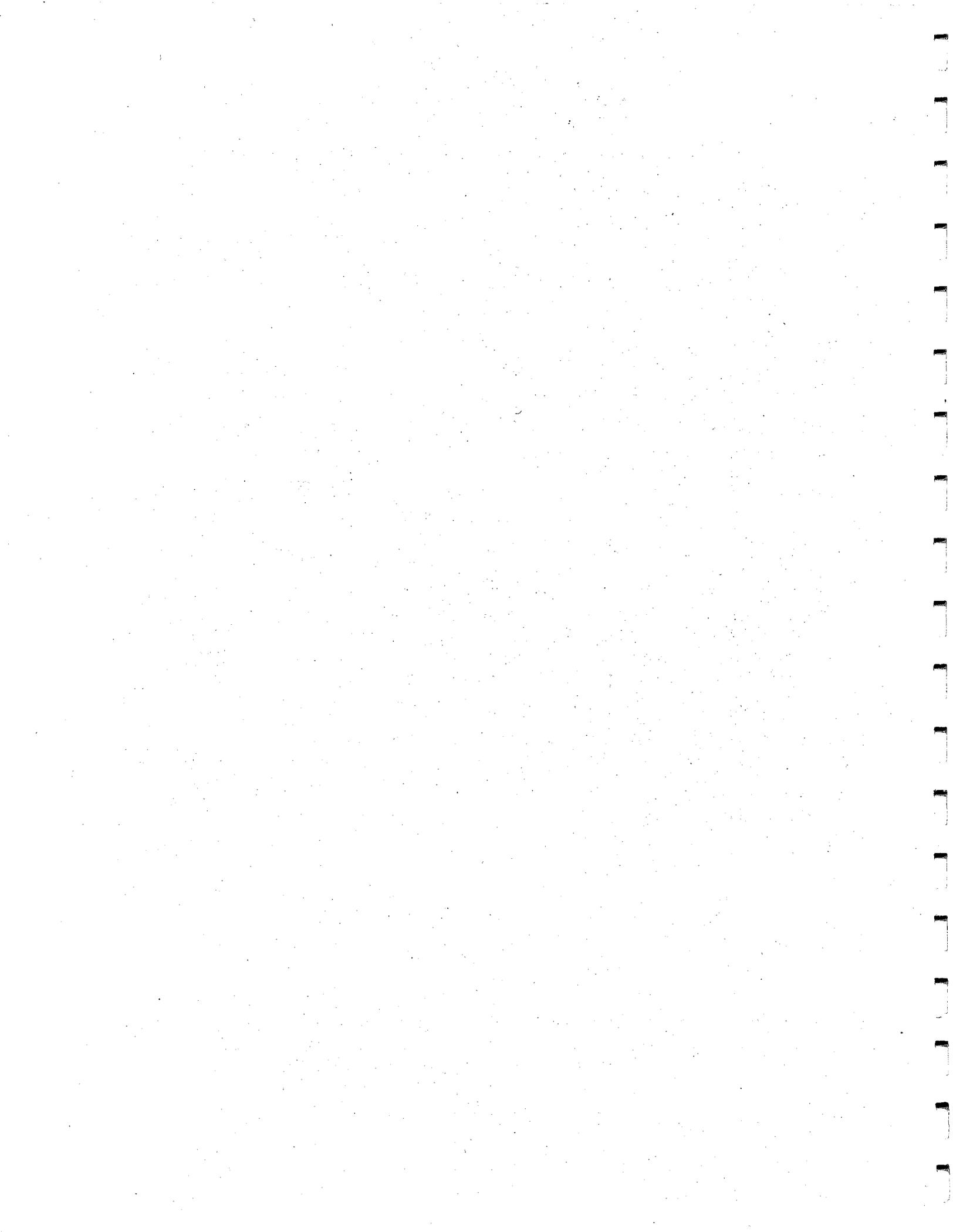


## TECHNICAL REPORT STANDARD TITLE PAGE

1. REPORT NO. <b>WA-RD 373.1</b>	2. GOVERNMENT ACCESSION NO.	3. RECIPIENT'S CATALOG NO.	
4. TITLE AND SUBTITLE <b>Urban Goods and Intercity Freight Movement</b>		5. REPORT DATE <b>February 1995</b>	
		6. PERFORMING ORGANIZATION CODE	
7. AUTHOR(S) <b>Ted Klasterin, Gary Pivo, Martha Pilcher, Daniel Carlson, Celia Hyman, Sonja Hansen, Paul Hess, Abhay Thatte</b>		8. PERFORMING ORGANIZATION REPORT NO.	
9. PERFORMING ORGANIZATION NAME AND ADDRESS <b>Washington State Transportation Center (TRAC) University of Washington, JD-10 University District Building; 1107 NE 45th Street, Suite 535 Seattle, Washington 98105-4631</b>		10. WORK UNIT NO.	
		11. CONTRACT OR GRANT NO. <b>Agreement T9903, Task 32</b>	
12. SPONSORING AGENCY NAME AND ADDRESS <b>Washington State Department of Transportation Transportation Building, MS 7370 Olympia, Washington 98504-7370</b>		13. TYPE OF REPORT AND PERIOD COVERED <b>Final Research Report</b>	
		14. SPONSORING AGENCY CODE	
15. SUPPLEMENTARY NOTES <b>This study was conducted in cooperation with the U.S. Department of Transportation, Federal Highway Administration.</b>			
16. ABSTRACT <p>This study examined the freight movement and logistics patterns of six businesses located in urban and suburban centers of metropolitan Seattle. Its two principle objectives were (1) to identify key factors that influence location and transportation choices, patterns, and times and (2) to build a sound foundation for future research regarding urban freight movement's relationship to compact urban form.</p> <p>The study found that firm location decisions are driven more by land costs than by transportation costs; proximity to denser urban areas means more business for four of six firms investigated; transportation managers adjust to increased congestion; innovations such as smaller trucks and urban-edge transfer stations facilitate freight movement in dense areas; and site and roadway design can have a big impact on urban goods movement. A variety of new approaches, including freight consolidation, congestion pricing, freight friendly urban design, and insights of truckers, were suggested for further analysis.</p>			
17. KEY WORDS <b>Urban goods, intercity freight movement</b>		18. DISTRIBUTION STATEMENT <b>No restrictions. This document is available to the public through the National Technical Information Service, Springfield, VA 22616</b>	
19. SECURITY CLASSIF. (of this report)  <b>None</b>	20. SECURITY CLASSIF. (of this page)  <b>None</b>	21. NO. OF PAGES  <b>94</b>	22. PRICE



**Final Research Report**  
Research Project T9903, Task 32  
Urban Goods Movement

**URBAN GOODS  
AND INTERCITY FREIGHT MOVEMENT**

by

Ted Klastorin  
Gary Pivo  
Martha Pilcher  
Daniel Carlson  
Celia Hyman  
Sonja Hansen  
Paul Hess  
Abhay Thatte

**Washington State Transportation Center (TRAC)**  
University of Washington, JD-10  
University District Building  
1107 NE 45th Street, Suite 535  
Seattle, Washington 98105-4631

Washington State Department of Transportation  
Technical Monitor  
Amy Arnis  
Policy Development Branch

Prepared for

**Washington State Transportation Commission**  
Department of Transportation  
and in cooperation with  
**U.S. Department of Transportation**  
Federal Highway Administration

February 1995

## **DISCLAIMER**

The contents of this report reflect the views of the authors, who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the Washington State Transportation Commission, Department of Transportation, or the Federal Highway Administration. This report does not constitute a standard, specification, or regulation.

## **REPORT PREPARATION**

This research study was conducted by an interdisciplinary study team from the School of Business Administration and the College of Architecture and Urban Planning at the University of Washington. The principal investigator was Ted Klastorin, Chair, Department of Management Science with co-principal investigators Gary Pivo, Associate Professor of Urban Planning and Design, and Martha Pilcher, Senior Lecturer in the Business School. The project manager and principal report author was Daniel Carlson, research consultant at the Institute for Public Policy and Management. Graduate research assistants and case study authors were Celia Hyman and Sonja Hansen, School of Business, and Paul Hess and Abhay Thatte, Department of Urban Design and Planning.

# TABLE OF CONTENTS

<u>Section</u>	<u>Page</u>
Executive Summary .....	v
<b>Part I</b>	
Introduction .....	1-1
Study Approach.....	1-2
Findings.....	1-8
A Future Research Agenda .....	1-15
<b>Part II Literature Review</b>	
Literature Review .....	2-1
Contact List .....	2-15
<b>Part III Case Studies</b>	
Darigold Incorporated .....	2-18
Avtech Corporation .....	2-27
Thaw Corporation .....	2-35
Weyerhaeuser Recycling Division .....	2-39
Boeing Licensed Transportation .....	2-53
Safeway Stores Incorporated .....	2-62
<b>Acknowledgments .....</b>	<b>2-69</b>
<b>Appendix A. The Max Diversity Problem</b>	

## LIST OF TABLES

<u>Table</u>	<u>Page</u>
1. Draft Firm Selection Matrix .....	1-5

## LIST OF FIGURES

<u>Figure</u>	<u>Page</u>
1. Case Study Sites .....	1-6

## **EXECUTIVE SUMMARY**

### **PURPOSE**

The purpose of this research report is to better understand how a selected variety of businesses move goods in the metropolitan King County area and how these freight patterns affect or are influenced by location, congestion, and urban form.

