PlanOp

Distribution and Logistics Network Planning and Optimization

White Paper
Overview

This paper will explore the complex processes of distribution and logistics and present an approach to streamlining the process and optimizing the outcomes.

The logistical problems of product delivery are some of the many complex tasks that distribution and logistics companies must overcome. Given that most companies are facing an increasingly competitive and ever more rapidly changing business environment, it is critical that they have excellent systems and processes for operating and managing all aspects of their delivery and transport systems. By optimizing and streamlining their transport networks, these companies can successfully improve service standards and reduce costs. Jeppesen offers an optimization approach to distribution network analysis and has incorporated this into deployable software, PlanOp, which can be used to realise increased operational efficiency.

PlanOp is a unique system for distribution and logistics network analysis. It enables significant cost savings, improved robustness to change and powerful network design and optimization based on the proven mathematical principles of operations research. The system is suitable for both small and large scale networks.

PlanOp delivers:

- a more efficient network design
- reduced distribution costs
- reduced planning timescales
- the ability to model, quantify, analyse and communicate network options
- a more robust network design
- improved network knowledge (network data encapsulation)
- evaluation on strategic distribution opportunities for better decisions
- optimized vehicle fleet size and mix
- optimized crew rostering
- the ability to develop contingency plans.
1 INTRODUCTION

1.1 THE ISSUE

Creating the transport networks and schedules that are required to run a company’s logistics operation can be a labour intensive and complex task. Some businesses have unwieldy non-integrated legacy systems for this planning, making it difficult to:

- react to frequent or short notice changes to flight or route availability
- analyse the impact of a range of legislative or infrastructure changes
- construct optimized road and air networks
- manage the range of changes presented on the day-of-operation
- exploit the synergies of multiple networks e.g. to merge two operations where one is a new acquisition or similar result of a change in ownership.
- consider simultaneous benefits of crew rostering in parallel with vehicle routing

Therefore, to remain competitive businesses must ensure that they have excellent transport networks and processes for operating and managing their vehicle fleets.

1.2 THE PROPOSAL

As a result of the increasing requirement to be more competitive, distribution and logistics companies must exploit and enhance their competitive advantage as product delivery specialists. They must have best-in-class network operations and take steps to increase planning and operational efficiency. To help companies realise these efficiencies, Jeppesen offers an optimization approach to distribution and logistics network analysis and has incorporated this into a deployable system called PlanOp.

The deployment of PlanOp allows efficiency of operation and the flexibility to face the challenges of a rapidly changing business environment. PlanOp provides the ability to quickly produce efficient air and road network designs, coupled with the capability to manage vehicle fleet operations and driver duties flexibly and accurately. Additionally, PlanOp provides the ability to examine a wide range of operational and network scenarios and thus quantify the impact of “What if?” decisions on operational and business performance.
2 NETWORK ANALYSIS AND DISTRIBUTION LOGISTICS

2.1 NETWORK PLANNING PROCESSES

In order to achieve consistently good quality outcomes, it is important to have a methodology that facilitates repeatable processes. The network planning methodology is based upon controlled iterations of intensive case study workshops followed by periods where PlanOp is used extensively to solve complex network modelling problems. The process applies effectively to:

- strategic network modelling
- detailed implementation network modelling.

The iterative nature of the methodology is illustrated in the diagram below.

![Network planning methodology diagram](image-url)
Case study workshops are designed to provide an environment for stakeholders (e.g. business managers, planners and optimization consultants) to ‘brainstorm’ and define network models in terms of:

- business objectives and scope
- operational/financial assumptions and constraints
- network model concepts
- approach
- deliverables and timescales.

Figure 2: Network modelling process
Based on the definition of the case study, several network models are developed to explore the different possible outcomes from implementation, operational and financial perspectives. Each case study will produce results that need to be evaluated in order to arrive at implementation recommendations.

