this hospitality company. These functions need to be completed to optimally complete the designs.

The Operations research function of route planning will be utilized to optimally conduct the tours in the best fashion between the destinations of these tours. Its output conveying the best route to follow, after the input of destinations and the distances to these destinations have been entered. The input will also serve as a way to decide whether road or air transport will be used, amongst other logistical decisions.

The information system will serve to structure all the extensive information pertaining to each tour and to monitor where and when all tours are in operation. The information system will simplify the logistics management task of the organization by structuring the information pertaining to the client details, booking of specific tours, payments made, contact details of clients and information on service providers, such as transport companies and accommodation suppliers.

Logistical issues in Sunset Safaris and Tours

In this project the information and distribution processes are created and managed in order to reduce the total logistics cost of the company and thereby enable them to reduce the price of their service to their guests.

To identify the optimal methods that can be used in route planning and information systems design, literature on similar projects have been studied, and used where those methods are applicable in this project and where can it be improved.

Route planning

Sunset Safaris and Tours operations take guests to the following locations: Johannesburg, Cape Town, The Garden route, Greater Kruger National Park, Kwazulu-Natal (iSimangaliso Wetland Park and Hluhluwe-Imfolosi Game Reserve), Namibia, Botswana and East Africa (Tanzania and Kenya)

The following options are available for the clients:

- o Escorted tours. Two options in this category are available namely: Tailor made or Standard. In the Standard category, four standard tours are available namely: Leopard tour, Lion tour, Cheetah tour and Safari only tour. Each of these standard tours has different itineraries.

- o Self drive tours: Again two options are available in the Self drive category namely: Tailor made or Standard. As in the case of the Escorted tours four options are again available namely: Leopard tour, Lion tour, Cheetah tour and Safari only tour.

- o South African specials: The SA special tours have a set itinerary and are therefore always standard and also always escorted.

Routes are designed for all tailor made and standard tours as well as all South African specials. All tours for international clients will start at OR Tambo international airport and all local tours in Pretoria or Johannesburg.

Procedural protocol

The following is a summary of the current arrival to departure procedural protocol for all international clients (OR Tambo airport). The transportation process begins when the clients arrive. The task of transportation is often difficult in terms of optimal utilization of recourses seeing as each type of tour and client transportation needs are different.

Arrival of flight/s

⇓

Clients are welcomed at airport by Sunset Safaris management.

⇓

Clients are introduces to their tour guide/leader where applicable.

⇓

Clients are taken to Johannesburg accommodation to rest and refresh.

⇓

Clients embark on their tour.

⇓

Routes and transportation organized beforehand.

⇓

Tour ends at the same point as it started.
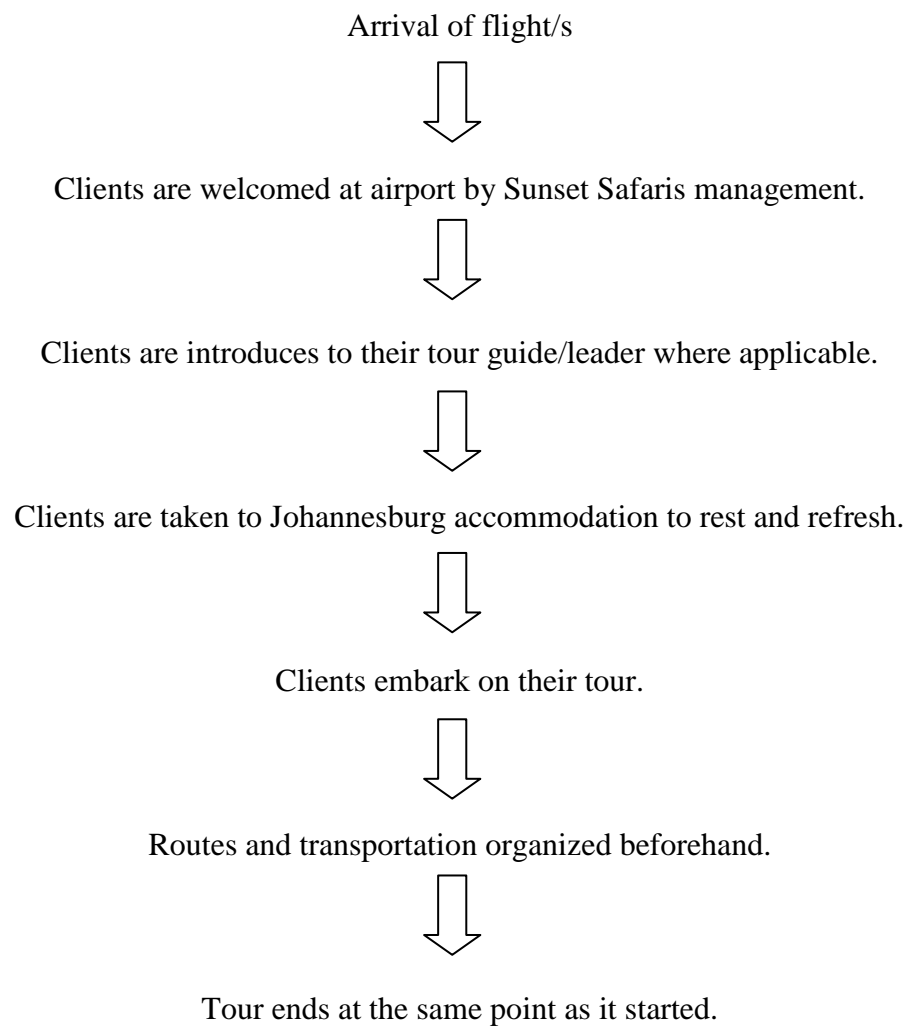
Vehicle usage and handling

Sunset Safaris and Tours mostly use motor transport but if it is more economical or distances are too long, air transport will be used. These flights will be booked for the clients in advance.

All vehicles are outsourced and to optimally hire these vehicles and flights are of big concern for the company as this is a large part of the cost of the tours. To optimally hire transport modes can reduce tour cost substantially. Vehicles should never be idle because even if the vehicle is not in use the company pays for it, therefore the vehicles should be hired so that this is never the case.

Transport in tourism is an important part of customer service and to use and handle your transport correctly can make or break the success of a tour. Different clients and different tours have different transportation needs and these needs must always be accommodated.

Operations research methods are used to develop a tool with which the routing sequence can be calculated.

Strengths and weaknesses of road transport

As can be seen Sunset Safaris and Tours will mainly use road transport except if this is unpractical and air transport will be most realistic. The following is a short explanation why it is most practical in this industry.

Strengths:

- o Door-to-door service: Transportation by road doesn't restrict vehicles to one specific path of terminals. Hence can pickups and drop offs be done straight at the destination.

- o Speed: Using road transport enables short transit times between destinations but this increase considerably when distances increase. It is also possible to take alternative routes when roads are congested, but with other transport this is not possible.

- Capacity: There are often choices between various vehicle sizes, this makes it easier to adapt and increase or decrease size as needed.

- Convenience / accessibility: By using road transport it is possible to transport guests in every nation or area in Africa.

- High frequency: A high service frequency can be maintained because of availability and high speed of delivery.

Weaknesses:

- Capacity: Sometimes the capacity of a single vehicle might not be enough to carry a touring party, if this is the case an upgrade to a larger vehicle or multiple vehicles must be considered.

- Ecological impact: The emission of environmentally unfriendly gasses is of major concern to the company partly because the environment is largely responsible for the survival of the company.

- External factors: Inclement weather conditions and unforeseen traffic delays can impact on the reliability of road transport, especially in urban area such as Johannesburg and Cape Town and places with severe weather conditions (fog, snowfall of hail)

- Shared right of way: On public roads, unlike other modes of transport, the right of way is shared with other vehicles. This could create safety and security threats, and cause unanticipated interruptions. In addition to high accident risk, road vehicles are susceptible to theft and hijackings.

As the above shows, road transport in this situation where the pros outweigh the cons will be the best mode of transport for the guests of Sunset Safaris and Tours.

Air carrier decision.