Washington is a rapidly growing state, and nowhere is this growth more evident than in the population, traffic, and urban development patterns of greater Seattle. The Growth Management Act establishes state policy to concentrate growth in already existing urban areas. This study seeks to understand more about constraints which compact urban form may place on truck movement and which policy and design factors facilitate urban freight movement under denser conditions.

Six firms were selected in varying lines of businesses, with different logistics characteristics, that are located in urban or suburban centers in Seattle and King County. The objectives were (1) to identify key factors that influence business decisions about location and choices of transportation modes, patterns, and times and (2) to build a sound foundation for future research.

We wanted to understand how companies respond to changes in the transportation environment. (For example, do companies increase inventory in response to greater congestion?) We wanted to learn what works and does not work well in more compact, denser urban activity centers so that places such as downtown Kent, Bellevue, or Seattle can be designed to be more "freight friendly."

The case studies describe the freight movement and logistics patterns of Avtech Corporation, Safeway Stores, Thaw Corporation, Darigold Inc., Boeing Company, and Weyerhaeuser Recycling.

## **FINDINGS**

- Firms make location decisions primarily on the basis of land cost and rent, less so on the costs of transportation.
- Proximity to denser urban form increases customer demand and revenues for four of the six firms studied.
- Transportation managers adapt to increased congestion, although the degree of explicitness with which they factor congestion delay or congestion-avoidance strategies into their bottom lines varies with individual managers and by type of industry.
- Firms have sought greater efficiency and reduced operating costs through a variety of methods, including the use of larger volume trailers, and computerizing loading, routing, and truck engine performance.
- Some firms use smaller trucks in dense urban areas, using nearby facilities to transfer to or from larger trucks.
- Congestion imposes significant costs to the metropolitan area and could be used to assess and change freight movement behavior.
- A variety of new approaches, including freight consolidation, congestion pricing, and freight access to HOV lanes, were identified.
- Site and roadway design (i.e., provision of curb loading zones, access to loading docks, and signage for alley direction) can have a big impact on urban goods movement.

## **FUTURE RESEARCH AGENDA**

The field of urban goods and freight movement is fascinating, under-researched, and poorly understood. Its inclusion in transportation, land-use, and growth management planning is fundamental to successful cities and businesses. To advance understanding and make improvements in the relationship of freight movement and urban form, the study recommends the following areas of further research.

- Examine a broader sample of businesses in the four-county Puget Sound area.
- Focus attention and learn from leading edge patterns of delivery services such as UPS and Federal Express.
- Explore congestion pricing options and impacts related to off-peak deliveries and access to HOV lanes.
- Learn more from truck drivers. They are the professionals most familiar with the successes and failures of the freight transportation infrastructure.
- Study the benefits and impacts of freight consolidation. Will this emerging trend reduce congestion and what incentives can the public offer?
- Identify "freight friendly"\* urban, site, and roadway design approaches that can be incorporated into urban areas.

---

\* Two new terms appear in this report. "Freight friction" refers to urban form or transportation policy impediments to the smooth flow of goods. "Freight friendly" refers to urban design or transportation policies that assist the efficient movement of goods (i.e., loading docks with proper slopes, alleys with clear directional signage.)

- Develop a conceptual framework and rigorous methodology for evaluating the costs and benefits of various projects relating to freight movement as mandated under Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA).
- Measure the effect of "freight friction" as a factor in the economic growth of the region, relating it to other important factors such as work force, environment, and infrastructure.

### **REPORT ORGANIZATION**

This report is arranged in two parts. Part I includes the study approach, findings and future research agenda. Part II includes a contact list, literature review, and the case studies themselves.

**PART I**

## INTRODUCTION

There are obvious relationships between freight movement, land uses, and transportation planning. However, recognizing the obvious does not mean that the relationships are well understood.

The purpose of this study was to learn how a representative variety of businesses in metropolitan King County actually ship and receive goods and manage the related issues of facility location and transportation congestion. To understand their transportation patterns, we visited six firms on-site and described our findings in case study format.

What we learned from these businesses is related to the broader policy and knowledge base concerning urban goods movement, to the increased attention given to freight movement in regional transportation planning, and to the concentration of urban residential and commercial activity into "centers" under Washington's growth management act. The specific areas of focus in this study were: how businesses deal with denser urban forms, how these forms can be made more "freight friendly" in the future, and what are the likely benefits from such changes?

The study is intended as a first step in a larger research agenda for the Washington State Department of Transportation on the subject of urban goods and intercity freight movement. We suggest topics worthy of further research in the report. The report is organized in two parts. Part I includes our study approach, findings, and future research agenda. Part II includes a literature review, a list of organizations and individuals contacted during our background research, and the case studies themselves.

## **STUDY APPROACH**

### **ADVISORY GROUP**

One of our first steps was formation of a study advisory group to provide us counsel on the practical and policy territory surrounding freight movement and land use in metropolitan King County. We met with the advisors at the outset of the study and throughout the four-month span of our case selection and site visits. Advisory group members included the following people:

- **Amy Arnis**, Policy Development Branch, WSDOT
- **Mike Bevers**, Transportation Manager, Darigold Inc. and President, Council of Logistics Management
- **Peter Beaulieu**, Regional Freight Mobility Project Manager, Puget Sound Regional Council
- **Mike Quinn**, Senior Growth Management Planner, King County
- **Martha Choe**, Seattle City Council member

### **LITERATURE REVIEW**

To inform our research and provide a context for the study, we conducted a focused literature review. The emphasis was urban goods movement, transportation, and land-use policy as they relate to compact urban form. The team conducted electronic searches using the university library system, as well as specialized national and international databases.

To increase the likelihood of obtaining the most current and useful information, we personally contacted individuals and organizations most directly involved in urban

freight movement, transportation, and planning, asking them to refer us to studies, books, and other data sources.

An annotated bibliography and list of telephone contacts made for this study are found in Part II of this report.

### **COORDINATION WITH PSRC**

The Puget Sound Regional Council (PSRC) has taken a leadership role in preparing the freight movement element of the regional transportation plan as part of its Metropolitan Planning Organization responsibilities under the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA). Working closely with the Economic Development Council, PSRC has formed a Regional Freight Mobility Roundtable. This approach at working jointly with industry representatives is a progressive national model. PSRC has hired consultants to analyze freight movement patterns and needs; in the process, it undertook a large-scale survey of firms in the Puget Sound region.

PSRC made the results of this survey available to us and provided us the opportunity to review survey data and their implications with its consultant team. We were able to use these existing data to create a pool of likely case study firms without burdening area businesses with another questionnaire. We reviewed business typologies and potential business representatives interested in participating in our work with PSRC consultants.

### **CREATING A POOL OF CANDIDATE CASE STUDY FIRMS**

It is difficult to characterize the scale of the urban portion of trucking activity for two main reasons: 1) intercity truck movements are rarely examined in terms of the portion of the intercity travel actually occurring within a metropolitan region; and 2) so much of trucking in urban areas is an ancillary activity of other functions, and is not, therefore, easily identified. Often, for instance, the largest truck fleets in a metropolitan

area are those belonging to the Postal Service, the phone company and the gas company. Data on their trucking-related activity are rarely separately identified.

This description of the urban freight sector, from the proceeds of the first Freight Transportation Conference held in 1992 (**Getting To Know You: Trucking, MPOs, and Urban Highway Planning/An Introduction to Urban Goods Movement Planning Issues**), is representative of much of what is known about urban goods movement: there are many players, large and small, engaged in almost endless configurations of shipments of different products in different forms to different places. It is also an understudied field with no generally agreed upon typology of activities or firms.

Our objective in identifying potential firms for our case studies was to have firms that represented a range of lines of business and locations in metropolitan King County. We considered factors such as the value density (the relationship of cost to weight) of the product shipped and its perishability. We concentrated on manufacturing and distribution firms as opposed to service firms to ensure that we captured businesses for which the physical movement of freight was an irreplaceable business function (that could not be substituted by electronic delivery of information, for example). We were interested in assuring mixes of urban and suburban center locations, national and local firms, large and small operations, and control or lack of control of delivery sites.

We segregated the King County responses to the Freight Roundtable's questionnaire and began to analyze the approximately 65 respondents. From this initial group we developed a list of 16 firms and created a Draft Firm Selection Matrix (see Table 1). We used this matrix to deliberate within the study team, with our advisors, and with PSRC staff and consultants about selection of a mix of case study firms. It became obvious that an additional important factor in the selection process was the interest of a key contact in a firm to participate in our study.

