The DSS LOGDIS Optimizes Delivery Routes for FRILAC’s Frozen Products

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We designed a decision-support system for FRILAC Company in Navarre, Spain, to optimize its routes for delivering frozen products. FRILAC’s logistics department had been organizing deliveries based on vehicle runs, but FRILAC deemed this process inaccurate and expensive. We suggested simplifying this procedure by creating a decision-support system (DSS). We had a twofold aim: to design a route builder geared specifically to the road network of the area and to integrate the DSS into the global management of the company. We achieved both objectives by constructing the DSS LOGDIS in Microsoft Access. LOGDIS, using Clarke and Wright’s (1964) algorithm, designs routes that minimize distances traveled, shows final outcomes on screen, creates reports for vehicle drivers, and estimates route costs. FRILAC has successfully implemented the results, reaching an average cost saving of 10 percent.

Key words: transportation: vehicle routing; information systems: decision-support systems.

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consider a broad range of transport strategies. It made gains in market share and customer loyalty during the 1980s, when the company’s current commercial network was set up. During the 1990s, FRILAC consolidated itself in the delivery market in Navarre, attaining prominence among firms ranked nationally within its sector. Nowadays, FRILAC has a 28 to 30 percent share of the Navarre ice cream market, which is similar to Frigo’s market share at the national level. FRILAC delivers its other frozen products to 60 percent of the Navarre population (approximately 350,000 people).

We approached this project by searching for a software tool to use to simplify route management in a middle-sized company by means of automatic computerization. FRILAC’s route calculation was frequently complex and unclear, but LOGDIS provided an easy, systematic method for generating routes, thus simplifying the routing problem.

We designed LOGDIS as a DSS to integrate route-optimization algorithms into FRILAC’s daily management. LOGDIS (logistic distribution) supports multiple model formats, integrates different routing algorithms, has a friendly interface, and offers good data integration. The research and development team included university professors, computer programmers, FRILAC staff, and graduate students, in addition to the authors. Team members met periodically at the university or at FRILAC’s head office. These meetings varied in their agendas, their purpose, and in the people attending. We held meetings at the university dedicated to developing the algorithmic procedures for solving FRILAC’s problems. On the other hand, meetings at FRILAC’s head office led to the design of the specific uses of the DSS and its application to company needs. We discussed the firm’s logistic problems and the ways to solve them. Almost the entire working team used to attend these general meetings, at which we set goals for improving the performance of the DSS in the project’s early stages and planned its verification later on.

Involved in developing the DSS were users, modelers, and decision makers. The users explained the logistics routing problem to the modelers. The modelers (the authors) chose the algorithms and the database for solving the routing problems, according to the users’ needs. The decision makers were FRILAC’s managers, who, with the company’s logistics staff, suggested, based on their experience, such issues as (1) how many vehicles of what type FRILAC needed, (2) how many routes FRILAC needed per vehicle per day, (3) which customers to put on each route, and (4) what load each vehicle should carry on each route. We considered these suggestions as initial ideas for performing routing algorithms.

We decided to base the DSS on Microsoft Access because it permits storage of the large amount of data needed to manage routes and the production of the final reports FRILAC’s drivers and logistics staff need.

**Description of FRILAC’s Problem**

FRILAC wanted to find the routes that would minimize the distances it traveled delivering frozen goods. FRILAC’s routing problem is basically a vehicle-routing problem (VRP) with potential delivery nodes all over Navarre and a single depot situated on the Landaben industrial estate in Pamplona (Table 1). The daily VRP has the following constraints: (1) a fixed fleet size, (2) a limited load for each vehicle, (3) in some cases, a limited time to cover the route, (4) an upper bound on driving time per driver, and (5) the total cost function cannot exceed the FRILAC daily delivery budget assigned by the logistics manager.

The problem’s parameters are (1) the number of types of vehicles, (2) deterministic demand associated with each customer, and (3) the number of customers to be included in the design. In terms of constructing a model, this problem is similar to the canning company problem Faulin (2003) and Faulin et al. (2002) describe.