The network modelling aspect of the process is illustrated in Figure 2. Analysis of optimization results and re-iteration (e.g. to correct input data or apply extra constraints) produces a number of viable options as case study outputs. A case study report can then be produced to summarise the implementation, operational and financial impacts of each viable option. This report will be based on the detailed information contained within a relevant set of PlanOp model files.

2.2 OPERATIONS

The logistical problems of product delivery depend largely on the mix of commodity types and the geography of product movements.

Geographically, the distribution network may be represented in terms of major network hubs and smaller peripheral nodes. For short haul routes land transport may be used, however long haul routes carrying premium product may mandate air transport. For both situations there are often complex loading and handling processes which are site-dependent (dependent for example on the availability and type of equipment and staff). Other sites such as airports, rail stations and road transport hubs also support transshipping of product between vehicles, which may also involve consolidation of product between containers.

Vehicle tours for companies which operate their own fleets will tend to be circular (beginning and ending at the same location). This avoids repositioning aircraft, trucks, pilots or drivers for start of work on the next day. The number of potential routings is very large even without taking into account the timings of movements. The central problem for planners is to design a set of tours that covers all required product deliveries; meets delivery time windows and takes into account both fixed and marginal flying and trucking costs.

There is often also a component of contractual services in which case the emphasis is more on deciding between the different competitive contracts on offer or deciding whether using a contractor will be cheaper than using dedicated transport. Costing in this situation thus tends to be focused on marginal costs, paying per weight or per volume of product moved.

Additionally, rules governing crew duty generation play a part in determining the legality and cost of vehicle tours. The ability to simultaneously create a set of driver duties and vehicle tours to cover a given set of services while taking these rules into consideration creates additional planning challenges.

Before the development of PlanOp, the search for good tours and crew rosters was often a manual process, firstly allocating aircraft or trucks to long haul routes then using these initial transports as a baseline, fitting in additional flights or truck journeys for the shorter legs and ensuring that contractual capacity is utilised where it “costs in” which often requires these services to mesh seamlessly with the rest of the network and crew duty rules. This process is evolutionary, searching for incremental improvements as a schedule is developed. Because of this step by step approach, it is hard to guarantee that schedules built this way are at or near the best possible. PlanOp was developed to find the best possible schedules. To achieve this, the core elements of PlanOp are optimization modules that implement mathematical models of air and surface networks.
3 OPTIMIZATION APPROACHES

3.1 OPTIMIZATION METHODOLOGY

The nature of optimization is iterative both in terms of the algorithms themselves and in the way results are applied. To this end the strong link between the model and the data is exploited by the model to ensure that:

- results are legal, in a broad sense
- the model is robust when relatively small data changes are made
- the model is sufficiently generic to handle a wide range of data.

These attributes will be assured by a process of testing, firstly at a technical level to validate mathematical correctness and then at an operational level to make sure the results are realistic. Where results are not realistic there is an opportunity to refine the common system knowledge and perhaps introduce new constraints and data. This process iterates until realistic solutions are found.

3.2 BUILDING A MODEL

A model in PlanOp takes the form of a plan, which contains enough data to describe a complete aspect of a transport network. A model expressed as a plan:

- represents a model of the network
- provides a data repository for transport-related data and a way to disseminate this data (e.g. through printouts or diagrams)
- encapsulates and quantifies knowledge of the network
- enables management of many versions of the network
- supports analysis of performance and robustness of the network.

Building a model usually involves:

- deciding the scope of the model
- gathering or bringing together the required data
- processing and/or aggregating ("rolling up") the data to the appropriate level
- calibrating the model (by comparing to known real world characteristics)
- solving, or optimizing the model
- analysing and measuring the results.
3.3 PRODUCTS

The network is described as an origin-destination model. This means that product movements are characterised by the following key components:

- origin (a geographic location)
- destination (a geographic location)
- product type (usually defined by service standard and/or availability times at origins and destinations)
- volume or weight.

Products may have an overnight service standard or a day two or three delivery. These categories are further sub-classified into product groups and product streams. Within PlanOp the products are presented at the product group level where various transformations can be applied prior to an optimization run.