Using this mix of factors, we defined numerical scores which characterized the degree of diversity between all pairs of firms. Using these scores, we then defined a

Table 1. Draft Firm Selection Matrix

Firm	Business Type	Location	Inventory Value Density	Shipping Mode	Shipments of Interest to:	Pounds Shipped	Shipment Time Sensitivity	Receptive Contact
Boeing	Heavy manufacturing	Renton, Seattle, Kent, Auburn, Everett	High	Multiple	Between plants		High	
Korry Electronics		Lower Queen Anne —moving to Bothell	High					
Darigold	Food Manufacturing/ Distribution	Issaquah, Interbay, Rainier Avenue	Low	Truck	Multiple sites		High	
Langendorf A la Francais Gai	Bakeries: food manufacturing/ distribution	4th Avenue S. Pioneer Square Central District	Low	Truck	Multiple sites		High	
Safeway	Food retail	Bellevue	Low	Truck, rail	Multiple sites		Medium to high	
Salmon Bay Lonestar	Sand, gravel	Ballard Marginal Way	Very low	Truck, barge	Multiple		Low - to plant High - from plant	
Seattle Times	Printing, delivery	Bothell, South Lake Union	Low	Truck, rail, foot, auto	Multiple		High	
Thaw	Manufacturing	by King Dome	Medium	Truck	REI (Sumner)		Medium	
UPS	Delivery service	Redmond, S. Seattle	Medium	Truck, air	Multiple		High	
Weyerhaeuser	Recycling	Kent	Low	Truck	Multiple			
Avetech		Wallingford						
Derby Cycles	Manufacturing, assembly	Kent	Medium					

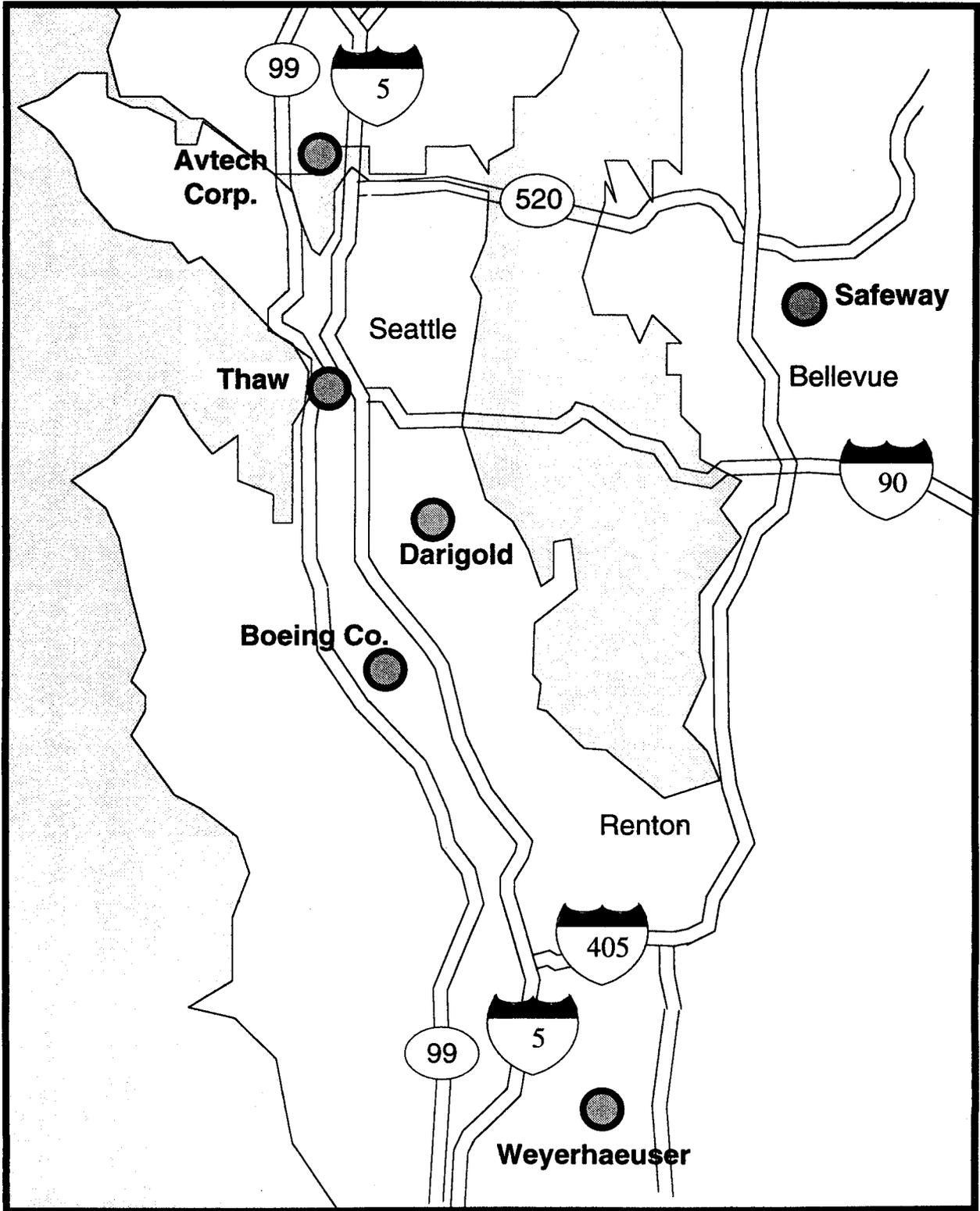


Figure 1. Case Study Sites

model to select the subset of firms which was "maximally diverse". Assisted by this methodology (which is described in Appendix A), we selected six firms for case study treatment (see Figure 1). Each firm would be visited on-site by a research team consisting of MBA and Urban Planning graduate students. All six firms agreed to participate and were visited. They were as follows:

<u>Firm</u>	<u>Location</u>
Boeing Company	Renton, Auburn, King County
Avtech	Seattle (Wallingford)
Weyerhaeuser Recycling	Kent
Thaw Corp.	Seattle (near Kingdome)
Safeway Stores	Bellevue
Darigold Inc	Seattle (Rainier Valley)

The study team conducted a prototype site visit with advisor Mike Bevers at Darigold's corporate headquarters and Rainier production facility in July. This visit allowed us to test and fine-tune our questions and site visit approach. The site visits were conducted during August 1994.<sup>1</sup>

---

<sup>1</sup>United Parcel Service was also selected in our study group of firms and agreed to participate. However, we did not include it here because of the limited time and resources of this short term study. UPS, unlike the other firms, is exclusively a delivery service. In addition to being the largest delivery service in the world, it offers very competitive and innovative approaches to the field of urban goods movement and was included largely for this reason. There is much to be learned from this and other delivery service firms, providing a rich area for further research.

## FINDINGS

Our case study firms intentionally span a wide range of industries, shipment patterns, and location characteristics. The case study firms include the following:

- Avtech Corporation, located in a dense, mixed-use neighborhood of Seattle, receives and sends relatively lightweight electronics parts and equipment via third party shippers—primarily UPS—or trucks to and from Boeing, its primary customer.
- Safeway Stores distribution center in Bellevue operates a fleet of 189 tractor-trailer trucks 24 hours a day, shipping large loads to its own stores in the Seattle metropolitan area and beyond.
- Thaw Corporation, with its main plant and offices in Seattle near the Kingdome, operates a single truck to serve its multiple locations. Thaw contracts out for regular trailer load deliveries to its parent company, REI.
- Darigold's Rainier Avenue processing plant receives raw milk from western Washington farms, turns it into milk products, and delivers truckloads 24 hours a day to businesses throughout King County and beyond.
- Boeing Company operates an internal transportation division, which services its employees and facilities in the Puget Sound region. This integrated operation moves people and goods in everything from courier cars to giant, specialized engine toting trailers.
- Weyerhaeuser Recycling operates a fleet of trucks from facilities in Woodinville, Seattle, and Kent, which "harvest the urban forest," picking

up waste paper at commercial facilities and taking it to a sorting and shipping facility in Kent.

Each firm, intentionally or by default, deals with issues of location, congestion, efficiency/cost, and urban form. The findings below are grouped in these four headings. If these four topics are addressed effectively, the metropolitan freight movement system enhances reliability, which is the guiding objective of PSRC's draft report on freight movement in the four-county Puget Sound region (**Regional Freight Mobility Action Packages**, PSRC, 1994). Reliability means that businesses have a high degree of certainty that goods needed for production will arrive on time and that products are delivered when promised. Different firms could be expected to have different requirements about reliability, depending on the perishability of their products and their methods of production (which could include just-in-time manufacturing).

### LOCATION

We wanted to know the extent to which firm location is driven by transportation costs and whether firms have considered moving into or away from denser urban centers. What we found is that many firms, such as Thaw, that are considering new locations are influenced more by the cost of land and building rent than the costs of transportation. This finding is supported by other case studies (e.g., Avtech) and earlier analyses by the principal investigator.

Density and compact urban form actually offer advantages to several of the firms studied. Darigold serves hundreds of accounts in and around Seattle. Therefore, dispatching trucks from a central location is efficient. Safeway grocery stores often generate greater sales volume in densely populated locations, offsetting drivers' difficulties in negotiating narrow city streets and tight turns. Were Safeway to expand its distribution functions, it would look to south King County because that is where it sees increased customer growth.

Weyerhaeuser Recycling has more commercial pick-up accounts near one another in Seattle. Thaw Corp., while looking for a new, larger warehouse in the Kent valley, plans on retaining its current sewing production facility near the Kingdome because of its highly skilled, urban-based work force living nearby.

Truck shipping proximity to its customer or supply base is not the key locational factor for Boeing. Of greater concern are land and work force availability. Similarly, Avtech has occupied its converted bakery facility in Wallingford for 15 years. The firm does not report any goods shipment problems at its location, but proximity to Lake Union and demand for in-city condominium and multi-family residential development in prime view locations may make this industrial/commercial land more valuable for other uses over time.

The implication of these findings is that if public policy is to integrate employment centers with residential centers to create urban villages (with a jobs/housing balance and short or no vehicular commute trips), then mechanisms must be employed to secure or subsidize the industrial/commercial land base.

## **CONGESTION**

Over the past 20 years Washington State has almost doubled in population, and King County has nearly followed suit, growing from 1 million to 1.8 million residents. More people, more cars, greater numbers of vehicle miles traveled per person, increased economic activity, and an expanding port have led to congestion on the roadways, especially during peak hour periods (which are also expanding).