Thus, the FRILAC model is a VRP with multiple vehicles, a single depot, and known, deterministic

<table>
<thead>
<tr>
<th>Characteristics of the VRP</th>
<th>Options for the FRILAC model</th>
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<tbody>
<tr>
<td>Size of fleet</td>
<td>Multiple vehicles</td>
</tr>
<tr>
<td>Type of fleet</td>
<td>Heterogeneous</td>
</tr>
<tr>
<td>Origin of vehicles</td>
<td>Single depot</td>
</tr>
<tr>
<td>Demand type</td>
<td>Known deterministic demand</td>
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<tr>
<td>Network type</td>
<td>Undirected</td>
</tr>
<tr>
<td>Route time</td>
<td>Bounded (not always)</td>
</tr>
<tr>
<td>Driving time per driver</td>
<td>Bounded (usually eight hours per day)</td>
</tr>
<tr>
<td>Activities</td>
<td>Deliveries only</td>
</tr>
<tr>
<td>Objectives</td>
<td>To minimize distances</td>
</tr>
</tbody>
</table>

Table 1: We considered various characteristics of the vehicle-routing models to solve delivery problems at FRILAC.
demand nodes in an undirected network. The goal is to minimize distances. In developing the DSS, we decided to assign Cartesian coordinates to each node representing a village or small town with customers. We then defined a list of arcs to link the nodes. These arcs formed a reticular structure representing the FRILAC problem, describing the Navarre road network, and taking into account the following hypotheses:

1. Although there should be a node to represent each customer, we designed our network with a node for each village or municipality that had a depot or one or more FRILAC customers. This simplification makes the network less extensive and the problem less complex. It also eliminates the need for modifications to incorporate any new customers. With the villages as nodes, we designed a fixed topology greatly easing network management. This simplification did not harm model fidelity because the distances between villages in road networks are much greater than the distances between customers in the same village. We could ignore the distances between customers at no cost.

2. After defining the network nodes, we connected them by using arcs to represent the roads between villages. We then attached to each arc a distance in kilometers, an average route speed, an origin, and a destination. We could then estimate route times based on the distance between nodes. We calculated the distances from the Campsa 2001 official guide, which was developed by the REPSOL YPF company with the help of the National Center of Geographic Information (CNIG), the National Geographic Institute (IGN), and the Department of Transport and Public Works, all parts of the Spanish government.

Using this information, we studied the direct links between neighboring nodes to verify the total distance initially calculated. Nodes are the actual locations of customers or groups of customers. The criteria we took into account in selecting these nodes were (1) minimizing distance, (2) avoiding roads with heavy traffic, and (3) using major highways, if possible. We classified the arcs into four types according to the kinds of road they represented. We then assigned an average speed to each type of route between nodes, according to the Spanish classification of roads (Table 2). We can modify these values for particular roads according to their characteristics. The final outcome is a scattered road network with 50 nodes, 100 arcs, and a density of two (ratio between the number of arcs and the number of nodes). After modeling the road network, we sought an algorithm for the shortest-path problem to find the routes and the minimum distances between each pair of vertices in the network.

Demand is concentrated in villages and municipalities, which we represented in the network by nodes. A single village may have several customers, in which case we assign their total demand to that village. Although doing this could cause heterogeneous demand because various kinds of customers exist in each village, this hypothesis was not very restrictive because the distribution of customers was similar in the various municipalities.

### Vehicle-Routing Problem Applications

We searched the literature for publications on the VRP and its applications to support our choice of algorithms for solving FRILAC’s delivery problems.

The most important and novel publication is the book edited by Toth and Vigo (2002). It is an excellent guide to new algorithms to implement in a new DSS and to understanding the state of the art in vehicle routing. Toth and Vigo (2002, pp. 225, 245) describe many cases and vehicle-routing applications. They also describe the VRP with pickup and delivery, formulating a mathematical model for solving real problems with characteristics analogous to those of the FRILAC delivery problem. Bodin et al. (1983) worked on routing algorithms prior to Toth and Vigo.