3.4 VEHICLES

The distribution network is defined in terms of sectors where each sector is represented by a vehicle (air or surface) travelling between two adjacent locations in the network at a given time. Each sector may also be differentiated by capacity and cost. The inclusion of potential start times in the sector definition means that for every physical point-to-point link there are many possible temporal sectors, each new one occurring at a new time. This differentiation between potential sectors and scheduled sectors allows for only a small subset to be chosen by network design to actually operate.

Vehicles are distinguished by cost (per kilometre and per hour), capacity (for both weight and volume), loading and unloading times (with fixed and variable components) and speed giving rise to a travel time matrix with possible variations by time of day. Product type restrictions may also be enforced on a per vehicle type basis.

3.5 CREW

The ability to define crew constraints requires the definition of Duty Rules. Each Duty contains a number of duty activities, and each Duty must conform to the rules defined for the type of Duty being performed. Examples of rules include Maximum Work Time, Minimum Work Time, Maximum Work Time with Overtime, Maximum Drive Time, Minimum Break Length, Intermediate Break Length, Maximum Duty before Break is required, and others.

Normally a Duty covers a single shift for an individual, and a number of activity types occur within the Duty. Each activity consists of a start and end time, an origin and destination location, and a distance (if the activity is between two different locations).
3.6 VALIDATING THE MODEL

PlanOp brings together the crucial ingredients of the data into a model. It has sophisticated data validity tools that ensure model correctness and check internal consistency. These tools include:

- visualisation and mapping capability
- an inbuilt SQL-like query engine for data interrogation
- constraint checking functionality.

Through this validation framework PlanOp ensures as much as possible that network optimization will yield useful and implementable solutions. Furthermore, a quality assurance checklist based process provides a standard way to run these data checking tools.
4 THE NETWORK FLOW OPTIMIZER

4.1 LARGE SCALE MULTI-MODAL TRANSPORT NETWORK OPTIMIZATION

The PlanOp Network Flow Optimizer is used to model large scale multi-modal transport networks where product can be transhipped many times en-route. It solves a problem that can be described as a transport cost minimization problem, where costs are described in terms of two major components:

1. Point to point travel costs: calculated for example from hourly flying costs or surface (per kilometre or per hour) costs
2. Overflow costs: used in the solution process for product that cannot be transported and nominally using the cost of alternative third party transport.

During the solution process weights applied to each of these components can be changed leading to a choice of solutions for further examination. To achieve a feasible solution the objective is subject to constraints that must be met for the model to provide sensible real world schedules. Constraint types are:

- service standards to ensure products are delivered by the required time
- product processing windows, detailing product supply and demand times
- capacities for each air and surface vehicle type
- specific depot locations and depot maximums per vehicle type.

4.2 SOLVING THE NETWORK FLOW PROBLEM

To deal with the complexities of product movements an origin-destination flow model generates potential product paths and then selects a subset of these that meet volume and processing constraints to deliver products on time. The flow of product from an origin to a destination can potentially travel on many sectors where a different vehicle or mode of transport may be used on each sector. In practice several products will be moved on the same sector simultaneously and this characteristic can be defined in terms of a classical Linear Programming (LP) problem, known as the Multi-Commodity Network Flow problem (or MCNF). What this means is that if all the vehicle tours are defined it is straightforward to test if they can carry the required products by solving the MCNF. In this way the MCNF acts as a feasibility checker. In those situations where a given network of tours is not feasible, product “overflows” onto a dummy vehicle. The MCNF is a key building block for implementation.

Given that the MCNF can be solved quickly and easily the remaining problem is how to generate potential tour sets for evaluation by the MCNF. Closed vehicle tours, consisting of contiguous scheduled sectors, are created out of the many thousands of potential sectors. There may be many millions of potential tours but a sophisticated heuristic search procedure iteratively finds the best set.