Given that the vast majority of intra- and inter-city goods in metropolitan King County are moved by truck, how do crowded road conditions effect firms' shipping patterns and costs? We found that the firms we studied adjust and adapt to congestion, viewing it as a fact of metropolitan life that affects everybody.

Weyerhaeuser, Safeway, and Darigold start shifts before rush-hour periods. Dispatchers send truckloads to furthest destinations first. Boeing and Safeway employ

computerized programs to most efficiently load and route shipments and vehicles. (Boeing's software factors in the time of the last several trips to estimate arrival time or suggest alternative routes.) Weyerhaeuser Recycling's Seattle employees use cellular phones to advise one another and customers about congestion bottlenecks and changes in arrival times.

Our findings regarding congestion from the six manufacturing firms we studied are similar to findings in a recent study conducted by Cambridge Systematics, **Impact of Urban Congestion on Business**, June 1994, which focused on urban service business responses to congestion. That study, based on nearly 100 interviews with firms in major urban areas, found that "...business managers in the predominantly service-sector firms that we interviewed did not view [congestion] costs as significant because both employees and firms are effective at adapting the way they operate to minimize their exposure to congestions and its costs."

It is important to point out that while managers are showing typical American ingenuity in dealing with congestion, congestion-avoidance strategies, as well as the lack of awareness of them, have costs. Congestion does have costs both internal to firms' bottom lines and external to the metropolitan region. In his very thorough book **Urban Goods Movement: A Guide to Policy and Planning**, K.W. Ogden sites the conclusion of an Australian study: "...it is clear that practice of evaluating the benefits of road improvements to commercial operators by simply looking at reductions in journey times, overlooks the significant costs that are incurred by the freight transport industry in trying to avoid the use of roads during periods of peak congestions."<sup>2</sup>

---

<sup>2</sup>K.W. Ogden, *Urban Goods Movement: A Guide to Policy and Planning*, Ashgate, Australia, p. 99.

As will be seen below, some case study firms are already extremely cost conscious. Congestion can be used as a force to assess costs, price access at peak times, and change freight transport behavior. Viewed as a regional phenomenon, Puget Sound's lesser congestion relative to California metropolitan areas may have been a competitive advantage over the recent decades in attracting new business. As local congestion has increased, this advantage may have diminished.

### **EFFICIENCIES AND COSTS**

We found a variation in awareness about transportation costs and congestion among the firms studied. Safeway, which operates in a highly competitive industry with very slim profit margins, utilizes a computer program to micro-adjust truck diesel engines to gain a half-mile per gallon increase in efficiency. The grocery giant also employs computers to maximize the mix and routing of merchandise to its stores. The firm knows its own and its competitors' costs of transporting goods and is constantly examining ways to reduce these expenses.

Weyerhaeuser Recycling, by contrast, seems less concerned about fine tuning its transportation costs. For example, a Woodinville based truck was sent on a round-about route that included Greenlake in Seattle, as well as Everett to the north. However, Weyerhaeuser did take the lead influencing the deregulation of recycled materials carriers. Recyclers have been exempted from Washington Utilities and Transportation rules restricting back-hauling, which has allowed much greater flexibility and profitability in the use of its fleet of trucks and drivers. This same deregulation now applies to any company that ships goods by truck and by air, meaning that United Parcel Service is also now deregulated under provisions of the Aviation Improvement Act of 1994.

## **URBAN FORM AND TSM/TDM<sup>3</sup> STRATEGIES**

Denser, more compact urban form as found in urban neighborhoods or central business districts places special requirements on the movement of goods. While firms are attempting to control costs by operating more efficiently and shipping more tonnage per load in ever longer trailers, transit and pedestrian oriented development calls for narrower streets and shorter turning radii.

Weyerhaeuser and Darigold address the issue of urban density constraints by using smaller, 24-foot trucks in many Seattle settings. Weyerhaeuser established a transfer facility south of downtown where waste paper is transferred from small trucks to long trailers and then taken to the main Kent facility. This satellite transfer facility offers proximity to downtown and has resulted in savings of 60,000 annual truck miles traveled and related congestion costs.

Several suggestions for using the existing transportation infrastructure more effectively emerged in our findings. The first is a nascent trend toward consolidation of deliveries required by some major chains as a cost savings measure. (Fewer but larger deliveries of snack foods to a 7-11 means fewer personnel devoted to receiving freight and more time selling goods and serving customers.) Such consolidation would also have the effect of removing a certain number of trucks from the roads, thus potentially reducing congestion. This consolidation trend was mentioned in interviews at Safeway and Darigold.

---

<sup>3</sup>TSM/TDM refers to Transportation Systems Management and Transportation Demand Management, related concepts of managing the existing transportation infrastructure more effectively and managing demand for using the transportation system. The former leans toward accomodating more traffic, the latter toward reducing the amount of traffic.

Another variation is for delivery rounds of a particular product to be pooled amongst carriers. An example of this are flowers in Portland, Oregon, where florists meet in a suburban parking lot at an agreed time each day, and swap their deliveries, so that each individual delivery vehicle covers only a portion of the total metropolitan area.<sup>4</sup>

Truck drivers interviewed as part of this study offered a variety of practical suggestions to accommodate the flow of freight in denser urban environments. Reinforcing one-way protocols for alley traffic would speed delivery times. Educating the driving population in general about trucks, their greater breaking distance requirements, and turning and vision constraints would make for smoother and safer driving conditions. Truckers had mixed attitudes about using HOV lanes. Some thought it would be great. Others thought trucks going up grades would slow traffic, thus defeating one of HOV lanes' purposes. And the left hand lane location of HOV lanes would necessitate trucks crossing all other lanes to enter and exit the road, a potentially difficult maneuver in congested traffic conditions.\*

---

<sup>4</sup>Ogden, p. 246

\* For additional findings on this subject see *Increasing Freight Transportation Productivity in Urban Corridors*, Fred Mannering and Jodi Koehne, Washington State Department of Transportation

## A FUTURE RESEARCH AGENDA

The field of urban goods and freight movement is fascinating, under-researched and poorly understood. Its inclusion in transportation, land-use, and growth management planning is fundamental to successful cities and businesses. This research was a first step in gaining an understanding of how firms actually manage their transportation in metropolitan King County, and it has yielded a great deal of useful information. It has also informed us about potential future research needs. We believe the following research topics constitute a productive applied research agenda with many potential benefits for the public and private sectors.

1. **Examine a broader sample of businesses.** It is important to confirm or adjust our findings by looking at other businesses that need to locate in urban areas. These include bakeries such as Gai's, Langendorf, and A La Francaise and sand/gravel and ready-mix concrete firms such as Salmon Bay and Lonestar, all of which responded to the Roundtable survey. It would also be useful to examine firms in the four-county metropolitan region, including Pierce, Snohomish, and Kitsap counties, along with King County.
2. **Focus on delivery service firms.** UPS, Federal Express, Airborne, and other delivery providers earn a premium for reliability. How do they navigate the urban freight system, and what can we learn about logistics and technology application from this sector of the urban goods movement industry? Our research with UPS leads us to believe there is much to learn about multi-modalism, transfer facilities at the CBD edge, scale of vehicles, and navigating in dense urban form that could be applied to development in a growth management environment.
3. **Explore congestion pricing.** The larger issue of congestion pricing related to freight movement was mentioned several times in our study. Should vehicles pay

to use major roads during congested periods? Should trucks pay to use HOV lanes? Would there be fewer trucks if pricing were implemented? Would customers agree to off-peak deliveries if they paid less? This is an area for further examination.

4. **Learn more from truck drivers.** K.W. Ogden writes, "Driving a truck is a skilled occupation, and driving it in traffic, especially a large truck, is a stressful job. In many instances, the road and traffic system is poorly designed for large vehicles, while access to and use of many loading and delivery areas leaves much to be desired; the truck driver must confront all of this. There has been no formal research on urban truck drivers..." We began to interview truckers and accompanied them on several routes as part of our study. Much could be learned from a more concerted effort and learning from this firsthand source.
5. **Analyze the possible benefits and impacts of freight consolidation.** Freight consolidation already exists *within* companies such as Safeway and Boeing and appears to be an emerging trend for companies making and receiving multiple deliveries. Will freight consolidation reduce freight congestion? Will it affect just-in-time delivery systems? Does it reinforce congestion pricing schemes? Does it have undesirable impacts such as larger trucks and loss of jobs?
6. **Develop "freight friendly" urban form.** This study and the Freight Mobility Roundtable's Action Package provide insight into freight related design requirements that could be incorporated into building and public right-of-way design. Prosaic improvements such as one-way alley protocols and the optimum location of curbside delivery zones could make a big difference in urban goods movement. Drawing on information from truck drivers, pedestrian advocates, case study transportation managers, architects, developers, and urban planners,

urban planners could develop design guidelines to retrofit and make future urban development more freight friendly.

7. **Develop project ranking methods.** A plethora of freight related transportation improvements will be requested of WSDOT. Under ISTEA these improvements need to be carefully related to state and regional plans and funding. For these reasons it seems important to develop a conceptual framework and rigorous methodology for evaluating the discounted costs and benefits of various projects relating to freight movement. The methodology would include the multicriteria nature of the project selection problem, and would incorporate appropriate optimization procedures.
  