Historically, the most important constructive algorithm is Clarke and Wright’s (1964) savings method (henceforth the CWS algorithm). This well-known method relies on intuitive ideas for constructing routes in VRP models. Other analysts have developed many variations on the savings algorithm since

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<table>
<thead>
<tr>
<th>Types of road</th>
<th>Average speed</th>
</tr>
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<tbody>
<tr>
<td>Secondary roads</td>
<td>50 km./h (31 miles/h)</td>
</tr>
<tr>
<td>Main roads</td>
<td>60 km./h (37 miles/h)</td>
</tr>
<tr>
<td>Fast main roads</td>
<td>70 km./h (44 miles/h)</td>
</tr>
<tr>
<td>Highways</td>
<td>90 km./h (56 miles/h)</td>
</tr>
</tbody>
</table>

Table 2: FRILAC drivers reported the average speeds they reached on the various categories of roads in the Spanish road network.
Clarke and Wright constructed it. Mole and Jameson (1976) generalize the definition of the savings function, introducing two parameters for controlling savings behavior. Holmes and Parker (1976) develop a procedure based on the CWS algorithm, using the same savings function but introducing a solution-perturbation scheme to avoid the poor-quality routes that sometimes result from the CWS method. Prior to this, Gaskell (1967) contrasted the difficulties in optimizing several cases of the VRP and reached the conclusion that the CWS algorithm was the most efficient existing method for solving routing problems. Paessens (1988) brilliantly explains other important considerations concerning the CWS method. Gillet and Miller’s (1974) sweep algorithm is another well-known constructive method for obtaining solutions to the VRP by simple means. These previous instances are close to FRILAC’s problem, and the publications helped us in designing the algorithm for FRILAC.

The use of metaheuristics in the VRP became really popular during the 1990s. The two most important papers on the use of heuristics and metaheuristics are those by Gendreau et al. (1994), who introduce the Taburoute algorithm, and by Laporte et al. (2000), who discuss classical and modern heuristics in detail. The paper by Van Breedam (2001) was also helpful for analyzing the main characteristics of the heuristics and metaheuristics of the VRP.

VRP applications have a long history in industry, where high delivery costs spurred analysts to find optimal solutions to the VRP. Thus, many papers concern route management and design within companies. VRP studies on distribution, inventory, and production are very helpful for finding practical solutions, for example, Glover et al. (1979), Martin et al. (1993), Pooley (1994), Fumero and Vercellis (1999), Köksalan and Súral (1999), Brown et al. (2001), and Gupta et al. (2002). These papers helped us in constructing and implementing our DSS, suggesting ways of working with the parameters of the routing problem at FRILAC.

Adenso-Díaz et al. (1998) provide a first-class account of the use of DSSs in making decisions about delivery problems. Other authors, such as Martin (1998), have used simulation methods to minimize costs in applied delivery cases. All achieved major improvements in managing firms’ distribution problems.

**The Daily-Goods-Delivery Problem: The Rationale**

We will provide a general description of FRILAC’s logistic activities prior to the implementation of the DSS LOGDIS. Some steps in the process have remained unaltered since the application of the DSS procedure.

Traditionally, FRILAC’s managers made decisions about (1) warehousing the frozen products bought from suppliers, (2) marketing products to the appropriate customer segment, and (3) delivering products to customers. In the past, FRILAC used three different delivery policies. Initially, distribution was completely integrated with sales, that is, the same person sold and delivered the product. During a second stage, a salesman handled customers’ orders, and another employee delivered the products the following day.

Whatever their individual jobs, all workers, including the drivers of delivery vehicles, should contribute to the sales effort. Drivers not only deliver the product but also play an important sales role by influencing customers’ future loyalty to the company. Thus, the behavior of drivers distributing products is important to ensuring successful sales.

Originally, FRILAC planned routes manually, taking into consideration certain geographic criteria to divide Navarre into delivery areas and subzones, which it could change to adapt to different products and customers. The FRILAC logistics staff performed this preliminary task of finding an initial solution based on their own experience. They found their manual solutions heuristically by comparison with similar cases with known optimal solutions. This approximation phase preceded our development and the implementation of LOGDIS.