The air carrier industry has a limited number of carriers and the cost is highly variable in proportion to fixed costs.

The major advantage is speed; it affords low transit times over very long distances while the major disadvantage is cost (higher than motor carriers). Accessibility is somewhat limited and land carriers must be used to move customers to and from the airport. Due to flight delays reliability is also a problem.

Because of these considerations air carriers will be used, as stated earlier, when travelling over long distances when road transport is undesired because of long transit times and fuel cost, as well as the fact that it will be uncomfortable for the clients to travel long distances in a bus or car. In these situations the high cost and variability of air carriers will be overlooked. This type of logistics system is known as intermodal transportation.

Vehicle routing tool

The vehicle routing problem is one that every company in the tourism industry faces. Determining an optimal route for a tour can drastically reduce the total time and total distance travelled by the vehicle and this will reduce transport cost. The optimal routing pattern for Sunset Safaris and Tours vehicles will be obtained using the "travelling salesman problem" as examined in the Literature review.

The travelling salesman must visit n number of cities. Each city must be visited exactly once and the travelling salesman must decide a route that initially begins in the home city, visits all the cities and then returns to the home city. The objective is to minimize the total travel time by the travelling salesman.

The travelling salesman that is created computes the optimal sequence to follow between the various destinations to ensure that all sites are visited and the optimal route is taken.

The algorithm determines for each step when the salesman is in town i, the next city the salesman should visit which will result in the lowest possible time (and thus lowest travelling cost) spent. This process will be repeated until all the cities have been visited.

For Sunset Safaris and Tours case, the travelling salesman is the vehicle transporting the clients, and the cities are destinations that will be visited.

The input for the model is the various destinations that have to be visited by the assigned vehicle. The model then computes in which sequence the vehicle has to do its visits in order for the distance travelled to be a minimum.

The destinations to be visited are read into an Excel spreadsheet, with user interface as shown below.

Destinations								

The user starts by entering the destinations in the top blue highlighted area. The travel time between destinations is then entered into the matrix.

Destinations	jo.burg	kruger	cape town	natal	g. Route	botswana	namibia	east africa
jo.burg	0	4	14	6	10	10	20	35
kruger	4	0	19	7	10	7	25	30
cape town	14	19	0	15	3	20	12	45
natal	6	7	15	0	5	15	25	40
g. Route	10	10	3	5	0	20	15	37
botswana	10	7	20	15	20	0	10	25
namibia	20	25	12	25	15	10	0	30
east africa	35	30	45	40	37	25	30	0

Data is now linked to the LINGO model using the @OLE function in LINGO, and this is used to do the calculation which determines the optimal sequence.

To give an example: say the tour goes to 4 locations starting at Johannesburg including Cape Town, the Garden route and Kruger Park. There thus exist 4! (24) Different combinations of routes to take on this tour. The model runs every one of these permutations and calculates the total travelling time of each of these sequences. The sequence with the lowest time will then be specified.

 Also consider that when travelling distance exceeds 700 km, air transport will be used, because road transport is undesirable due to high cost and long travel time.

> o   A travelling salesman can be formulated as follows:

Suppose tour visits destinations 1, 2, 3, 4,……, N. for $i \neq j$ let c_{ij} be the time from destination i to destination j and let $t_{ii} = M$, where M is a very large number. This ensures the correct sequence of destination (not repeating).

Also:

   $X_{ij} = 1$ if salesman goes from destination i to destination j.
      0 otherwise

Solution:

$$\text{Min } z = \sum_i \sum_j c_{ij} x_{ij} \dots\dots\dots\dots\dots\dots\dots\dots\dots(1)$$

Subject to:

$$\sum_{i=1}^{i=N} x(ij) = 1 \text{ (for } j = 1, 2, \dots, N)\dots\dots\dots\dots(2)$$

$$\sum_{j=1}^{j=N} x(ij) = 1 \text{ (for } i = 1, 2, \dots,N)\dots\dots\dots\dots(3)$$

$$u(i) - u(j) + Nx(ij) \leq N - 1 \text{ (for } i \neq j; i = 2, 3, 4, \dots, N) \dots\dots(4)$$

$$\text{All } x_{ij} = 0 \text{ or } 1, \text{ All } u_j \geq 0 \dots\dots\dots\dots\dots\dots(5)$$

Objective function (1) is the total travel time between destinations.

Constraints (2) and (3) make sure that all destinations are visited.

Constraints (4) make sure that no double tours are made to relevant destinations also that results for x_{ij} are feasible and all uj values satisfy the constraints.

Information system

In the design of the information system several engineering function needed to be completed before final design can begin. This is done to better understand the functions that the system must be able to accomplish.

The basic functions which take place at Sunset Safaris and Tours are the following:

- Booking function: booking are made for a variety of tours on a daily basis.
- Managing function: tours are managed from the time they are booked until the tour is finished.
- Control function: control of information to better handle all areas of conducting a tour. Limited control processes are currently implemented.

Interaction of data

The types of data as well as the interaction of the system were modelled in a Context Data Flow Diagram. The diagram depicts the basic flow of data through the organization in terms of bookings, managing and control processes. The external factors and how they interact with each other and the current system can clearly be recognized.
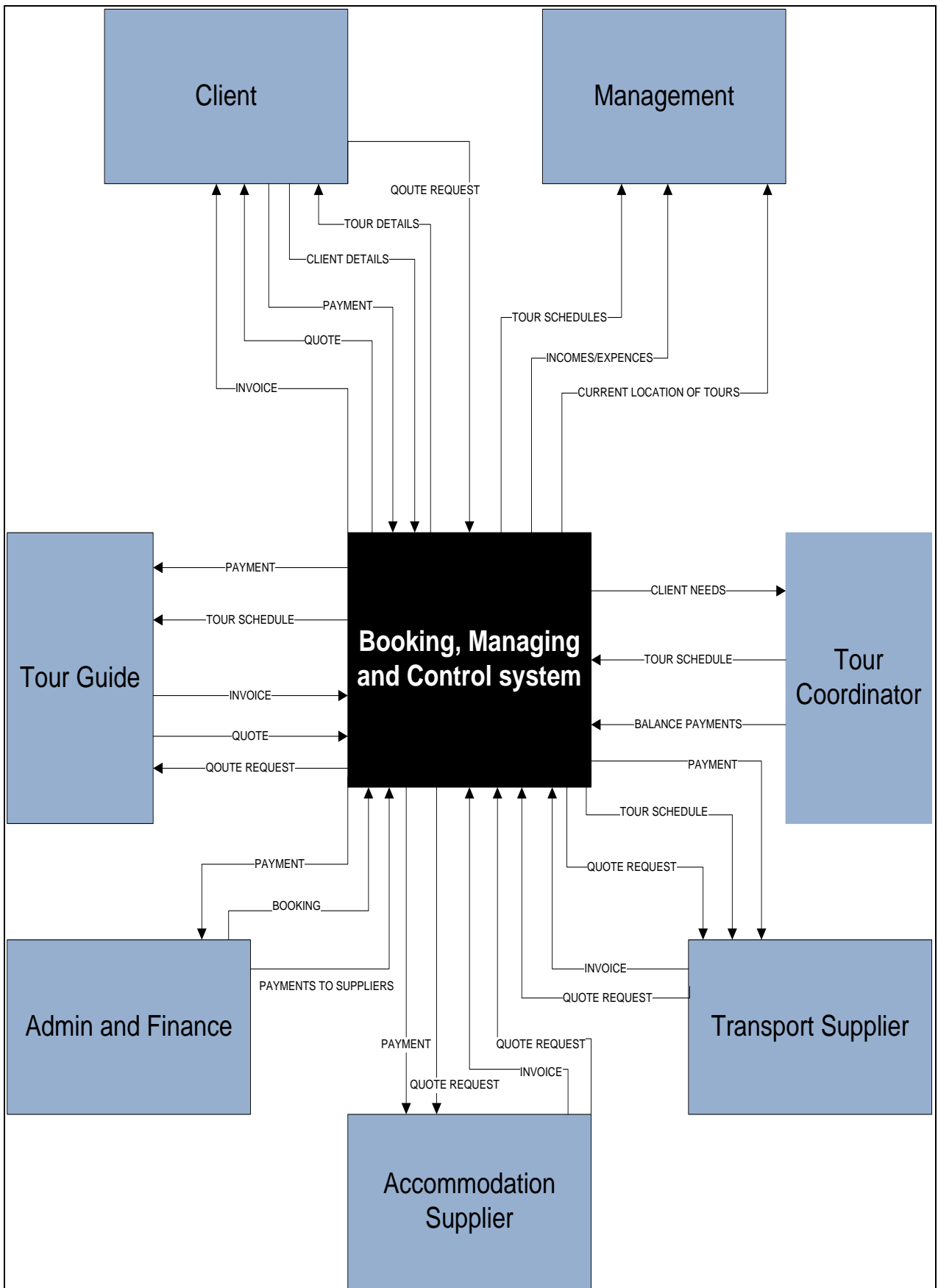
Figure 5: Context DFD

PIECES Analysis

During the scope definition phase the baseline opportunities and problems within the organization were also established in the form of PIECES (Performance, Information, Economics, Control, Efficiency, and Service). The focus of analysis was the booking procedure as well as managing and controlling various aspects of a tour.