8. **Measure the effect of "freight friction"** as a factor in the economic growth of the region. The region's economy may be less sensitive to the freight issue and more sensitive to work force, environment, and infrastructure issues. To help focus WSDOT's limited resources on freight related improvements with the greatest benefits, it is important to identify the types of changes that make the best transportation investments and when public investments should be made in other sectors.

**PART II**  
**LITERATURE REVIEW**

## LITERATURE REVIEW

Randolph W. Hall and Wei Hua Lin, *Less-Than-Truckload Trucking in Los Angeles: Congestion Relief Through Terminal Siting*, Transportation Research Record, num. 1320, 1991. At U.W. Engineering Library.

Summarizes the findings of a research study conducted at the University of California that assessed the potential for reducing trucking delays caused by urban road congestion in the Los Angeles region. The emphasis is on improved selection of terminal sites for LTL common carriers, especially on the feasibility of placing terminals at locations that exploit surplus freeway capacity.

*Trucking issues 1990: freight transportation*, Transportation Research Record, no. 1256, 1990. The first page of each article was retrieved. At U.W. Engineering library. Contains the following article titles:

- "Developing a Market Artery System to Identify Priority Commercial Truck Routes"
- "Operational Considerations Relating to Long Trucks in Rural Areas"
- "Urban Freeway Gridlock Study: Decreasing the Effects of Large Trucks on Peak-Period Urban Freeway Congestion"

Investigates the effects of large trucks on peak-period urban freeway congestion. Addresses strategies to reduce congestion (improved traffic management, expanded incident management, mandatory night shipping and receiving, and mandatory peak-period truck bans) and the economic effects of these strategies.

- "Effect of 49th-50th Street Bus and Taxiway on Traffic Congestion in Manhattan"
- "Effects of Truck Restrictions on Regional Transportation Demand Estimates"
- "Effect of Truck Strategies on Traffic Flow and Safety on Multilane Highways"

*Freight Transportation*, Transportation Research Record, no. 1061, 1986. At U.W. Engineering Library. Contains the following article titles:

- "Container Competitive Strategies of Two Atlantic Ports"
- "Rationalization of Regional Distribution Systems for Containerized Freight"
- "Economics of Coal Transportation: Implications for Railroad and Shipper Strategies"

- "Factors That Determine Mode Choice in the Transportation of General Freight"
- "Distributing Nonstorable Items Without Transshipments"

*Freight Transportation Issues*, Transportation Research Record, no. 1154, 1987. At U.W. Engineering Library. Contains the following article titles:

- "Measuring the Impacts of Freight Transport Regulatory Policies"
- "Innovation in Trucking: Advanced Truckload Firms"
- "Implications of Open Access for Natural Gas Markets"

The ASCE Committee on Urban Goods Movement, *Issues and Problems of Moving Goods in Urban Areas*, Journal of Transportation Engineering, vol. 115, no.1 (Jan. 1989). Acquired copy of paper.

Presents an overview of the characteristics of urban goods movement and its major problems and issues. The major topics addressed are: movement of trucks along urban roads and through intersections; loading and unloading of trucks in central business district (CBD) and non-CBS areas; and truck terminals and stops.

U.S. Department of Transportation, *Urban Goods Movement*, March 1980. Pamphlet borrowed from U.W. library, Gov. Docs.

A small booklet written for local officials and managers on the problems of goods movement and suggested steps toward solutions. Contains statistics on urban freight, and discusses in general way the difficulties associated with trucking of urban goods.

Federal Highway Administration, *Urban Transportation Planning for Goods and Services*, June 1979, at U.W. Gov. Docs.

A reference guide to address short-range traffic engineering and transportation planning needs associated with urban trucking. Documents data, techniques, and methodologies that can be used by traffic engineers and planners to both identify the nature of the problems and to evaluate alternative problem solutions. Also, methods for "spot-checking" the applicability of the data presented to the problem being evaluated.

An excellent reference for planning, although the data is probably dated (from around 1965-1970). Has a great overview of selected improvements such as "peak period curb parking prohibitions" and "Median width", the applicability of the improvement, the implementing agencies, implementing factors, and impacts.

Samy A. Loeb, *Aspects of the Demand for Urban Goods Movement in City Centers*, Doctoral Dissertation, June, 1975 at the Polytechnic Institute of New York, borrowed from the University of California, Berkeley.

A study that investigates the economic and locational parameters which give rise to the pattern of UGM as measured for a case study in Downtown Brooklyn, N.Y. The objective of the study is to investigate the nature of the correlation between the demand for UGM, or goods trip-generation, and the level of economic activity of the area. The study develops measurements for UGM demand in downtown areas as a first step in the development of a model for the utilization of UGM facilities, formulated with companion studies.

Regional Plan Association-New Jersey, *Improving Freight Movement in Downstate New York*, November 1992. Acquired copy.

A generalized overview of the current problems facing the region of Downstate New York, and suggested solutions.

American Trucking Association, *Getting to Know You: Trucking, MPOs, and Urban Highway Planning*, 1992. Acquired copy.

"To initiate a dialogue on mutual freight transportation concerns, interests, and issues, the American Trucking Associations, the U.S. Federal Highway Administration, and the National Association of Regional Councils joined together in sponsoring a Conference on Freight Transportation in October, 1992. This document is intended to report the findings of that conference and to provide urban planners, local officials, freight providers and shippers, with a background report on urban goods movement requirements."

This document contains an overview of ISTEA and its objectives, a description of the nature of the trucking industry and of urban goods movement in the metro planning process, and a list of recommended action items for trucking industry, MPO's, and federal government to "encourage a continuing, comprehensive and cooperative process to monitor and identify emerging issues with the other participants".

Peter L. Shaw, *Seaport-Surface Transportation Access and Urban Transportation Congestion*, University of California Transportation Center, Berkeley, working paper, no. 116. Received on loan from the U.C. Berkeley, made copy of bibliography.

"Research that examines the impact of urban surface transportation congestion upon the flow of international cargo. Within the specific frame-of-reference of Southern California, the following elements are reviewed: 1. the larger context of urban congestion; 2. congestion in Southern California; 3. a framework of policy options to improve the flow of cargo via land access; 4. attractive policies, action and implementation." This work is centered around access to seaports.

Institute of Transportation Studies, University of California, Davis. Received list of research reports, reprints and presentations available from the Transportation Center.

Virginia Polytechnic Institute and State University Center for Urban and Regional Studies, J.W. Dickey and R.D. Gustley. Prepared for the National Science Foundation, *A Guide for Analyzing Local Government Service Pricing Policies (With Special Reference to the Effects on Urban Development)*, 1975. Received on loan for the State Library of Ohio.

"This report is intended as a guide to help local governments in identifying and assessing means for controlling growth through various service pricing mechanisms. The study attempts to lift the state-of-the-art to a respectable level. A twelve-step process was created and detailed. The authors have attempted to apply the process using Fairfax County, Virginia as an example. For each of the twelve steps, the authors provide (1) a brief description of the methodology employed in that step; (2) an elaboration of the major advantages and disadvantages of the methodology; (3) a summary of the findings from the example application; (4) a set of conclusions based on the findings; and (5) a small number of references from the literature. These five items are presented in handbook form for each step in the process. For more technical detail, the major papers documenting different parts of the study are included in the appendices."

Eugene R. Russell, L. Orlo Sorenson, and Rick Miller, Midwest Transportation Center, Iowa State University, *Microcomputer Transportation Planning Models Used to Develop Key Highway Commodity Flows and to Estimate ESAL Values*, 1992. Received on loan from Iowa Department of Transportation Library.

"The primary purpose of this report is to improve Kansas DOT ability to manage the increasing truck volumes and axle loads on the state highway system. By determining truck type, size and estimated weight and volumes by commodity, equivalent single axle loads (ESAL) estimates by commodity can be determined. The current personal computer version of Quick Response System II was used to distribute and assign heavy truck trips to the statewide network".

"...to analyze current heavy truck commodity movement in Kansas in order to have better base data for current use and to act as a base to predict state highway needs for future heavy truck commodity movement, and associated axle loads, to aid in programming long-range planning and maintenance of the state highway system."

JHK and Associates, *Urban Goods Movement*, 1983. Prepared for the Federal highway Administration, made copy.

"This report provides a brief overview of urban goods movement issues in the transportation planning process to transportation professionals with little exposure to urban goods movement planning issues.....cases and urban goods movement efforts in two U.S. cities are analyzed to isolate major determinants of successful goods movement planning in urban areas. A methodology for public agencies to analyze urban goods movement problems is presented including guidelines for the best design, implementation, and operation of techniques for assisting in the cost-effective and congestion-free movement of urban goods."

Cambridge Systematics, Inc., *Impact of Urban Congestion on Business*, June 1994. Prepared for the national Cooperative Highway Research Program, received summary from Peter Beaulieu.

The objective of the research was to "identify and quantify the impact of urban congestion on the cost of doing business." This study used case studies of firms in the manufacturing and service industries, but the sample was 80% from the service industry.

"The research found that some congestion costs are passed through to business, and it identifies and describes those impacts....What was unexpected was the finding that business managers in service-sector firms did not view those costs as significant because both employees and firms were effective at adapting the way they operate to minimize their exposure to congestion and its costs. The study found that most firms do not internalize the costs of congestion and therefore do not measure and account for those costs in ways that directly influence business decisions and the "bottom line" of the firm."

Transportation Northwest, University of Washington, Seattle, Washington, received their five year summary of research reports through 1993.