FRILAC now, after the LOGDIS implementation, receives orders through the Internet or by telephone and delivers them within 24 hours. The current setup has proven very efficient compared to other alternatives. Under this method, FRILAC converts the daily orders into routes as follows: (1) It builds each route based on a maximum of 40 orders or 1,200 kilograms per truck; (2) The logistics manager compares his planned routes with those of other logistics department staff; (3) He manually corrects and rationalizes the routes; and (4) Shipping staff members...
give their opinions to the logistics manager and load the trucks.

The number of deliveries and the weight and volume of goods are directly related. FRILAC uses two main delivery zones: Pamplona, the chief town and its suburbs, and the rest of Navarre, and it has different delivery policies for them. FRILAC delivers to customers in Pamplona the day they order or, for afternoon orders, the following day at the latest, while it delivers to customers in the rest of the region once a week.

Once the logistics department schedules the routes, a specialized team loads the trucks, organizing the load by customers to be visited rather than by type of order. The shipping staff sets the delivery schedule using a standardized procedure that takes into account the temperature requirements and weight of the products. Furthermore, FRILAC always needs freezer trucks or freezer vans that are capable of meeting demanding temperature conditions (−25°C or −20°C, which is −13°F or −4°F). The freezer trucks have only eight hours’ autonomy, because the cold is generated overnight at FRILAC headquarters and cannot last for more than eight hours.

The logistics staff log its activities in a daily report; drivers fill in their activities when they return to headquarters around 16:00 h (4:00 pm). They record important incidents, such as delivery problems or returned goods, in these reports, with a view to improving transport management the following day (Table 3).

In 2000, FRILAC’s logistics manager realized that a minor geometrical variation in the distribution routes could save tens of thousands of euros (€1 ~ $1.30) per month, but he did not know how to make the modifications. He wanted to conduct a study of this area as part of a general management revision at FRILAC. With this goal in mind, FRILAC hired Tecnicia, a consulting firm that specializes in improving internal management processes. Tecnicia analyzed several aspects of FRILAC’s internal structure, including its logistics. Once aware of the intricacy of the routing problem, Tecnicia obtained advice and assistance from faculty members of the Public University of Navarre.

The meeting we had with the FRILAC logistics staff brought to light the need for an integrated instrument for making routing decisions that would take into account other areas of management. We decided to create a DSS to meet this objective (Sauter 1997). We analyzed the problem and decided we needed (1) to simplify the logistic decisions, (2) to plan routes for the minimum number of vehicles, and (3) to optimize the total distance covered daily in the whole distribution process (daily mileage for all vehicles). After we analyzed the problem, chose
algorithms, and obtained relevant data, we constructed LOGDIS.

Choosing Solution Techniques and Algorithms

We carefully considered route-optimization algorithms. The FRILAC logistics manager wanted an intuitive method (that is, a method a nonexpert person could understand) that would be easy to program. Taking into account these characteristics and the size of the problem (the maximum number of nodes is around 50, and FRILAC does not take into account time windows), we considered some of the classical heuristics for the VRP (Toth and Vigo 2002, Chapter 5). We tested several procedures: Clarke and Wright’s (1964) algorithm and its variants, sequential insertion heuristics, and two-phase methods (the sweep algorithm, and Fisher and Jaikumar’s 1981 algorithm). We discussed their advantages and disadvantages in solving some benchmark problems we had built from FRILAC’s real delivery cases. We also solved the same benchmark problems using similar exact procedures (based chiefly on linear programming models) and, finding, for instance, the CWS solution to be only 95 percent suboptimal in the worst case, decided to consider solutions within five percent of the optimum to be acceptable. These benchmark problems helped us to decide which were the best procedures to implement in the DSS.

FRILAC’s logistics manager had strong decision-making power, and his ideas finally held sway over other technical considerations (he wanted a simple method rather than complex procedures with better quasi-optimal solutions). He favored the CWS method as the best algorithm for his purposes at FRILAC. We suggested Fisher and Jaikumar’s algorithm, but the logistics manager rejected it because he considered it too complex. We therefore implemented Clarke and Wright’s algorithm in LOGDIS. Some arguments supporting the choice of CWS are its simplicity, its intuitive nature, its low computation costs, and the quality of its solutions in reaching optima.