A potential set of tours is generated and their costs are recorded by adding the individual sector costs for each tour. The MCNF is run and based on the cost of this tour set and the overall quantity of products moved, some of the sectors in these tours will be dropped and others inserted. The choice of which sectors to drop and which to insert is based on various well-defined combinations of improvement steps. If no further improvement can be found to the current tour set then the current solution is optimal. In many instances users will need only to test a plan modification, rather than
develop a new plan from scratch. The MCNF is particularly useful here because plan adjustments can be made very quickly (a matter of minutes) and feasibility tested against required product flows in a short time frame.

The Network Flow Optimizer incorporates many advanced modelling features to help produce optimization results that closely parallel real world constraints. These include the ability to:

- stop certain locations from transhipping product between certain vehicle types (e.g. to discourage excess truck-to-truck transhipping at airports)
- disallow product on certain vehicle types and specific transport sectors
- disallow product destined for certain locations from using specific existing transports
- specify loading and unloading overrides for certain vehicle types at certain locations with possible variations by time of day
- specify a travel time matrix that varies by time of day
- specify constraints on the routes that product coming from or destined for a specific location must conform to including reprocessing delays that may also vary by time of day
- specify loading and unloading profiles for specific transports that override the default loading model
- freeze portions of the transport network when optimizing so they remain unchanged
- set curfews at specified locations for specified vehicle types (for example to model “no-fly” times at airports).

The PlanOp Network Flow Optimizer is ideal for modelling and optimizing large-scale (e.g. national level) multi-modal transport networks.
5 THE VEHICLE ROUTING AND CREW SCHEDULING OPTIMIZER

5.1 VEHICLE ROUTING

To deal with road networks on a national or regional basis, PlanOp offers a powerful Vehicle Routing Optimizer. The starting point for this approach is a region whose boundaries are well defined and potential shipments are “contained” within the region. Potential vehicle tours are generated that can carry shipments or parts of shipments on several types of truck and costs are differentiated by truck type and origin-destination. Each regional centre has a limit on the number of trucks of each type that may be based there. Shipments are characterised in PlanOp by a table containing:

- origin
- destination
- quantity
- time available at the origin (supply time)
- time required at the destination (demand time)
- a potential transhipment location and time.

Taking these characteristics into account, the tour generation process includes shipments on each tour, meeting the supply and demand time constraints for pickup and delivery as well as adhering to a number of further constraints:

- truck capacities (weight and volume)
- vehicle type and depot limits (maximum number of vehicles allowed)
- maximum tour duration
- tour “imbalances” – allowing specific tours to not return to base
- compatibility constraints – e.g. given product types not being allowed to travel together
- incorporation of driver breaks
- possibility of overtime.

Shipments may also be split creating more flexible tours and reducing the need for many large trucks. For example a 60m³ shipment can be split into two shipments of 40m³ and 20m³ provided two separate tours could include the split shipments. By this mechanism large shipments can be carried on medium sized trucks.

The PlanOp Vehicle Routing Optimizer has two main solution approaches to solve the optimization problem of finding the best set of tours.

1. The first approach is based on LP technology and is called the Column Generation approach. This approach works best for “low cardinality” problems. That is, where there are on average few shipments on a vehicle (e.g. less than ten), but many vehicle tours (e.g. hundreds) required to deliver all the shipments. For a given network and set of shipments, the PlanOp Vehicle Routing Optimizer can generate all possible circular tours.
from those depots used as truck bases. Each tour will carry some of the shipments and have a known cost. To choose a good set of tours PlanOp uses LP technology to minimise total costs while moving all shipments. Technically this is a Mixed Integer Programming problem known as the Set Covering problem. In practice, it is not necessary to generate all potential tours at once (there may be many millions). A small subset is generated first and the problem solved but without forcing tours to be used “as a whole”. The tour selection process is also known as Column Generation because each tour is represented as a column in the LP matrix. Enough information is generated to estimate whether candidate tours should be considered for downstream processing. In other words, candidates are chosen based on their “price”. This pricing operation is iterated several times as new tours are considered and either accepted or rejected for final optimization of the set covering problem.