American Society of Civil Engineers, *Goods Transportation in Urban Areas: Proceeding of the Fifth Conference sponsored by the Engineering Foundation*, March 6-11, 1988, Santa Barbara, CA. Available at UW. Contains papers on: Truck Accommodation in Urban Areas, Urban Intermodal Freight Movements and Data Requirements for Urban Freight Policy, Planning.

American Trucking Association, list of publications.

Edward Beimborn, Harvey Rabinowitz, Peter Gugliotta, Charles Mrotek, and Shuming Yan, *The New Suburb: Guidelines for Transit Sensitive Suburban Land Use Design*, prepared for the Urban Mass Transportation Administration and the United States Department of Transportation, published by the Center for Urban Transportation Studies and the School of Architecture and Urban Planning of the University of Wisconsin (Milwaukee), July 1991.

Discusses ways to design communities to make the best use of transit options. No direct mention of freight issues. Possible applications to freight topics of the following discussions: Transit Corridor Districts, the provision of amenities to encourage transit, the need to plan future suburbs as mixed-use communities and to consider traffic flows carefully, and the possible uses of zoning to accomplish the above.

Belknap Data Solutions Ltd, *Facility Location Decisions: A Fortune Market Research Survey*, published by Fortune, September 1977.

Study of factors governing location decisions. Presents reasons why companies choose to locate in a particular area, as well as ways in which companies gather the information to help them to make this decision. Data was collected by

manufacturing industry classification, as well as for distribution centers, regional headquarters and corporate headquarters. Factors in the selection of an overseas location are also presented. The study is dated and may not include recent changes in the relative importance of location decision factors.

Ease of freight movement was consistently rated highly in this study as a factor in location decisions.

James Bookbinder and Wendy Lynn, *Impact on a Trucking Company of a Customer's Use of Distribution Requirements Planning*, Journal of Business Logistics, vol. 7, no. 2, pp. 47-63, 1986.

Discussion of Distribution Requirements Planning and presentation of a simulation model of a trucking company with a major customer that uses DRP. The study concludes that a trucking company can benefit from the use of DRP by its customers, that a trucker may want to incent its customers to use DRP by offering them lower rates if they do so, and that the use of DRP by a trucking company may result in lateness to a trucker's non-DRP customers.

Arun Chatterjee (editor), Gordon P. Fisher, and Richard A. Staley, (co-editors), *Goods Transportation in Urban Areas: Proceedings of the Fifth Conference, Santa Barbara, California, 1988*. Sponsored by the Engineering Foundation, published by the American Society of Civil Engineers, 1989.

Presents papers and probe group reports in the following three areas:

- Truck Accommodation in Urban Areas
- Urban Intermodal Freight
- Data Requirements for Policy, Planning, and Design

Good general background in the probe group reports, including an excellent summary of current trends in urban goods movement (p. 15), such as JIT policies and the increasing suburbanization of urban goods movement.

Particularly relevant paper topics include:

- "Assessing the Role of Regulation in Urban Goods Movement" (Richard A. Staley)
- "Economic Impact of Alternative Downtown UGM Strategies" (Carol H. Walters)
- "Land Use Implication of Urban Intermodal Operations" (Richard A. Staley)
- "Moving Intermodal Containers Over Urban/Suburban Highways" (Richard A. Staley)

(Includes a discussion of common dimensions and weights of intermodal freight containers and how they often exceed U.S. limits, the common inadequacies of

many urban intermodal transfer facilities, and the impact of the foregoing on safe and efficient freight movements.)

- "Information Needs for Policy, Planning and Design" (F. Gerald Rawling)

Benjamin Chinitz, *Freight and the Metropolis: The Impact of America's Transport Revolutions on the New York Region*, Cambridge: Harvard University Press, 1960.

Extensive urban goods movement study of the New York metropolitan area. Includes historical background of past goods movement patterns. Raises the concept of "external economies"—that a company might locate in an area where labor costs are higher but where the economies that it realizes from other benefits, such as proximity to other shippers and therefore access to lower freight rates and a greater variety of routes, are more significant.

Dennis L. Christiansen and Ronald W. Holder, *Off-Street Loading Space Requirements for Downtown Buildings*, Texas Transportation Researcher, pp. 5-7, January 1974.

General discussion of results of a study of off-street loading requirements in downtown Dallas, with an emphasis on office buildings. Includes a survey of other cities' off-street loading requirements. Discussion of the tradeoff between capacity of delivery areas and queuing of vehicles and resultant congestion and wasted driver time. Includes a bibliography with the original study citations.

Michael F. Collins and Timothy M. Pharoah, *Transport Organization in a Great City: The Case of London*, Beverly Hills, CA: SAGE Publications, 1974.

Study of the transportation system of London. Includes a case study, "Operation Moondrop: An Experiment in Out-of-Hours Deliveries of Goods".

Federal Highway Administration. TRIS Search for goods movement sources.

*Freight Modeling and Forecasting*, Transportation Research Record, no. 889, Transportation Research Board, Washington D.C., 1982.

Contains four papers relative to urban goods movement and freight modeling and forecasting:

- "Practical Methodology for Freight Forecasting"
- "Development and Application of Statewide, Multimodal Freight Forecasting Procedures for Florida"
- "Model for Statewide Freight Transportation Planning"
- "Value of Overweighting to Inter-City Truckers"

Nicholas A. Glaskowsky, *Effects of Deregulation on Motor Carriers*, ENO Foundation for Transportation, Inc., Westport, CT, 1986.

Analysis of developments in the trucking industry and of the effects of the Motor Carrier Act of 1980.

General areas covered are:

- "Deregulation Expectations and Outcomes"
- "Effects of the Business Environment"
- "The Future of the Industry"

Includes an annotated bibliography on the trucking industry and on trucking regulation.

Institute of Transportation Engineers, *New Technology for Urban Goods Movement*, ITE Journal, vol. 55, no. 3, pp. 33-36, March 1985.

Summary of a full report by the same title. Discusses automated freight handling, transportation systems management, stratified charge engines, liquefied petroleum gasoline or propane powered engines, service truck "van pools", and electric vehicles.

Institute of Transportation Engineers. Publications list of materials related to goods movement.

Institute of Transportation Studies, University of California, Berkeley. ITS publications list.

International Seminar on Freight Transport Planning and Logistics (Bressanone, Italy, 1987), *Freight Transport Planning and Logistics*, Springer-Verlag, Berlin, Germany, 1988.

A collection of proceedings of the above conference, mainly mathematical models for freight transport situations. Particularly relevant papers include:

- "Current Trends and Perspectives on Freight Transport in North America" (E. K. Morlok) (not a mathematical paper)

Comprehensive treatment of major freight sectors (i.e. rail, marine, truck, etc.) and emerging trends likely to affect each sector. Discussion of the complexities and interrelationships of the freight movement system.

- "Issues and Models for Planning and Regulating Freight Transport Systems" (P. T. Harker) Presents mathematical models of freight transportation, including the GSPM framework.

- "Analysis of Regulation Effects in the Trucking Industry: A Technological Approach" (R. Gagné)
 

Presents mathematical models for analysis of technology in the trucking industry, including applications to issues of returns to scale, productivity growth, and the beneficiaries of regulation.
- "Evaluating the Economic Impact of Transportation Investment: an Input-Output Approach" (D. Campisi and A. La Bella)
 

Presents mathematical modeling techniques for evaluating the economic impact of changes in transportation supply in a multiregional, multisectoral system for the purposes of devising location and transportation policies and of providing a method for identifying possible bottlenecks in transportation infrastructure which hamper development policies for some regions and/or sectors.
- "Rail Tactical Planning: Issues, Models, and Tools" (T. G. Crainic)
 

Presents tactical planning issues relative to freight rail transportation as well as a mathematical modeling framework suitable for building a planning model.

Lewis Center for Regional Policy Studies, School of Public Policy and Social Research, University of California, Los Angeles. List of working papers.

LUTRAQ (Land Use, Transportation, Air Quality Connection). LUTRAQ study reports, literature review on site design and travel behavior, 1993.

Metropolitan Transportation Commission, *Regional Transportation Plan: June 1994*, Metropolitan Transportation Commission, Oakland, CA, 1994.

Includes short discussion of freight movement. Presents concept of "garage-based" vs. "linked" (truck) trips.

Cassandra Chrones Moore, *Interstate Trucking: Stronghold of the Regulators*, Policy Analysis, no. 204, February 16, 1994. Published by the CATO Institute.

Discussion of current intrastate freight regulation and benefits to be derived from deregulation of intrastate freight. Also discusses and refutes objections to intrastate deregulation.

Edward A. Morash and George D. Wagenheim, *State Regulation of Motor Carriers in a Deregulated Transportation Environment*, *Transportation Journal*, vol. 30, no. 3, pp. 39-54, Spring, 1991.

Discussion of possible effects that federal deregulation of the trucking industry will have on state government freight regulation. Relates issues of state

competitiveness for attracting both producers and carriers with state regulation of freight movements, and offers a methodology for assessing this relationship.

Presents the concept of "value density" and its impact on the weight that freight considerations carry in location decisions.

Richard A. Nordahl, *Waterborne Commerce Trends and Port Access Provision: San Francisco Bay Ports Access Study*, prepared for the California Department of Transportation, 1985.

Discussion of ways in which the state of California's transportation systems might be affected by the growth in international trade moving through its seaports. Includes a discussion of international trade and cargo transport trends and their effects on goods movements and on ports access requirements.

Kenneth Wade Ogden, *Urban Goods Movement: A Guide to Policy and Planning*, Ashgate Publishing Co., Brookfield, VT, 1992.