PERFORMANCE

- Customer requests could be processed faster.
- Data could be captured faster.
- Monitoring of data made easier.

INFORMATION

- Client and tour details are not necessarily captured accurately.
- Possibility of capturing client or tour details redundantly.
- Client and tour details are not always in useful format.
- Client and tour details could be better organized.
- Client and tour details are not easily accessible to all relevant parties.
- A system is needed for backing up data.
- Time and place can be monitored for each tour in the system.

ECONOMICS

- Current accommodation cost could be too high.
- Current transport costs could be too high.
- Profits will be increased by obtaining more clients.
- The number of clients will increase with increased marketing.
- Funds are limited due to the international economic recession.

CONTROL

- There is a need for better control of resources and information.
- Better control of future and current tours.

EFFICIENCY

- Inefficient software is being used to capture and store data.
- Some tasks can be processed and executed with much less effort.
- Paperwork is excessive and is bad for the environment.
- Difficult to access information fast and easy when storage and control is done in different locations.

SERVICE

- Better customer service can be offered with improved information processes.
- Quick access to information will make service to clients and suppliers more efficient.

SWOT Analysis

This techniques aim was to carry out an in depth study in order to identify areas of opportunity, problems and causes. The SWOT analysis was conducted to identify Sunset Safaris strengths, weaknesses, opportunities and threats.

Sunset Safaris should strive to increase their strength, focus on opportunities available and decrease any weaknesses and keep a close eye on potential threats, in all the functional areas of the business.

STRENGTHS

- The organization provides high quality service.
- The employees are dedicated and enthusiastic about their work.
- They offer a unique product in the South African tourism industry.
- They have extensive knowledge of the area which sets them apart from their overseas competitors.
- The staff members are highly qualified in their specific fields.
- A quality website.
- The best quality product available and the most professional staff.

WEAKNESSES

- The organization is very young.
- They do not have any travel agents representing them overseas or a large client base.
- Their budget do not allow for expensive marketing campaigns, equipment or software.
- Their data capturing and booking methods are insufficient.
- Little knowledge of the different methods to reach potential clients.

OPPURTUNITIES

- Studies show that the South African tourism industry will boom in the next two years despite the international economic recession.
- Management and staff are willing to make improvements to current business processes.
- Possible agreements with embassies and international travel agents for conducting their tours in exchange for a commission.

THREATS

- Limited publicity and marketing opportunities.
- Larger companies attract most of their potential clients.
- Limited resources for conducting tours increases tour prices.
- Struggle to reach potential clients with their product.

Requirements

o Documentation was studied to fully understand the applicable processes. These documents provided information on specific resources needed for a particular tour.
o Interviews were conducted with management as well as employees who interact with the system. These results were documented and logical models could be constructed from the written requirements.
o System requirements were identified through the use of a Use Case Diagram.

Outputs that were obtained from the requirements phase include:

- Departmental and functional diagram
- Functional requirements
- Use Case Diagram

The purpose of the proposed system is to improve current business processes by simplifying and automating certain booking, managing and control functions. The system will enable employees to work more efficiently. Secondary stakeholders can be seen as clients and suppliers as they will also benefit from the new system.

Departmental and functional diagram

In order to understand Sunset Safaris and Tours and its functions, a function tree was constructed. There are five main departments, each with their own functions and tasks to perform.
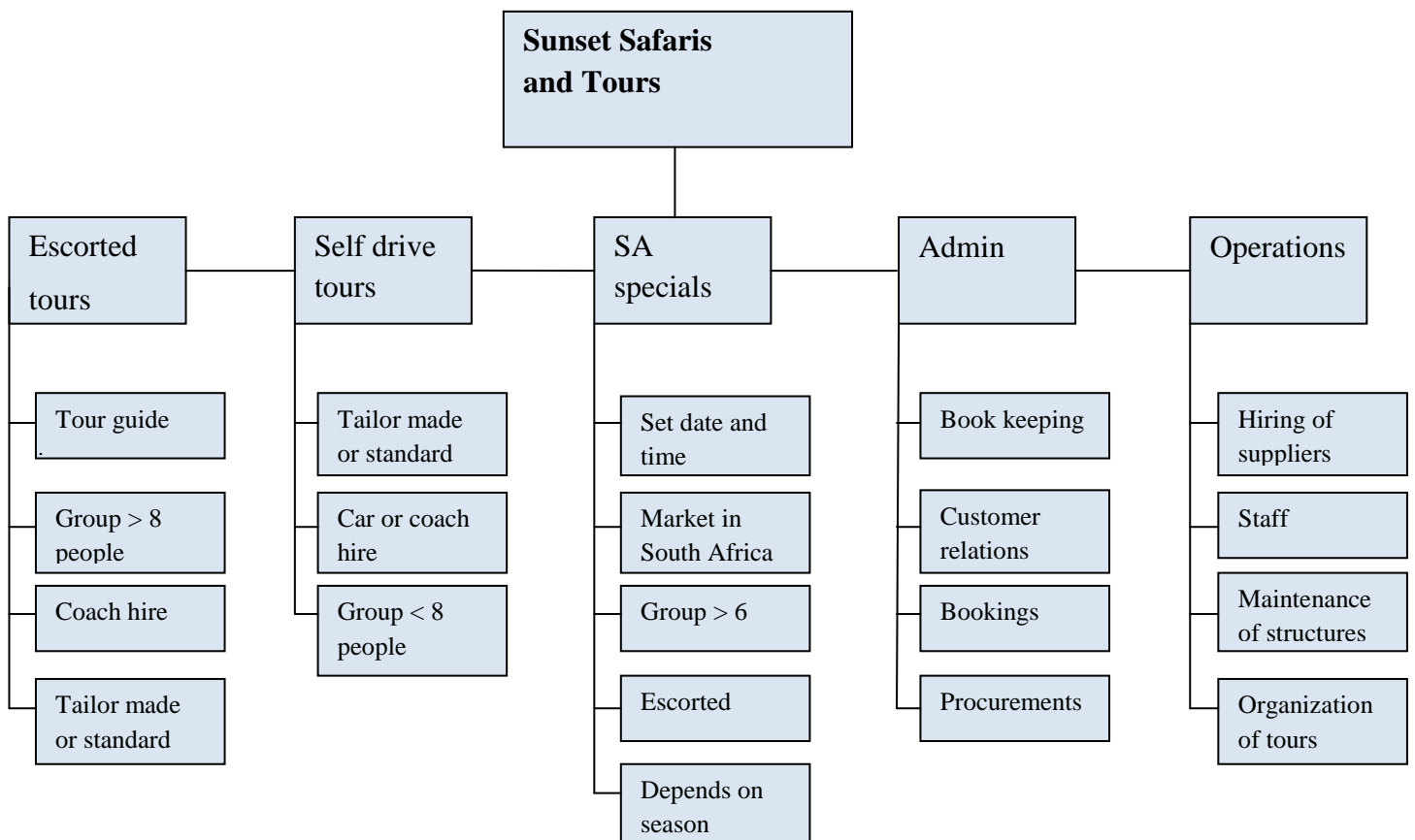

Figure 6: Function tree

Functional requirements

The requirements of the system in terms of functionality are discussed in the following section. It is divided into different tours which the system must perform.