2. The second Vehicle Routing Optimization approach in PlanOp is a meta-heuristic approach. This approach is most effective on “high cardinality” problems – that is, where there are on average many shipments on a vehicle (e.g. 40 or more), and not many vehicle tours required (e.g. less than 50) to deliver all the shipments. This approach constructs an initial feasible set of vehicle tours which exactly cover the shipments, and uses state of the art searching techniques (so-called meta-heuristics) to iteratively improve the total cost of the tours, whilst always maintaining a feasible solution. A characteristic of the approach is a component called Ejection Chains, which considers sophisticated “moves” that alter the current set of tours with the intention of finding solutions that use less overall vehicles.

The most useful scenarios for investigation centre on vehicle types and bases (depots). A key decision variable when evaluating a set of output tours is the total cost. The cost curve across many scenarios is likely to be relatively flat, so that a good baseline cost reflecting current fleet arrangements should be used to measure effectiveness, in conjunction with the practical aspects of fleet management.

5.2 VEHICLE AND CREW SCHEDULING OPTIMIZER

For transport networks where drivers can change vehicles during a shift and/or vehicles are used by more than one driver within a given period, an efficient, robust and compatible set of vehicle and crew schedules is essential in achieving the lowest total operating costs.

The PlanOp Vehicle and Crew Scheduling Optimizer (VCSO) is used to solve the combined vehicle and crew scheduling problem where a minimum cost set of compatible vehicle and driver schedules needs to be created to cover a given set of transport routes. The VCSO solves the vehicle and crew scheduling problem simultaneously, allowing both fixed and variable costs of vehicles and drivers to interact and therefore be modelled accurately.

The traditional approach to solving the vehicle and crew scheduling problem is in two phases. First the vehicle schedules are resolved. These may be the result of solving a multi-depot vehicle routing problem with many customer pick-ups and drop-offs or the result of solving a more general network flow problem with arbitrary transhipping within a large hub and spoke distribution network.

Secondly the driver schedules are generated to cover the given set of vehicle schedules. For many organisations there is often a complicated set of rules that govern the legality of driver schedules. These rules include: maximum work time; break profiles, which include rules governing the maximum work time before a break of a certain duration is required for both the first and subsequent breaks that may appear in a legal schedule; maximum overtime allowed; costs involving the number of kilometres
travelled; number of pickups performed; hours worked; penalty rates; time allowed for signing on and off; prepping and returning certain vehicle types; whether or not a driver can have a break during loading or unloading times at certain locations if not participating in the loading and unloading of the vehicle. There may be restrictions on what driver types can operate certain vehicle types and out of which depots specific vehicle tours can be operated. There may be depot targets and overall driver type mix requirements.

There may also be limitations on the amount of tinkering that can be done to the pre-defined set of vehicle schedules when generating legal driver schedules. For example, dead-heading between the start and end of vehicle schedules may or may not be allowed in certain situations.

The PlanOP Vehicle and Crew Scheduling Optimizer solves the vehicle and crew scheduling problem simultaneously.

There are many obvious opportunities that can be exploited when simultaneously solving the vehicle and crew scheduling problem that cannot be taken into consideration when the two problems are solved sequentially. The most important of these include:

- The incorporation of both fixed and variable driver and vehicle costs within the one optimization leading to a solution where these costs can be traded off directly.
- Given that a simultaneous approach can guarantee that either all vehicles return to base or that vehicle type balancing occurs, there may be opportunities for drivers to swap vehicles at intermediate depots or hubs.

There are other not so obvious properties of a distribution network that can be exploited using a simultaneous approach. These include:

- Substitutability of vehicle types for a given vehicle route
  - It may be possible to save a vehicle and or an entire schedule by substituting a vehicle type for any given route of equal or larger capacity than that currently operating it.
  - It may be possible to save a vehicle or an entire schedule by using two or more smaller vehicles to cover any given route given that their cumulative capacity is sufficient.
- There may be time windows associated with the transports requiring delivery in the network or there may be windows of operation for the line-haul truck movements that have to be covered by vehicles and drivers. Exploiting the slidability of the network when using a simultaneous approach often leads substantial to reductions in the number of vehicles and drivers.