The CWS method, moreover, permits users to interact rapidly with the LOGDIS solutions to adapt them to FRILAC’s specific circumstances. After testing several examples, we decided against using exact methods based on linear programming or integer programming as general tools to solve FRILAC’s routing problems. Our reasons for this decision were as follows:

1. We had employed a two-phase algorithm, based on CWS, Gillet and Miller’s algorithm, and linear programming, with a model of exactly the same characteristics and found that the results improved by only five percent (Faulin 2003).

2. FRILAC’s logistics manager considered exact methods too complex to implement in LOGDIS. He wanted a simple, efficient method in a versatile DSS.

3. In many cases, the calculation time of exact methods was acceptable, but in others, it was not because they required many constraints to avoid subtours and cycles.

We opted for a well-known intuitive heuristic method (CWS) that could rapidly obtain solutions within five percent of optimal in the worst case. FRILAC needs rapid solutions when unforeseen events force truck drivers to alter their routes.

The CWS method finds the shortest distance between nodes using the Navarre road network. We calculated the set of shortest distances using Dijkstra’s (1959) algorithm, which has given excellent results in some well-known cases (Eiselt and Sandblom 2000). We can also use this algorithm to produce a minimum distance matrix and a sorted list of nodes for every shortest path between each pair of nodes for which a road connection exists. It is important to say that, generally speaking, the shortest path in Navarre does not depend on the roads’ congestion, because there is little congestion, and therefore the shortest path is independent of the time of day in which a trip is carried out.

Thus, after deleting arcs known to represent roads that will not be used (roads in bad condition), we have an interconnected network of nodes. We stored the network data in a database that includes fields for registering the origin and destination nodes, the distance, and the average speed for each arc. Whiting and Hillier (1960) developed similar processes. Thus, we stored the shortest distance between nodes in this network and the minimum times for each stretch of road in a suitable matrix. In this way, by storing the reticular structure of the shortest routes for the pertinent pairs of nodes (pairs for which delivery makes sense), we improved the performance of Clarke and Wright’s algorithm.
The DSS LOGDIS: Defining Delivery Routes

We developed the DSS LOGDIS to give FRILAC a powerful decision-making tool with which to design transportation routes, to manage data, and to create reports.

It uses the DSS LOGDIS to improve decisions in a strategic arena. For instance, FRILAC can create different scenarios based on fleet size or depot location and use LOGDIS to examine them and evaluate the round-trip distances for the various scenarios. FRILAC investigated setting up a depot in Tudela (southern Navarre) in addition to the one in Pamplona. We created two scenarios: the first, with only one depot in Pamplona; and the second, with two depots (one in Pamplona and another in Tudela). We compared both scenarios considering the customers’ data in September 2001, and the second scenario with two depots was more costly than the first. FRILAC eventually abandoned the idea in light of the LOGDIS results.

FRILAC has also used the DSS to analyze routing costs, total delivery times, total distance traveled, goods delivered, and percentage vehicle usage (Figure 1). By entering the data manually, users can obtain data on the Navarre road network to use in computing routes. They can also print, alter, and sort the data they enter to facilitate analysis.

LOGDIS relies on an optimization model that minimizes distances in the overall delivery process (all routes in any single day). Our model for optimizing distribution routes assumes the following constraints:

1. The vehicle assigned to any route has a capacity constraint different from other vehicles in the heterogeneous fleet, and
2. Each vehicle has a maximum round-trip time of eight hours.

The DSS automates daily route design to minimize the length of the itineraries traveled to deliver goods to customers and also facilitates data management by integrating databases (Figure 2) in the same computer program to create logistic reports and to answer questions concerning delivery. The main menu of LOGDIS (Figure 3) facilitates access to any part of the DSS, offering a variety of options, such as the following:

1. Customer data management (registration, deletion, and modification);
2. Fleet data management (such as vehicles, purchase value, depreciation, and gas consumption) to permit calculation of route costs;
3. Customer-order data management as customers call so LOGDIS can solve the routing-design problem based on the orders received up to a deadline;
4. Consideration of data on screen (Figure 4) or printed out;
5. Generation of transportation routes based on the known data (Figures 5, 6, 7, 8);
6. Printed route sheets for vehicle drivers (Figure 8) showing the sequence of deliveries and the products to be delivered;
7. Recalculation of routes to improve initial solutions;
8. Displayed and printed activity reports;
9. Configuration of LOGDIS to modify some DSS parameters.