Escorted tours

This function must:

- Capture client details.
    - Client name and surname.
    - Client telephone/cell phone number and e-mail address.
    - Address, city and country.
    - Company of employment.
    - Where did he/she hear about the company?
- Capture tour details.
    - Type of tour.
    - Dates of tour.
    - Luxury level.
    - Standard or tailor made?
    - Which standard tour does the client prefer?
    - Destinations a tailor made tour party will be visiting.
    - Number of people?
    - Any children?
    - Other requests.
    - Any special transportation or accommodation needs?
- Generate quote.
    - How are the costs made up?
    - What is the subtotal and total amount?
- Capture invoice details.
    - What is the reference number for the tours?
    - How will the client be paying?
    - What is the amount paid?

- Generate invoice.
  - Total amount.
  - Due date.

Inputs

The inputs needed for this function to be performed are:

- Client details.
- Accommodation and luxury level.
- Selection of destinations.
- Selection of transportation.

Outputs

The outputs which can be obtained from the system:

- Date of the tour.
- Schedule.
- Accommodation and date.
- Transport and date.
- Summary of all escorted bookings made.
- Summary of all accommodation and transport used.

<u>Self drive tours</u>

This function must:

- Capture client details.
  - Client name and surname.
  - Client telephone/cell phone number and e-mail address.
  - Address, city and country.
  - Company of employment.
  - Where did he/she hear about the company?
- Capture tour details.
  - Type of tour.
  - Dates of tour.
  - Luxury level.

- o Standard or tailor made?
- o Which standard tour does the client prefer?
- o Destinations a tailor made tour party will be visiting.
- o Number of people?
- o Any children?
- o Other requests.
- o Any special transportation or accommodation needs?
- o Type of transport (air/car/minibus)
- Generate quote.
  - o How are the costs made up?
  - o What is the subtotal and total amount?
- Capture invoice details.
  - o What is the reference number for the tours?
  - o How will the client be paying?
  - o What is the amount to be paid?
- Generate invoice.
  - o Total amount.
  - o Due date.

Inputs

The inputs needed for this function to be performed are:

- Client details.
- Accommodation and luxury level.
- Selection of destinations.
- Selection of transportation.

Outputs

The outputs which can be obtained from the system:

- Dates of the tour.
- Schedule.
- Accommodation and date.
- Transport and date.

- Summary of all self drive bookings made.
- Summary of all accommodation and transport used.

South African specials

This function must:

- Capture client details.
  - Client name and surname.
  - Client telephone/cell phone number and e-mail address.
  - Address, city and country.
  - Company of employment.
  - Where did he/she hear about the company?
- Capture tour details.
  - Which special?
  - Number of people?
  - Any children?
  - Other requests.
- Generate quote.
  - How are the costs made up?
  - What is the subtotal and total amount?
- Capture invoice details.
  - What is the reference number for the tours?
  - How will the client be paying?
  - What is the amount to be paid?
- Generate invoice.
  - Total amount.
  - Due date.

Inputs

The inputs needed for this function to be performed are:

- Client details.
- Destinations.
- Transportation.

Outputs

The outputs which can be obtained from the system:

- Dates of the tour.

- Accommodation and date.

- Transport and date.

- Summary of all specials bookings made.

- Summary of all accommodation and transport used.

<u>Use Case Diagram</u>

A Use Case Diagram was modelled capturing the functional requirements for the development of the system. Interactions of the actors in terms of who initiated an action and who receives an output can clearly be seen on the figure below. Use Case narratives explain the function of each numbered arrow in detail.

Potential
client

1

2

Client

5

6

7

Request
quote

Generate
quote

3

4

8

9

Tour
coordinator

Pay
outstanding
balance

Repay
balance

Pay deposit

Pay
suppliers

22

Supplier

Generate
invoice

10

19

18

20

21

Generate
provisional
booking

Generate
final
booking

11

12

17

Financial
department

Maintain
client
details

13

14

16

15

Generate
tour sheet

Maintain
calendar

Operations
manager

23

24

Generate
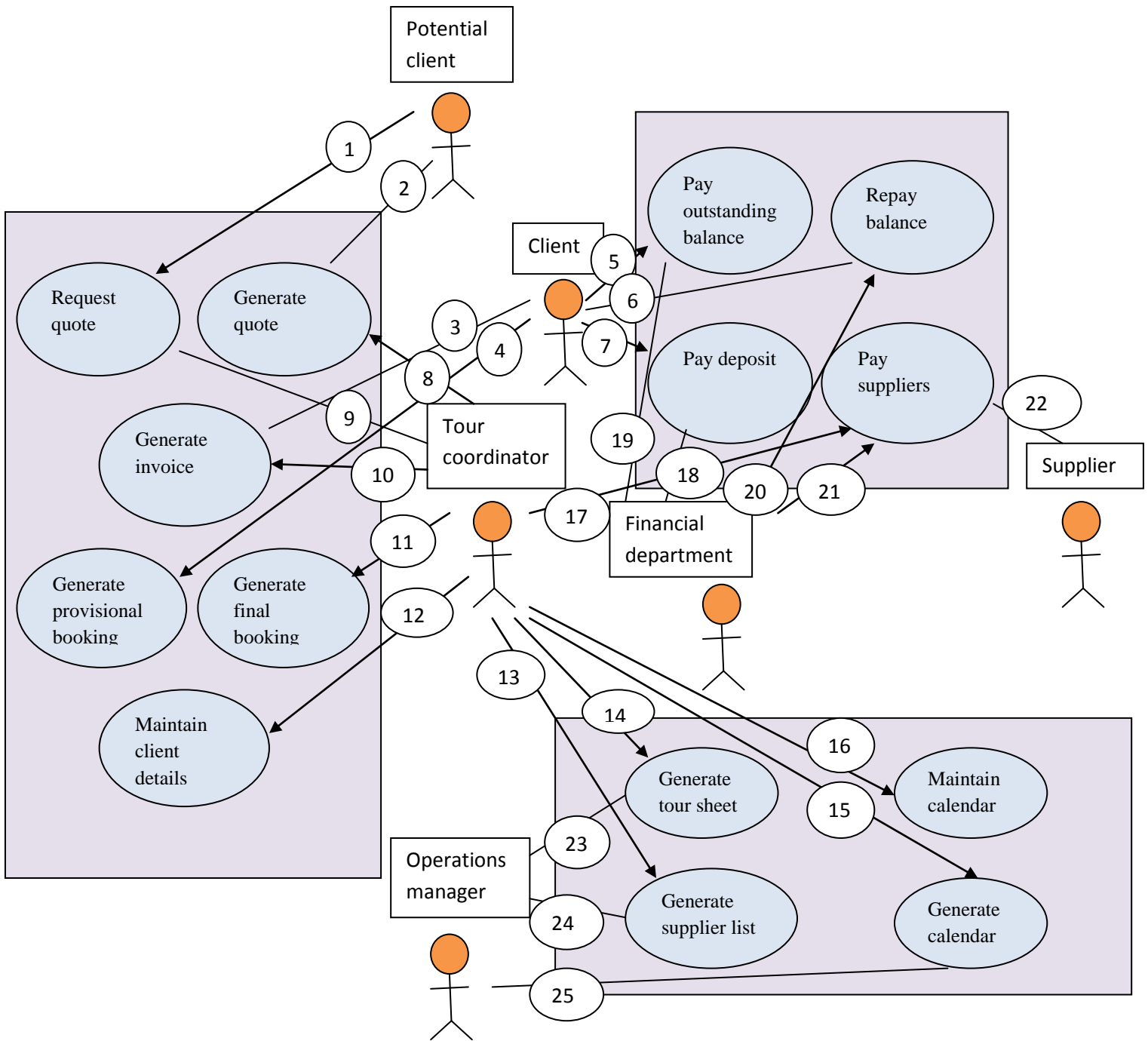supplier list

Generate
calendar

25

Figure 7: Use Case Diagram

Use Case diagram explained

Use case	a. Request quote [1,9]
Description	A client requests a quote for a tour.
Actors	Client (primary) Tour coordinator
Steps	1. Client contacts Sunset safaris 2. Client provides personal details 3. Client requests your specifications
Variations	Client may phone the company or send an e-mail.
Non-functional	The time to capture client details and tour specifications should not take more than 10 minutes depending on detail and method of communication.