The PlanOp Vehicle and Crew Scheduling Optimizer uses a Set Covering mathematical approach to find the best (minimum cost) set of vehicle and driver schedules subject to the constraints. Very often the objective will be to simply find the least number of vehicles and drivers required to operate the network, although different scenarios based on altering the allowable number of part time versus full time drivers and the maximum number of vehicle changes within a duty can also be explored.
5.3 HUB SELECTION OPTIMIZER

The PlanOp Hub Selection Optimizer solves a mathematical optimization problem which locates the optimal sites for transport hubs or processing facilities in a transport network. This is useful not only for determining the best geographical location for a proposed new site, but also for investigating the best way to close existing locations and aggregate their workload into larger existing or new facilities.

The inputs are:

- the set of locations to solve for
- the set of potential hubs
- a set of vehicle travel time records which link locations to potential hubs
- a set of volumes
- an optional cost versus processing capacity curve defining the cost of adding extra processing ability
- optional maximum processing capacity
- opening and closing costs (or bonuses) for potential (or existing) hubs
- a set of optimization parameters, e.g. the maximum number of hubs to choose.

The “cost” of any potential hub is calculated as the sum of the distances (measured in minutes of drive time) of all the locations that would hub to it and optionally the cost associated with operating the facility at the processing capacity defined by the total volume inward and outward to the locations that are hubbing to it. This cost can be weighted by the total volume (either out-going or incoming, or both) that flows to or from each location. Overall, the least cost configuration of hubs is chosen by a mathematical model (a Mixed Integer Program) such that all locations hub to a chosen hub. The optimization is very fast - usually almost instantaneous even for very large numbers of locations - so that many possible alternatives can be examined in a short time.

The output of the optimization is the subset of transport hubs chosen and a map of the vehicle movements around each hub that specify the shortest paths to each location in the hub's catchment area.

The hubbing networks investigated by this optimizer can form the basis of the transport infrastructure for full network optimizations using the Network Flow Optimizer or the Vehicle Routing Optimizer.
6 GEOCODER AND TRAVEL TIME CALCULATOR

PlanOp includes two tools that can be used to construct the necessary data for network modelling and optimization. Both of them take street map data files as input.

The first tool is the PlanOp Geocoder, which uses addresses to generate latitude/longitude coordinates (so-called geocodes) for each network location. Geocoding will work best when addresses are given as exactly as possible; however, the geocoder has a number of “fuzzy” matching algorithms that allow it to intelligently guess the intended address. If an exact match on an address is not found, the geocoder will usually have a number of candidate results that are ranked (using a percentage score) in order of how likely each result is to be the intended address, and the user can select the intended address from this list.

The second tool is the PlanOp Travel Time Calculator, which solves a shortest path optimization problem to calculate travel times and distances based upon a given road map and the geocodes of the endpoint locations. The tool includes a flexible model of road types and speeds as well as taking into account one-way streets and turn restrictions. Functions are available to check the street map data for errors such as node disconnects and “stacked” roads, within prescribed tolerances.

Viewing of routes and location geocodes is integrated within PlanOp using MapX. The routes show for each Travel Time record in PlanOp the sequence of roads traversed to get from the Travel Time’s origin to the destination. Many routes can also be shown at once, which is useful for example to show all routes from a particular location as well as isochrones based on time and/or distance.

The PlanOp Travel Time Calculator frees the user from providing potentially contentious travel time data by calculating the travel time and distance between any two points based upon the actual underlying network of roads.
7 AN OPTIMAL SYSTEM: PLANOP

7.1 SYSTEM OVERVIEW

Individual plans, which include schedules for air and surface transport, represent the highest level data object within the PlanOp system. A given plan, identified by name, contains all data (described above in Building a Model) pertaining to the plan and can be shown through a variety of flexible grid views. Typical grid views are shown below.