General introduction and description of the urban goods movement system, its problems, and strategies for its optimization. The individual chapters focus on the following topics:

- The conceptual underpinning of freight
- The objectives of the freight system from a public sector position, including:
  - economic objectives
  - efficiency
  - road safety
  - environmental
  - infrastructure
  - urban structure
- Strategies for pursuing urban goods movement objectives (pp. 16-18), including:
  - traffic management
  - location and zoning of land use
  - infrastructure
  - licensing and regulations
  - pricing

- terminals and modal interchange
- operational strategies (i.e. improved pick up and delivery practices and off-hours shipping and receiving)
- Urban freight modeling
- Implementation issues relating to urban freight planning and policy
- Case study examples of provisions for urban goods movement in specific situations

OECD Road Transport Research Programme, *Road Transport Research: Advanced Logistics and Road Freight Transport*, Organization for Economic Co-Operation and Development, 1992.

Overview of integrative logistics concepts and presentation of future trends in logistics and freight movement. Manufacturing and retailing in Europe, the USA, and Japan, respectively, are described and analyzed from the perspective of their logistics needs and strategies. Particular attention is paid to the role of information technology in logistics activities of the future. The role of government and the effects of regulation are also discussed. Seems to be a very good general source.

Robert Premus, *Location of High Technology Firms and Regional Economic Development*, prepared for the Subcommittee on Monetary and Fiscal Policy of the Joint Economic Committee, Congress of the United States, May 1982.

Survey of factors affecting facility location decisions of high technology firms. Presents examples of economic development initiatives by various state and local governments directed at attracting high technology firms to their area.

Ease of freight movement was not rated highly in this study as a factor in location decisions.

Roy J. Sampson, Martin T. Farris, and David L. Schrock, *Domestic Transportation: Practice, Theory, and Policy*. Houghton Mifflin Company, Boston, MA, 1985.

Very complete discussion of transportation functions and issues. Includes sections on:

- International Freight Transportation: Domestic Interfaces
- Freight Rate Structures
- Transportation Costs and Competition, Location Determinants, and Regional

Economic Development

- The Era of Deregulation

- National Transportation Policy in Transition

*Southwest Washington Regional Freight Transportation Study*, prepared by JHK & Associates, for Southwest Washington Regional Transportation Council, 1993.

Analysis of freight movements in the southwest Washington region. Discussion of ways in which heavy truck traffic affects traffic flow, and gives passenger car equivalents for various types of trucks, terrain and infrastructure. Includes a literature review.

Thomas J. Stone, *Feasibility of Urban Goods Movement by Public Transit* (thesis), University of Colorado at Boulder, Boulder, CO, 1977.

Discussion of the development of a model for the evaluation of intra-urban goods movement by public transit. Presentation of three case studies investigating the potential of public transit for moving freight, including the movement of U.S. Mail on Denver city buses, and goods movement on fixed rail transit in Denver. Describes freight movement capabilities of the Airtrans intra-airport transportation system at the Dallas-Ft. Worth airport. Includes a bibliography.

*Strategic Planning for Freight: Issues and Research Needs*, Transportation Research Circular, no. 294, Transportation Research Board, Washington D.C., 1985.

Summary of the proceedings of a conference sponsored by the Transportation Research Board on strategic planning for freight transportation. Includes transcripts of presentations on the following topics: "Strategic Planning at the Port Authority of New York and New Jersey", "Future Directions for Freight Transportation", "Use of Strategic Planning by a Railroad", "Use of Strategic Planning by a Motor Carrier", and "Use of Strategic Planning by a Shipper/Receiver". Also included are proceedings from a panel discussion "Strategic Planning--Where Does It Fit?", and the reports of the various TRB Committees regarding identification of research needs, including the committees of: Freight Transportation Planning and Marketing, Intermodal Freight Transport, Surface Freight Transport Regulations, and Urban Goods Movement.

Surface Transportation Policy Project: Bibliography of non-STPP sources, list of STPP publications, and May 1994 Bulletin with reading list.

Transportation Redefined: The Movement of People, Goods, Services and Information: A Final Report: A Policy Development Conference held November, 1991, California Engineering Foundation, Sacramento, CA, 1992.

Discussion of the role of telecommunications and electronics technology in relieving traffic congestion. Interesting definitions of telecommunications as a form of surface transportation and of transportation as "the movement of people, goods, services, and information."

*Trucking Issues 1990*, Transportation Research Record, no. 1256, Transportation Research Board, Washington D.C., 1990.

Six papers including the following titles: "Developing a Market Artery System to Identify Priority Commercial Truck Routes", "Urban Freeway Gridlock Study: Decreasing the Effect of Large Trucks on Peak-Period Urban Freeway Congestion", "Effects of Truck Restrictions on Regional Transportation Demand Estimates", "Effects of Truck Strategies on Traffic Flow and Safety on Multilane Highways". The "Urban Freeway Gridlock" Study appears particularly relevant and discusses the effects of large trucks on urban freeway congestion, strategies to reduce congestion, and the economic effects of the proposed strategies. The study finds that large trucks do not significantly impact peak-period freeway congestion except for "incidents" and accidents, and that efforts to reduce congestion should therefore be concentrated on better incident management.

U.S. Department of Transportation and Polytechnic Institute of New York, *Mobility of People and Goods in the Urban Environment: Facilitation of Urban Goods Movement*, published by U.S. Department of Transportation, available through National Technical Information Service, 1974.

Study of urban goods movement using the downtown Brooklyn, NY area as a test site. Found that land use type at destination was the main factor affecting goods movement patterns. Includes interviews with receivers and carriers.

Peter L. Watson, *Urban Goods Movement: A Disaggregate Approach*, Lexington, MA: Lexington Books, 1975.

General background on the urban goods movement problem, the disaggregate approach to urban goods movement analysis, and previous work on commercial trip generation, as well as a description of an urban goods movement study "to examine the goods movement generation characteristics of manufacturing establishments and to develop a . . . model to estimate the freight-oriented flows which result from the activities of these establishments."

Discussion of the role of government in urban goods movement issues and research. Presentation of factors leading to freight delays and higher freight costs. Application of the concept of externalities, road pricing, and the costs of congestion to urban goods movement analysis. Presentation of a framework for the analysis of urban goods movement scenarios.

James O. Wheeler, *The Urban Circulation Noose*, Belmont, CA: Wadsworth Publishing Company, Inc., 1974.

General overview of urban transportation using a geography framework. A good introductory book, including a chapter on "Communication Costs and Urban Industrial Location". Good discussion of the role of transport and communication costs in industrial location.

Clifford Winston, Thomas M. Corsi, Curtis M. Grimm, and Carol A. Evans, *The Economic Effects of Surface Freight Deregulation*, The Brookings Institution, Washington D.C., 1990.

Study of the effects of the 1980 Motor Carrier Act and the Staggers Rail Act of 1980 which essentially deregulated the rail and trucking industries. The study concludes that shippers and rail carriers have fared better under deregulation than less-than-truckload carriers and railroad and trucking industry workers. The study also calculates that deregulation has resulted in an "annual net gain to the nation" of roughly \$16 billion. Recommendations are given for "further increases in competition and operating efficiency" in the surface freight sector.

### CONTACT LIST

The following individuals and organizations were contacted in order to develop the most useful literature review possible.

Name of Agency/Association	Phone	FAX
Allen, Bruce	215-898-7696	898-7635
American Planning Association Research Dept. (Chicago Office)	202-872-0611 312-955-9100	
American Society of Civil Engineers	212-705-7496	
American Trucking Association	703-838-1700	
Association of American Railroads	202-639-2334	
Bradshaw, Ted, Professor, U.C. Berkeley, in City Planning	510-642-4770	
California Engineering Foundation	916-448-5411	
CalTrans	916-324-7563	
Cass Logistics	314-770-2231	
Center for Real Estate and Urban Economics, U.C. Berkeley	510-643-6105	
Center for Transportation Studies U.C. Berkeley	510-643-7378	
Council of Logistics Management	708-574-0985	
Deacon, Betty Prof., U.C. Berkeley <i>In New Hampshire for the summer--&gt;</i>	510-642-4749 603-495-3971	
Engineering Foundation	212-705-7835	
ENO Foundation	703-729-7200	729-7219
Federal Highway Administration Research and Development Systems Analysis Branch	703-285-2051 202-366-9237	
Garrison, Bill U.C. Berkeley	510-642-9062	
Great Lakes Center for Truck Transportation Research		

<b>Name of Agency/Association</b>	<b>Phone</b>	<b>FAX</b>
Highway Research Board—now Transportation Research Board—has Transportation Systems Planning and Administration Group	202-334-2934	334-2003
Institute for Transportation Research and Education University of North Carolina	919-878-8080	878-8129
Institute for Transportation Studies University of Calgary	403-220-6398	282-4663
Institute for Urban Studies University of Notre Dame	219-631-8129	631-6371
Institute for Urban Transportation Indiana University-Bloomington	812-855-8143	855-8022
Institute of Transportation Engineers has Transportation Planning Committee	202-554-8050	863-5486
Institute of Transportation Studies University of California-Berkeley	510-642-3585	642-1246
Institute of Transportation Studies University of California-Irvine	714-856-5989	856-8385
Institute of Urban and Regional Economic Development (IURD) University of California-Berkeley	510-642-4874	643-9576
Institute of Urban & Regional Economic Analysis—Part of the United States Conference of Mayors	202-293-7330	293-7330
LUTRAQ—Land Use Transportation Air Quality <i>How have they factored freight into study?</i>	503-223-4396	
<b>MIT Center for Transportation Studies</b> switchboard—617-253-1000	617-253-5320	
Metropolitan Transportation Commission (MTC)	510-464-7700	464-7848
Moore, Cassandra (Dr.) Competitive Enterprise Institute	202-547-1010	546-7757
National Freight Transportation Association	607-562-3378	562-3378