Use case	b. Generate quote [8,2]
Description	A quote is generated according to the clients' request.
Actors	Tour coordinator (primary) Client
Steps	1. The tour coordinator enters additional information into system. 2. The system generates a quote. 3. Quote is sent to the client. REPEAT THESE STEPS UNTIL 4. the client is satisfied or not interested
Variations	Quote is sent by e-mail or fax.
Non-functional	Time to generate the quote (get prices of transport/accommodation/tour guides) and sent to client, should not take longer than 24 hours.
Issues	The original quote might not be exactly what the client wants (luxury levels or destinations).

Use case	c. Generate provisional booking [4]
Description	The client accepts the quote and initiates a provisional booking.
Actors	Client (primary)
Steps	1. The client approves the quote. 2. A provisional booking is made on the system.
Variations	The client confirms via phone, fax or e-mail.

Use case	d. Generate invoice [10,3]
Description	An invoice including all the details including balances and due dates is generated and sent to the client.
Actors	Tour coordinator (primary) Client
Steps	1. Information is entered into the account section. 2. The invoice is generated and sent to the client.
Variations	The invoice can be: initial, after deposit payment or balance to be paid back invoices.
Non-functional	The invoice must be sent immediately after the client approves the quote.

Use case	e. Pay deposit [7,18]
Description	The client pays the deposit as indicated on the invoice.
Actors	Client (primary) Financial department
Steps	1. The client makes a payment into Sunset safaris account. 2. The client sends a proof of payment to Sunset safaris. 3. The financial department receives the proof. 4. The financial department notifies the tour coordinator that the payment has been made.

Use case	f. Generate final booking [11]
Description	After the proof of payment has been received, the tour coordinator generates the final booking.
Actors	Tour coordinator (primary)
Steps	1. The final booking is generated on the system.

Use case	g. Pay outstanding balance [5,19]
Description	The outstanding balance according to the invoice is paid.
Actors	Client (primary) Financial department
Steps	1. The client receives the new invoice. 2. The client makes a payment into Sunset safaris account. 3. The client sends a proof of payment to Sunset safaris. 4. The financial department receives the proof. 5. The financial department notifies the function coordinator that the outstanding balance has been paid.

Use case	h. Generate tour sheet [14,23]
Description	The client requirements are used to generate a tour sheet which contains details about each tour.
Actors	Tour coordinator (primary) Operations manager
Steps	1. The tour coordinator enters information onto the system. 2. The tour sheet id generated by the system.

Use case	i. Generate supplier list [13,24]
Description	The client requirements are used to generate a list of all suppliers used in the different tours.
Actors	Tour coordinator (primary) Operations manager
Steps	1. The tour coordinator enters information into the system. 2. The list of suppliers is generated by the system.

Use case	j. Pay suppliers [17,21,22]
Description	The suppliers are paid for their services according to invoices sent to the company.
Actors	Tour coordinator (primary) Financial department Suppliers
Steps	The tour coordinator makes bookings for the correct suppliers and receives invoices to be paid by the financial department to these suppliers.

Use case	k. Repay balance [20,6]
Description	The security deposit less breakage is paid back to the client after the tour has taken place.
Actors	Financial department (primary) Client
Steps	1. The client receives a new invoice. 2. The financial department makes a payment into the clients account.
Non-functional	The repayment should be paid within 5 days of the tour.

Use case	l. Generate calendar [15,25]
Description	By request of the operations manager a calendar can be generated showing the dates and tours on operation on any particular day.
Actors	Tour coordinator (primary) Operations manager
Steps	1. The tour coordinator keeps the calendar up to date by entering relevant information about all the tours onto the calendar. 2. The operations manager pulls the calendar for useful day to day information..

Logical design

The following diagrams were used to model the functional requirements:

- *A functional decomposition diagram*: this provides a top down structure of the proposed system. The diagram is divided into 5 subsystems, namely the SA specials subsystem, the Self drive tours subsystem, the Escorted tours subsystem and the External suppliers' subsystem. Each subsystem will perform a few main functions.

- *Entity relationship diagram*: from which the information system can be constructed.
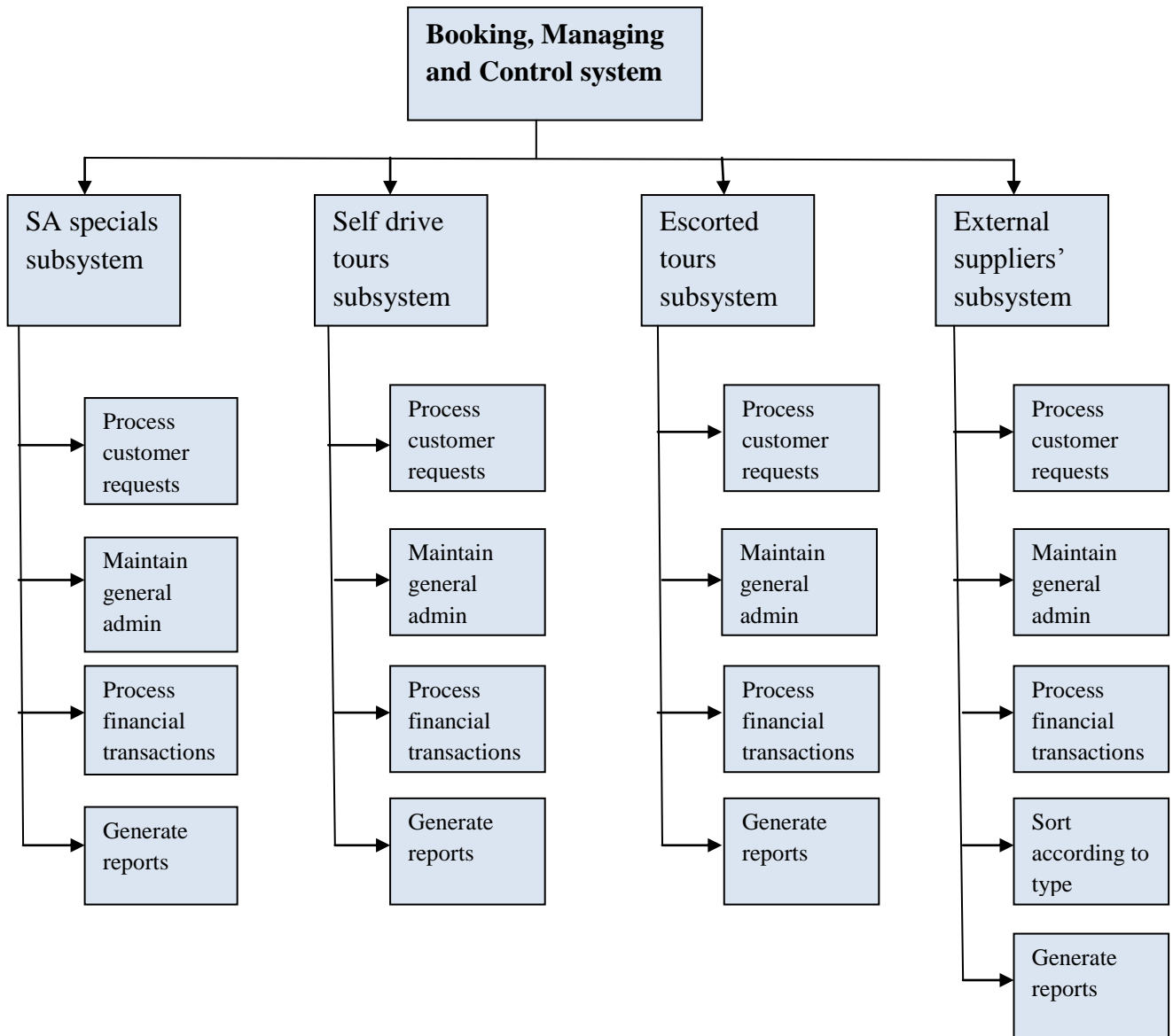
Functional decomposition

```
                    ┌─────────────────────┐
                    │  Booking, Managing  │
                    │  and Control system │
                    └─────────────────────┘
                              │
      ┌──────────────┬────────┴────────┬──────────────┐
      │              │                 │              │
┌──────────┐  ┌──────────┐     ┌──────────┐   ┌──────────┐
│ SA       │  │ Self     │     │ Escorted │   │ External │
│ specials │  │ drive    │     │ tours    │   │ suppliers'│
│ subsystem│  │ tours    │     │ subsystem│   │ subsystem │
│          │  │ subsystem│     │          │   │           │
└──────────┘  └──────────┘     └──────────┘   └──────────┘
```