At point (3) the user runs the route-generator after all orders have been accepted. LOGDIS solves the VRP using Clarke and Wright’s algorithm to find a convenient solution. This solution will be accompanied by a data report indicating total cost of solution, distance covered by vehicles, total delivery time, and a list of the routes involved in each solution with the customer names for every route. Each route LOGDIS generates is represented on a map of Navarre (Figures 5 and 8).
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Figure 2: Three characteristic databases in DSS LOGDIS are a list of municipalities, a distance matrix, and a shortest paths matrix, each in a separate column. After the user inputs these data, Dijkstra’s algorithm finds the shortest distance between all pairs of municipalities involved in the delivery.

Figure 3: The main menu of the DSS LOGDIS offers several options: customer management, fleet management, implementation of Dijkstra’s algorithm, order management, implementation of Clarke and Wright’s algorithm, constraints, and exit. The customer-management option allows users to input customers’ data in this database, the fleet-management option controls the available vehicles for each delivery, and the order-management option stores the customers’ orders by importance and priority. The remaining options are related to the algorithm’s implementation.

The printouts described in point (4) can be used as working plans for drivers. Those printouts should be of suitable size and give details of the sequence in which customers should be visited and the quantities of each product to be delivered on each visit.

Furthermore, when LOGDIS supplies a set of final routes, the logistics manager analyzes them carefully. If he considers it necessary to change some or all routes to meet any additional constraints, he will alter the parameters to be introduced in the DSS (in the LOGDIS compact menu, Figure 4) and thus obtain a new solution. Once the logistics manager has validated the set of routes, in the light of his previous experience and knowledge of individual customer needs, the solution is printed out in a graphical report and sent to the corresponding driver.
At this stage, the drivers give their opinions of the route plans. Any important remark or observation from the drivers is sent to the logistics manager, who reconsider any subsequent recalculation of routes by LOGDIS. Drivers have no direct access to LOGDIS.

Using its database, LOGDIS produces the reports the company generally needs. This approach reduces paperwork and prevents mistakes in data management.

Moreover, users can modify some DSS parameters to adjust LOGDIS’s performance. It would be possible, for instance, to alter the maximum time allowed for a route or the gas price or any data in the network matrix, and LOGDIS would then recalculate a new cost value. It is also plausible to alter the road-network topology by adding or deleting arcs or modifying data on existing arcs. Other road-network conditions, such as highway congestion or road works, could also be considered. Such changes could leave the current optimum solution unaltered; fluctuating gas prices, for instance, do not affect route optimization but will alter the final cost.

The data LOGDIS manages are stored in a Microsoft Access database, which has proven to be an ideal tool for FRILAC. In our search for computing speed and power, we considered various computer codes for implementing the CWS algorithms. Likewise, because data are stored in Access and the program is popular, we decided to use Visual Basic to apply the algorithms because of its similarity to Access. This choice cut programming time from two months to approximately three weeks. Furthermore, the integration of the algorithms into the DSS was remarkable (Figure 4).

LOGDIS automates FRILAC’s data management. It is connected to other databases within FRILAC’s ERP (enterprise resources planning) and provides
crystal-clear reports that contain only the information needed for making decisions.

Generally, the logistics manager must check the quasi-optimal routes supplied by LOGDIS (they are quasi-optimal because CWS is a heuristic procedure). Sometimes, the manager will change the DSS routes to accommodate last-minute changes or to avoid nodes that are inconvenient on a specific day of the week because of such factors as heavy traffic. Such a change in parameters or in problem characteristics usually means rerunning LOGDIS. Thus, FRILAC uses LOGDIS for daily logistic tasks, and it completely fulfills FRILAC’s initial goals. This is the habitual way of implementing LOGDIS within FRILAC.