![PlanOp grid](image)

The Services View shown at the bottom here represents a schedule of services and sectors broken down into tours and showing vehicle types (aircraft in this case), origin-destination locations and times and the specific products carried on each sector.

Data within each plan is shown and entered in a total of 25+ grid views. There is provision to enter data for haulage contractors, airport curfews, service standards and a variety of data overrides (e.g. loading and unloading times) for specific locations.
The Duties View below shows driver duties as determined by the Vehicle and Crew Scheduling Optimizer. Different types of activity within a duty are distinguished by colour.

![PlanOp duties](image)

**Figure 4:** PlanOp duties

The modus operandi for most new plans will be to copy an existing plan and then modify it by editing cells within the data views but to complement this approach, bulk data take-on from a spreadsheet can be performed with normal cut-and-paste operations. Output from the optimization process is displayed textually in the grid views shown above and also as a variety of diagram views such as the zigzag diagram shown below.
In the zigzag diagram, aircraft tours are shown as sectors connected by location and through time. This type of display is useful for identifying potential bottlenecks at locations caused by simultaneous aircraft arrivals. In these cases PlanOp separates arrivals/departures by at least five minutes in time so that unload/load operations can be managed and congestion reduced. An alternative view of service connections is shown with the aid of service trunk diagrams, showing major routes and interconnecting services.
In this view the trunk route is represented by the large boxes BHE - AKL - CHC - AKL with products interconnecting on other flights. The shape of this view can be easily altered on-screen by dragging the various boxes onto or away from the trunk route. This dynamically changes, focusing attention on the required trunk route.

The network diagram view is another view which is distinguished by its configurability - the user may place boxes and links anywhere within the window and the layout is remembered. PlanOp assists the drawing process by the option of automatically routing links. This view is primarily useful as a communication tool - for printing and distributing plans or aspects of plans to other members of the organization.
PlanOp has an extensive set of tools for data visualisation such as maps to show a range of system data with a geographical interpretation.
Figure 8: PlanOp data visualisation – track plans

This example shows some selected track plans for a truck network in the Waikato region in New Zealand. Track Plans are sectors that product actually travels on, in contrast to the larger number of candidate sectors analysed by the Optimizers.
Figure 9: PlanOp data visualisation - street maps

This example shows the output of the PlanOp Travel Time Calculator in the form of truck routes through a network of city streets. Other forms of visualisation are provided with graphs and time charts. The following graphic shows a selection of these other graphic views available.
All screens and graphical user interfaces in PlanOp are fully customizable to the user’s needs. Data input, schedule optimization and the subsequent presentation of results demand a flexible and highly interactive system. The data demand in terms of quantity is not large, but compared with many commercial systems the data used by PlanOp is all important, combining as it does many interrelated facets of an operation. For this reason the views presented here allow the user to display information in different ways, controlled by filters to separate out particular features in terms of schedules, products, product paths, volumes and timings.

7.2 SUMMARY OF FEATURES

PlanOp is a complete network analysis software system that combines the automatic optimization of both air and surface networks working with the available vehicle types and their characteristics while observing the constraints imposed by service standards, curfews, and other rules. The system gathers together details of vehicle types and travel times, locations and sorting schedules, product types and service standards into the one electronic environment and also allows easy access to visual diagrams and reports based on that information. PlanOp allows for:

- multi-modal network optimization and design
- network aggregation (network design with a contracted fleet)
- hub selection optimization
- driver duties optimization
- geo-coding and travel time calculation using street map data
- containerization
- compare and merge facility for comparing and resolving differences between plans
- animation/simulation capability to display data such as transport schedules during a 24 hour period
- variations by time of day for timings, and overrides (e.g. by location) of costs and capacities
- extensive legality checking of data
- inbuilt SQL-like query language
- key performance indicators for the network
- full undo/redo capability on all user operations.