SA specials subsystem	Self drive tours subsystem	Escorted tours subsystem	External suppliers' subsystem
Process customer requests	Process customer requests	Process customer requests	Process customer requests
Maintain general admin	Maintain general admin	Maintain general admin	Maintain general admin
Process financial transactions	Process financial transactions	Process financial transactions	Process financial transactions
Generate reports	Generate reports	Generate reports	Sort according to type
			Generate reports

Figure 8: Functional Decomposition Diagram

Entity relationship diagram

The following data model was used to construct the information system. The ERD was broken down into each functional area. All types of tours are combined due to their similarity.

In the figure the relationships (zero-to-many, one-to-many, etc.) is indicated, as well as entities and their attributes. Next to these attributes it is indicated whether they are the entities Primary key (PK), Alternate key (AK) or Foreign key (FK). Attributes are easily understandable and self explanatory.

- o *Client entity*: ClientID is the unique identifier of the entity. For one client there can be zero-to-many bookings.

- o *Booking entity*: Booking = unique identifier. For each booking there can be many-to-many accommodations, guides, transport and miscellaneous attributes, hence the nonspecific relationships (Accommodation per booking, Transport per booking, Guide per booking and Miscellaneous per booking).

- o *Associative entities*: their unique identifiers are AccomodatioperbookingID, TransportperbookingID, GuideperbookingID and MiscellaneousperbookingID.

- o *Accommodation, Transport, Guide and Miscellaneous entities*: AccomodationID, TransportID, GuideID and MiscellaneousID are their unique identifiers.

- o *Associative entities 2*: again there exists a situation where there are a many-to-many relationships between related entities hence another four associative entities is needed namely Tour per accommodation, Tour per transport, Tour per guide and Tour per miscellaneous with their unique identifiers being TourperaccomodationID, TourpertransportID, TourperguideID and TourpermiscelaneousID.

- o *Tour entity*: TourID = unique identifier. When it comes to this stage of the system all information should already have been entered into the system.
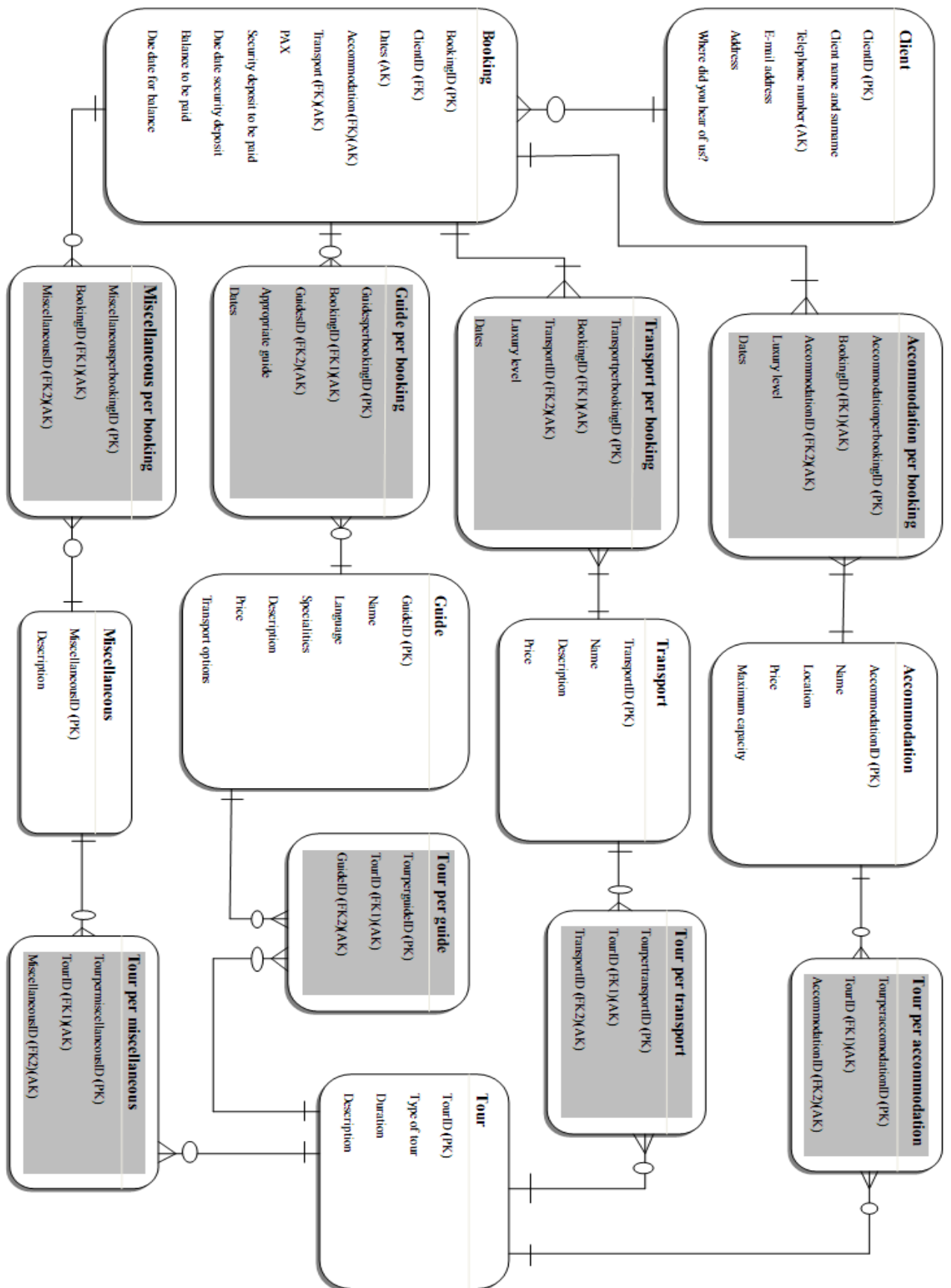
Figure 9: Entity Relationship Diagram

Summary

It is beyond doubt that the process of implementing a logistics system in the tourism sector requires advanced knowledge of transportation systems, information systems and customer behaviour.

The hospitality services market is a modern and competitive market where high quality tenders is of great priority. However, it is the cost considerations rather than the price that is emphasized when making business decisions. Therefore it is important to pay close attention to cost analysis of certain links in the supply chain in order to gain a strong position in the market, maintain it and leave the competition behind.

The logistics and operations management of the company were intensively studied in order to gain a better understanding of the business dynamics and the complexities of the industry as a whole. The aim of this was to implement a transportation management system that would lower transportation cost by improving the routes of the tours.

What resulted from the study was that there are potentially huge benefits that can be gained from implementing industrial engineering theory and techniques in the logistics and tourism industry.

Sunset Safaris and Tours realized that their current booking, resource management and control management processes are not carried out efficiently. Therefore a system is designed which will aid in improving the companies booking procedure and management and controlling the allocation of their resources.

The problem description and operations analysis of the project was explained above. A description of the tools and techniques which could be used to achieve the aim of the project was also highlighted. The design phase of then project will be addressed in the forthcoming appendices.