LOGDIS Implementation

We implemented LOGDIS in November 2001 after a series of trials designed to improve its performance. Initially, the FRILAC staff had several problems. Inputting road-network data into an Access file was tedious, and staff members doubted LOGDIS would be successful. They also displayed the passive resistance to change that is common in any company. We conducted several training sessions for the logistics staff to get them used to generating routes in a systematic way. Some employees and managers needed that training to learn to use the DSS, to enable them to make decisions, and to interpret LOGDIS results. Decision makers must review the DSS’s recommended routes. Usually, decision makers advise drivers how to visit customers with small orders, grouping them for delivery over the following days.

After the training sessions, they quickly became accustomed to using the DSS and to generating new routes with ease. The vehicle drivers found the route reports the DSS created very useful. The logistics staff recognized the improvement brought about by the DSS solutions.

Benefits and Drawbacks of LOGDIS

The advantages of LOGDIS can be summarized as follows: (1) its intuitive use in managing data and in producing routes, (2) its complete integration of routing management with daily paperwork, (3) its easily comprehensible algorithms for route optimization, (4) its amalgamation of routing data with customer data, facilitating the creation of reports for vehicle drivers, and (5) the easy recalculation of routes when conditions change, particularly order sizes, number of trucks available, and goods available. FRILAC has
been able to optimize staff time and distribution costs. More efficient use of company resources has enhanced teamwork and staff integration in the firm’s corporate culture.

The drawbacks of LOGDIS are (1) that it requires careful, hard and tedious input of customer data, and (2) that its algorithms are less efficient than other available procedures. The first drawback was really important at the beginning of the LOGDIS implementation, because the amount of data to input was significant. Nevertheless, now the importance of this drawback has diminished because the data for the most important customers have already been inputted in LOGDIS. The drawback concerning the choice of algorithm is now open to discussion at FRILAC. The current algorithm works properly, but the FRILAC logistics manager thinks that a more efficient procedure would not necessarily reduce delivery costs significantly. On balance, however, LOGDIS’s advantages clearly outweigh its disadvantages.

Practical Outcomes

DSS LOGDIS has saved FRILAC’s staff members time in performing their daily tasks, allowing them to perform activities and cut costs for deliveries. We focused initially on the DSS’s effects on company management. Clearly, the improvement in daily paperwork and organization enhanced the quality of customer service and the firm’s corporate image. The logistics manager now has a range of efficient options for distribution. Designing routes manually was time consuming and harmful to other company departments. Because LOGDIS calculates and designs delivery routes, FRILAC has been able to transfer some logistics staff members to other positions. Since the implementation of the DSS, the work environment
has improved, stress-inducing factors have decreased, and quality and productivity within the company have increased. These positive effects are mainly due to the ease and convenience of using LOGDIS in calculating routes. Furthermore, customers’ complaints have decreased.

LOGDIS’s improvement in transportation routes also had positive side effects, such as reduced environmental impact, because shorter routes reduce gasoline consumption; increased road safety, because of the reduction in driving time; and improved customer service, with quicker deliveries.

Between November 2001 and May 2002, by using LOGDIS, FRILAC saved 10 percent per day compared to its former practices. It also made savings in distance traveled, staff time, staff, and number of routes (Table 4). These savings affect the entire delivery region in Navarre and not just one particular part.

FRILAC also saved on gas and maintenance, and the DSS increased managers’ awareness of costs and expenditure, which affected company policy. The risk of road accidents has fallen as drivers have gained knowledge of the routing network and taken responsibility in the delivery process. As a result of the implementation of LOGDIS at FRILAC, drivers have better knowledge of the routing network and taken responsibility in the delivery process. We conducted a survey among drivers at the end of the LOGDIS implementation process: they reported 12 percent fewer accidents taking place in 2003 than in 2000, before FRILAC had the DSS.

In May 2003, we registered DSS LOGDIS to protect our copyright. FRILAC continued to use LOGDIS between May 2003 and May 2004 with outstanding results.