7.3 A UNIQUE APPROACH

Jeppesen has developed a unique approach to distribution and logistics network analysis. The four principles that we have applied throughout the development of our approach are:

Automation is not optimization

There is obviously merit in using systems to capture and manipulate data and to automate a previously onerous manual process. Indeed a large portion of our approach is underpinned by such techniques. However, in order for all the efficiency improvement opportunities to be revealed it is necessary to use higher-level techniques. Jeppesen’s optimization approach provides for greater efficiencies than simple automation. By combining our algorithmic and systems expertise in our optimization approaches we have been able to extract much greater value from the network analysis process.

Logistics and distribution operations have unique characteristics and constraints

It is feasible to modify an existing network analysis system that has been developed for use in another industry for use in a logistics or distribution framework. However, the unique operational characteristics and constraints of logistics are best addressed by a proven approach that has been specifically and successfully applied to these sorts of problems in the past.

Air and surface networks have different optimization drivers

Jeppesen has developed several distinct optimization engines to extract the maximum benefits for both air and surface networks.

On-going research and development

Jeppesen continues to put significant effort into research and development for all its products, extracting the best possible optimization results using the latest algorithms and exploiting the available computational processing power to the limit. This ensures that users will continue to enjoy faster solution procedures even as more and more practical and operational constraints are reflected within the models solved.
8 THE CASE FOR DEPLOYMENT

8.1 BENEFITS

Traditionally, large scale network planning involving a variety of products and many transport modes has been done manually, gradually evolving over time to meet changing network needs, advances in transportation and product changes. The deployment of PlanOp adds value to this process by:

- reducing distribution costs
- speeding up the solution process via mathematical models
- analysing “what-if” scenarios for strategic planning
- encapsulating the knowledge base
- improving information management.

With the combination of optimization tools, graphics and advanced data views, PlanOp helps the planner to work towards best practice, exploring potential alternatives and resulting in improved economics for the organization.

8.2 WHY JEPPESEN?

Jeppesen offers:

- a powerful combination of business know-how and world-leading optimization technology that solves a wide range of resource management problems
- proven solutions that work in production even for the largest operations
- a clear strategy of product integration, making it possible to make quick, end-client-oriented decisions with detailed system support
- the combination of world class optimization and maximum flexibility, through the use of business modelling language, Jeppesen Rave
- possibility to use features such as advanced simulations, individual crew requests and web-based crew communication.

Jeppesen’s expertise is centred on five main solutions:

- PlanOp - Distribution and logistics network planning and optimization
- RMS-R - Resource Management Solution - Rail crew and fleet management
- IPTIS - Public transport journey planning
- TMS - Terminal Management Solution – airport resource allocation
- OR Services - Operations research consulting.
8.3 DIFFERENTIATORS

Jeppesen’s competitive advantage is based on its ability to combine advanced optimization algorithms, first class software development skills and extensive experience in the transport industry. This unique combination allows Jeppesen to provide optimal solutions to complex client problems and requirements. Specifically, Jeppesen is differentiated by the following factors:

- Strong planning experience within the postal industry
- Expertise in resource allocation and scheduling
- Experience in management of large IT projects
- PlanOp is a proven system
- Jeppesen’s optimization engines are advanced software developed specifically for postal network analysis
- Jeppesen has written and owns the software source code making modifications possible
- High calibre support is available for the use of the software
- Jeppesen delivers projects to budget.
9 GLOSSARY

Grid views The textual representation of data in PlanOp

Hub selection An optimization engine within PlanOp that chooses the best locations for transport hubs

Network model A representation of a network, embodied in a plan in PlanOp

Plan A complete set of data encapsulating a network model

Sector A point-to-point transport occurring at a particular time of day and also characterised by capacity and cost

Shipment An origin-destination volume that must be transported

Track plan A contiguous sequence of sectors that describes how a piece of product travels through the transport network from its origin to its destination

Vehicle tour A closed, contiguous sequence of transport sectors that describes a particular vehicle’s activity during a 24-hour period