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Information system: User manual and Reports

1. Open the information system from the desktop.
2. It is optional for the user to be prompted for a password, if privacy is an issue.
3. The main menu shown below, will appear:

  - The Capture tour details button will open the Tour details form, Fig 12.

  - The Capture client details button will open the Client details form, Fig 11.

  - The View accommodation suppliers' button will open the Outsourced accommodation report, Fig 13.

  - The View transport suppliers' button will open the Outsourced transport Report, Fig 14.

  - The View all bookings button will open the All bookings Report, Fig 15.

  - The View tour schedules button opens a certain tours schedule as a report, Fig 16.

  - The Capture accommodation supplier button will open the Add accommodation supplier form, Fig 17.

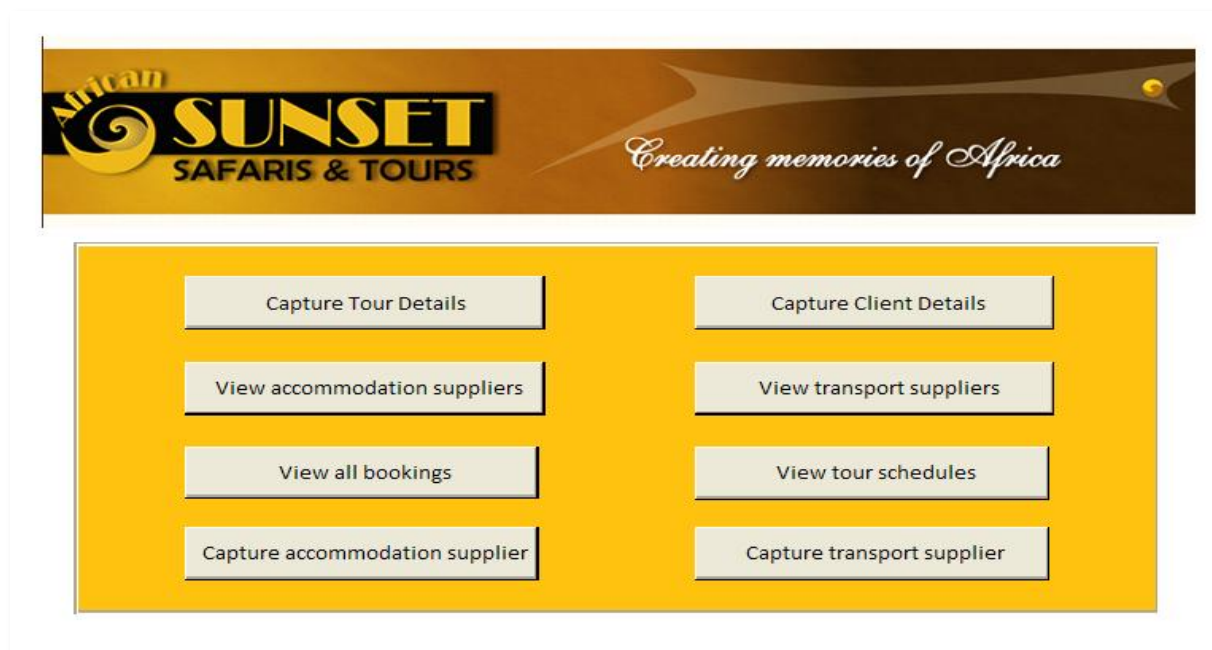 - The Capture transport supplier button will open the Add transport supplier form, Fig 18.

Fig 10 – main menu

Contact person details

The Contact person details form allows the user to capture all the personal details of the clients by entering the fields in this form.

Navigation between clients is possible through the arrow buttons and a new field can be entered by clicking on the 'add new' button. The user can return to the main menu by clicking on the 'main menu' button.

Fig 11 – Contact person details

Tour details

The Tour details form enables the user to capture all the details about a tour that the company will handle. When the information is entered into the specific fields all the information will be available for future reference.

By clicking on the quote, invoice or schedule buttons the fields will be saved and the desired report will be opened. Again buttons are available to add a new tour, go back to the main menu and to navigate between the tours.

Fig 12 – Tour details

Outsourced accommodation Report

The Outsourced accommodation report shows all the accommodation suppliers used in the tours. This report will help the company to keep track of its different tours in operation and will also help when looking for accommodation specifics when creating a tour for clients. The fields in this report are sufficient for the details of each supplier and what they offer.

Fig 13 – Outsourced accommodation

<u>Outsourced transport Report</u>

As in the Outsourced accommodation report this report is needed for the keeping track of
what the different suppliers have to offer and which supplier will be suited for the different
tours.

Fig 14 – Outsourced transport

All bookings Report

The All bookings report shows all the booking for a certain period, and some of the relevant details associated with the particular tours. This is an important report when tracking tours or looking for a certain tour and its details.

TourType	ContactPerson	DateStart	DateEnd
Self-drive Tour	Archie Japaridze	2010/09/30	2010/10/07
Self-drive Tour	Wikus Theron	2010/10/01	2010/10/08
Escorted Tour	Danie Theron	2011/02/01	2011/02/20
Self-drive Tour	Joost Loeb	2011/04/13	2011/04/27
Self-drive Tour	Mike du Toit	2010/09/29	2010/09/30
SA Special	Louis Hugo	2010/09/29	2010/10/01
Escorted Tour	Wessel Oosthuysen	2010/09/29	2010/09/30
SA Special	Nihann van Rooyen	2011/07/01	2011/07/08
Escorted Tour	Maryke Steenkamp	2010/09/30	2010/10/09

Fig 15 – All bookings

Tour Schedule report

This report shows a specific tours schedule and other relevant information. This is an important report to keep track of the tours that is currently in operation and the dates that the tour will be in operation.
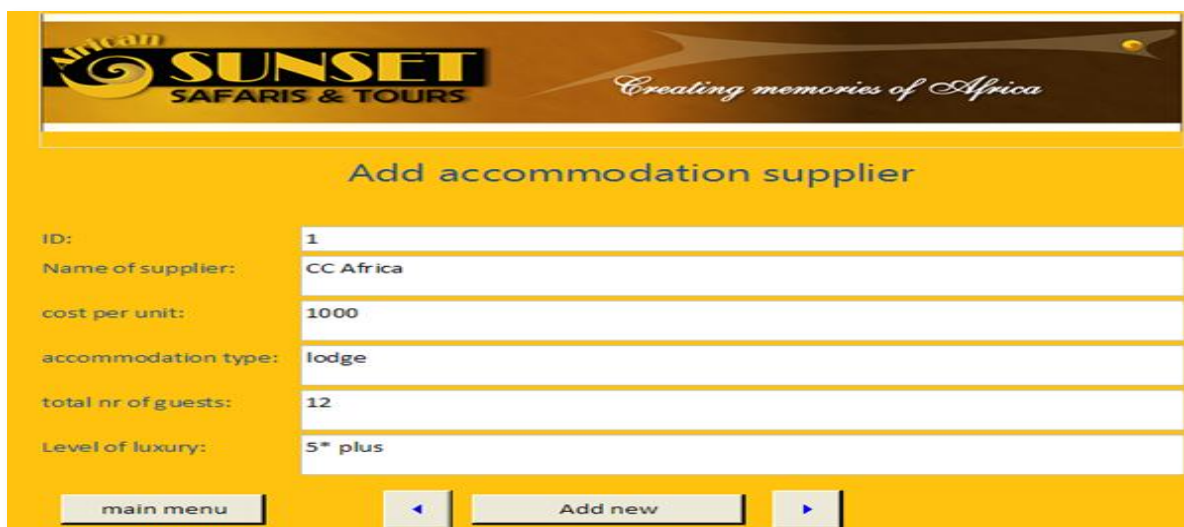
Fig 16 – Tour schedule

Add accommodation supplier

When a new supplier will be used its details will be entered in this form and then saved in the Outsourced accommodation report by the system. Navigation buttons are present for convenience.