<table>
<thead>
<tr>
<th>Savings per day</th>
<th>Average percentage savings</th>
<th>Average savings in absolute terms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance</td>
<td>13.55%</td>
<td>1445 km (898 miles)</td>
</tr>
<tr>
<td>Cost</td>
<td>10.87%</td>
<td>€83.23 ($108.20)</td>
</tr>
<tr>
<td>Time</td>
<td>8.5%</td>
<td>20.74 hours</td>
</tr>
<tr>
<td>Routes</td>
<td>6.7%</td>
<td>5.3 routes</td>
</tr>
</tbody>
</table>

Table 4: This table shows the average savings per day for distance, cost, time, and number of routes. FRILAC’s implementation of LOGDIS has produced. It is clear that the savings are more significant in cost and distance. Even so, the reduction in time and in number of routes is not negligible.

Conclusions

FRILAC has found the DSS LOGDIS to be a good optimization tool for managing its distribution. It has improved the company’s corporate image and increased the staff’s commitment to its delivery mission. The optimization methods (Clarke and Wright’s algorithm and Dijkstra’s algorithm) are traditional and easy to understand and implement. They seem appropriate for optimizing a network with up to 50 nodes. They are simple and effective for problems of that size. The FRILAC corporate culture stresses straightforwardness. After the LOGDIS start-up, FRILAC staff members made complimentary remarks about the DSS. We have implemented some employees’ suggestions concerning the DSS’s performance, improving its applicability to very long routes.

Acknowledgments

We are grateful for the support FRILAC staff members gave us during the development of LOGDIS, mainly to the following people: José Javier Díez (FRILAC’s logistics manager), Ramón Aguinaga (FRILAC’s marketing manager), and Carlos Villanueva (FRILAC’s CEO). We also appreciate the assistance and advice of Ismael Coridio (Tecnicia’s CEO) in the construction of the DSS LOGDIS.

References


Ismael Ciordia, CEO Tecnicia Consulting, Tecnicia Corporation, 31012 Pamplona, Spain, writes: “Tecnicia Corporation has recently developed the DSS LOGDIS with the help of Javier Faulin belonging to the faculty of the Public University of Navarra in order to improve the management of routes in FRILAC, one of our best clients. The outcome of the DSS LOGDIS has been of significant value to FRILAC, saving up to 14% of the initial delivery costs. The DSS involved the development and analysis of a model for optimizing routes for the vans and trucks of FRILAC. The resulting model has formed the basis of decision-support software that is used on a regular basis to aid in advance planning of drivers and staff requirements.

“Javier Faulin helped us to build the heuristic algorithms based on Clarke and Wright’s method and on Dijkstra’s procedure which support the DSS LOGDIS. We benefited a great deal from this thorough analysis and solution development. Those methods, along with the computer analysis developed by two people of our staff (Pablo Sarobe and Jorge Simal), managed the construction of the said DSS.

“The development of DSS LOGDIS permitted us to satisfy FRILAC appropriately, and it was the beginning of other important contracts with this client.”

Ramón Aguinaga, FRILAC Marketing Manager, Poligono Landaben, calle F patio 2, 31012 Pamplona, Spain, writes: “FRILAC S.A. has recently implemented in its distribution system all over Navarra the DSS LOGDIS for making the calculation of routes easier. The DSS LOGDIS was developed in the period 2000-2001 as a result of the cooperation between Tecnicia Corporation and the faculty of Public University of Navarra. The use of this DSS has been completely satisfactory, reaching an important progress in the logistic process in FRILAC. It has involved an updating of the available technologies in our company, managing a more professional service to the final customer.

“The routing design is a sophisticated problem that we were previously solving with some simple rules of thumb. We thought that the delivery process could be improved if we used some kind of optimization model to face the problem. This was our purpose when we asked Tecnicia Corporation to analyze our distribution policy. At the very beginning, we found a lot of difficulties for the development of new models for the routing design, but we overcame them little by little. The development of LOGDIS has helped us to better understand the trade-offs underlying in our decision making, improving our perception about the distribution policy in FRILAC. Finally, the use of this DSS involved an average saving in costs of 14% in the daily management of routes.

“Concerning the marketing field, I perceived an improvement in our relationship with customers because of a better fulfillment of our distribution goals. I think that the DSS LOGDIS implementation has involved a clear advance in our commercial aims.”