Fig 17 – Add accommodation supplier

Add transport supplier

As in the Add accommodation supplier form, any new transport supplier can be entered into the form and will be saved on the Outsourced transport report. As in the previous form the navigation buttons can be used as in other reports.

Fig 18 – Add transport supplier

Tour Quote report

A quote is created from the Tour details form that can be sent to the client after all the relevant information has been entered. Some tour information is present on the report but if the company would like to add further fields, or change the current design to be more sufficient for a quote to be sent to a client, it is possible.

When the quote button on the Tour details form is clicked the total cost of the specific tour is automatically calculated and the information saved and the report opened.

Tour Quote

TourType	Pax	ContactPerson	DateStart	DateEnd	TotalTransportCost	Total Accommodation cost
SA Special	7	Nihann van Rooyen	2011/07/01	2011/07/08	R 45,000.00	R 80,000.00
				Total Cost of Tour:	R 125,000.00	

Invoice report

This report creates an invoice that can be sent to client after a payment has been made. This report is created from the Tour details form where the information is saved and the report is opened.

Relevant information is shown in the invoice and the total cost of the tour is calculated. Again the company can change the form according to their specifications.

Invoice

ReferenceNumber	MethodPayment	Total Transport Cost	Total Accommodation Cost	PaymentDate
SS05	Cash	R 5,000.00	R 90,000.00	2010/09/14
		Total Cost of Tour:	R 95,000.00	

Fig 19 – Tour Quote and invoice

Escorted tours report

This report shows all the escorted tours for a certain period with some important information shown in the report that will be used to manage the escorted tours.

ID	5
TourType	Escorted Tour
Standard	Tailor made
WhatStandard	
Destination	Garden route, Cape Town
Luxury	Five Star Plus
Fax	1
Children	0
ContactPerson	Danie Theron
DateStart	2011/02/01
DateEnd	2011/02/10
PaymentDate	2010/12/20

ID	3
TourType	Escorted Tour
Standard	Standard
WhatStandard	lion
Destination	Cape Town, garden route, Johannesburg, Kruger Ntional Park
Luxury	Three Star
Fax	4
Children	0
ContactPerson	Wessel Oosthuysen
DateStart	2010/09/29
DateEnd	2010/09/30
PaymentDate	2010/09/08

Fig 21 – Escorted tours

Self drive tours report

This report shows all the self drive tours for a certain period and also some useful information to better manage the self drive tours.

Fig 22 – Self drive tours

<u>SA Specials report</u>

This report shows the clients on the South African specials tours for a certain period and some useful information about the tour and the individual clients.

Fig 23 – SA specials

Appendix B

Operations research design

1. Lingo input for vehicle routing IP formulation

```
SETS:
DESTINATION/1..4/:U;
LINK(DESTINATION,DESTINATION):DIST,X;
ENDSETS
DATA:
DIST = @OLE('C:\Documents and Settings\Wikus Theron.SONOP-135DB2247\My Documents\Skripsie
\ABCDE.XLS','Dist');
ENDDATA
N=@SIZE(DESTINATION);
MIN=@SUM(LINK:DIST*X);
@FOR(DESTINATION(K):@SUM(DESTINATION(I):X(I,K))=1;);
@FOR(DESTINATION(K):@SUM(DESTINATION(J):X(K,J))=1;);
@FOR(DESTINATION(K):@FOR(DESTINATION(J)|J#GT#1#AND#K#GT#1:
U(J)-U(K)+N*X(J,K)<N-1;);
@FOR(LINK:@BIN(X););
END
```

2. LINGO output for vehicle routing IP formulation

```
Global optimal solution found at step:              84
 Objective value:                            3200.000
 Branch count:                                     14

                  Variable           Value      Reduced Cost
                         N        4.000000         0.0000000
                    U( 1)         0.0000000        0.0000000
                    U( 2)         2.000000         0.0000000
                    U( 3)         1.000000         0.0000000
                    U( 4)         0.0000000        0.0000000
               DIST( 1, 1)        0.0000000        0.0000000
               DIST( 1, 2)        1000.000         0.0000000
               DIST( 1, 3)        1700.000         0.0000000
               DIST( 1, 4)        500.0000         0.0000000
               DIST( 2, 1)        1000.000         0.0000000
               DIST( 2, 2)        0.0000000        0.0000000
               DIST( 2, 3)        400.0000         0.0000000
               DIST( 2, 4)        1200.000         0.0000000
               DIST( 3, 1)        1700.000         0.0000000
               DIST( 3, 2)        400.0000         0.0000000
               DIST( 3, 3)        0.0000000        0.0000000
               DIST( 3, 4)        1300.000         0.0000000
               DIST( 4, 1)        500.0000         0.0000000
```

```
                DIST( 4, 2)        1200.000           0.0000000
                DIST( 4, 3)        1300.000           0.0000000
                DIST( 4, 4)        0.0000000          0.0000000
                   X( 1, 1)        0.0000000          0.0000000
                   X( 1, 2)        0.0000000          1000.000
                   X( 1, 3)        0.0000000          1700.000
                   X( 1, 4)        1.000000           500.0000
                   X( 2, 1)        1.000000           1000.000
                   X( 2, 2)        0.0000000          0.0000000
                   X( 2, 3)        0.0000000          400.0000
                   X( 2, 4)        0.0000000          1200.000
                   X( 3, 1)        0.0000000          1700.000
                   X( 3, 2)        1.000000           400.0000
                   X( 3, 3)        0.0000000          0.0000000
                   X( 3, 4)        0.0000000          1300.000
                   X( 4, 1)        0.0000000          500.0000
                   X( 4, 2)        0.0000000          1200.000
                   X( 4, 3)        1.000000           1300.000
                   X( 4, 4)        0.0000000          0.0000000

                   Row      Slack or Surplus        Dual Price
                     1        0.0000000             0.0000000
                     2        3200.000             -1.000000
                     3        0.0000000             0.0000000
                     4        0.0000000             0.0000000
                     5        0.0000000             0.0000000
                     6        0.0000000             0.0000000
                     7        0.0000000             0.0000000
                     8        0.0000000             0.0000000
                     9        0.0000000             0.0000000
                    10        0.0000000             0.0000000
                    11        3.000000              0.0000000
                    12        0.0000000             0.0000000
                    13        5.000000              0.0000000
                    14        2.000000              0.0000000
                    15        3.000000              0.0000000
                    16        0.0000000             0.0000000
                    17        1.000000              0.0000000
                    18        2.000000              0.0000000
                    19        3.000000              0.0000000
```

Interpretation of output

Destinations	Kruger	Garden Route	Cape Town	J'burg
Kruger	0	1000	1700	500
Garden Route	1000	0	400	1200
Cape Town	1700	400	0	1300
J'burg	500	1200	1300	0

The sequence of the trip will be: Kruger National Park to Johannesburg, from Johannesburg to the Garden Route, the Garden Route to Cape Town and back. This will result in an objective value of 3200 that will be the total distance travelled in this particular tour.

```
Global optimal solution found at step:                84
Objective value:                              3200.000
Branch count:                                       14

                    Variable           Value        Reduced Cost
                    X( 1,  1)       0.0000000          0.0000000
                    X( 1,  2)       0.0000000          1000.000
                    X( 1,  3)       0.0000000          1700.000
                    X( 1,  4)       1.000000           500.0000
                    X( 2,  1)       1.000000           1000.000
                    X( 2,  2)       0.0000000          0.0000000
                    X( 2,  3)       0.0000000          400.0000
                    X( 2,  4)       0.0000000          1200.000
                    X( 3,  1)       0.0000000          1700.000
                    X( 3,  2)       1.000000           400.0000
                    X( 3,  3)       0.0000000          0.0000000
                    X( 3,  4)       0.0000000          1300.000
                    X( 4,  1)       0.0000000          500.0000
                    X( 4,  2)       0.0000000          1200.000
                    X( 4,  3)       1.000000           1300.000
                    X( 4,  4)       0.0000000          0.0000000
```

This is a very simple example with a simple itinerary, but as the destinations and distance complexity increase, for example if the starting location is a long distance from the other locations, the importance of this formulation will become more and more apparent in decision making.