<b>Name of Agency/Association</b>	<b>Phone</b>	<b>FAX</b>
<b>National Motor Freight Traffic Assoc.</b>	703-838-1810	683-1094
<b>National Private Truck Council</b>	703-683-1300	
National Technical Information Service Research services	703-487-4636 703-487-4780	487-4009
Northwestern Transportation Center	708-491-7287	
O'Neal, Daniel	206-282-1640	
Small, Ken Professor, U.C. Irvine	714-856-5658	
Southwestern Washington Regional Council Vancouver, WA	206-737-6067	
Surface Transportation Policy Project	202-939-3470	
Texas Transportation Institute Texas A & M	409-845-5815 (Econ. & Planning Division)	845-9761
Transportation Research Institute U. of Michigan	313-936-1064 313-747-1532	936-1081
Lewis Center for Regional Policy Studies UCLA	310-206-4417	206-5566
Urban Land Institute	202-624-7000	624-7000
USDOT	202-366-3282	
WSDOT—Carla Sawyer Library Research	206-705-7972 206-705-7750 206-705-7971	

**PART III**  
**CASE STUDIES**

**DARIGOLD INCORPORATED'S RAINIER VALLEY PLANT,  
SEATTLE, WASHINGTON**

**GENERAL DESCRIPTION**

**Darigold and the Dairy Industry**

Darigold Incorporated is the milk and dairy foods processing and marketing subsidiary of Darigold Farms Cooperative, the oldest and largest dairy operation in the Pacific Northwest<sup>5</sup>, and the fourth largest dairy cooperative in the nation.

Darigold's main offices are located near downtown Seattle on Elliott Avenue. Other facilities in King County are a butter and cultured products manufacturing plant in Issaquah, a milk and ice cream facility on South Rainier Avenue, and rented warehouse space for frozen product at Sea-Freeze Cold Storage in southwest Seattle. The South Rainier location, which also serves as the distribution warehouse for the western Washington region, was the focus of this study.

**Production and Distribution**

Darigold's revenues last year were \$895 million overall, including \$385 million from consumer products (i.e. milk, ice cream and cheese) and \$500 million from dry milk powder. Liquid milk is the most profitable segment of Darigold's market, followed by cultured products, ice cream, and milk powder. The general strategy of Darigold Inc. is to secure the highest possible prices for coop member's milk, selling as much liquid milk as the market will allow, and expanding the market and Darigold's market share for other types of dairy products. Toward that end, Darigold produces and markets a variety of

---

<sup>5</sup>Alan Levitt, *Darigold Rush: Darigold Farms Cooperative, the Pacific Northwest's Largest Dairy, is Poised for Growth*, Dairy Foods Magazine, vol. 92, no. 2, p. 15, February 1991.

products, among them liquid milk (including protein-fortified and cholesterol-reduced formulations), cheese, yogurt, butter, and milk powder. Darigold Inc. currently enjoys approximately 40 percent of the market for all dairy products in Washington and Oregon.

The milk industry is subsidized by the United States government, which both provides price subsidies and guarantees a market for any surplus production, principally in the form of dry milk powder and butter. The United States government buys and stores this milk powder and butter as national food surplus and distributes it as a form of assistance and disaster relief, both domestically and internationally. Large quantities of milk powder are also sold to foreign countries. Last year, Darigold was the largest U.S. exporter of dry milk powder, with 24 percent of the market, most of which was shipped to Algeria and México.

There are three levels of federal price subsidies: the highest is for liquid milk, then for cultured dairy products (such as cheese and yogurt), and finally for dry milk powder. The most profitable product for the dairy farmer and processor is liquid milk, although this market is limited because liquid milk is very perishable (with a total shelf life of only about 15 days) and because supply exceeds demand. Darigold must continually strive to produce just the right amount of liquid milk for the market in order to maximize profits.

Darigold has had to develop impressive production and distribution abilities to ensure that its milk is made into the right product at the right time and then delivered at the least cost. The Rainier plant is one of the highest volume milk plants in the country. Because the value of dairy products is relatively low in proportion to their weight and volume, Darigold's transportation costs are high for each unit of product it produces.

Darigold drivers are responsible for more than just delivering product—they also act as salespeople for Darigold products and maintain inventory levels for customers. Darigold owns and operates all of its own trucks, although it uses outside carriers for some interstate shipments to Idaho and California.

These production and distribution capabilities have enabled Darigold to enter a number of strategic alliances and non-dairy endeavors, namely its partnership with Nestlé Foods to produce and distribute Nestlé brand products, such as Nestlé's Quick, production under various labels for other firms, and its production of bottled water and fruit juices. With these product lines, Darigold benefits from economies of scale, as well as diversification away from the competitive dairy market.

### **GOODS MOVEMENT PATTERNS**

Most of Darigold's milk supply for the Rainier plant comes from Snohomish and Skagit counties, while some comes from Whatcom County and from the Enumclaw area in Pierce County. Rainier receives 16 trailers for a total of 960,000 pounds of milk daily, with deliveries spaced throughout the day. Other inputs average two trucks per day (50,000 to 60,000 pounds) of other raw materials and supplies, much of which come from Darigold's stocking warehouse in Chehalis, and one truckload of packaging materials from Vancouver, Washington (about 20,000 pounds). Three trucks daily (30,000 pounds each) deliver cultured products, such as cottage cheese and yogurt, from the Issaquah plant. A truck also comes from Boise four times per week with extended shelf-life and Nestle brand products. Darigold is able to bring in these supplies and, sometimes, raw materials from California on a backhaul basis by coordinating these loads with its deliveries.

Of the liquid milk that Darigold processes at the Rainier plant, seven to eight truckloads daily (44,000 pounds each) are shipped to other distribution centers in Western and Central Washington (Mt. Vernon, Bremerton, Port Angeles, Olympia, and Yakima). Five trailers per night service Albertson's stores.

Four to six truckloads per day of ice cream (weighing 43,000 pounds each) are shipped to the Sea-Freeze warehouse, of which two to three truckloads come back to Rainier with the product mix that is needed for current distribution, while the rest is

shipped directly from Sea-Freeze to distribution centers in Spokane, Oregon, California, Idaho, Montana, and Alaska.

Twenty-seven trailers deliver a mix of Darigold products (except cultured products) to supermarkets for Associated Grocers each day. Individual customers (including supermarkets, convenience stores, restaurants, and schools) are delivered a full range of Darigold products in the Seattle metropolitan area (Seattle/Tacoma/Everett) from the Rainier warehouse by 60 to 70 route trucks (weighing between 8,000 to 12,000 pounds each) daily.

Darigold also supplies the Alaskan market from the Rainier plant, shipping 20 containers (each about 36,000 pounds) weekly of all Darigold products except liquid milk, which is shipped in bulk (already pasteurized by Darigold) for packaging in Alaska. The Alaskan freight is intermodal via truck and steamship.

In total, the Rainier location receives about 22 trucks and 2,100,000 pounds of raw materials, supplies, and finished products for distribution daily. Outgoing shipments total 96 trucks and 2,315,000 pounds of finished goods.

## **FACTORS INFLUENCING GOODS AND FREIGHT MOVEMENT**

### **Land-Use Issues**

Like many of Darigold's facilities, the site of the firm's Rainier Valley plant is a former dairy farm, and the plant is principally located at its present site for historical reasons. Although the plant has reasonable access to Interstate-5 and is centrally located for milk distribution to the Seattle-Tacoma metropolitan region, the location presents several challenges for the firm.

First, the refrigeration units on waiting truck trailers produce considerable noise, and the plant immediately adjoins a residential neighborhood. Because of this, the City of Seattle has required Darigold to set aside a substantial portion of its lot to act as a sound buffer between the plant and adjoining housing. Even if this space cannot be used

by trucks, the firm would like to use this space for other, less noisy purposes, such as employee parking, or possibly as warehouse expansion space. A warehouse or other structure could actually act as an improved noise buffer. Darigold reported to us that the city has not been flexible on this issue. This seems to be an important issue to the firm, especially at a location where the firm is already feels pressed for space. In general, our subject felt that the complexities and length of the building permitting process in the City of Seattle and in King County were excessive and unduly expensive.

A related issue has to do with the recent development of a shopping center immediately north of the plant. The shopping center and plant are separated by a public street that Darigold formerly used for access for its plant. Because of traffic conflicts, Darigold no longer uses this street for truck access during most of the day. Trucks must now both enter and exit the facility from the south, creating congestion and delay for truck movements. This was described as a very serious constraint on plant operations. As with the issue of noise buffers, it may be possible to reduce this problem with design solutions (for example by relocating driveways at both Darigold and at the shopping center to reduce conflicts), through increased use of traffic control devices, or through other measures. We do not know whether such solutions have been explored, or whether they are viable.

Security is another issue for the firm at the Rainier facility. Loaded trucks have been broken into on several occasions. Additionally, we were told that employees do not feel safe on the lot at night, and that the plant's milk silos have been use for "target practice" and have been damaged by gun fire.

Because of the space limitations described above, Darigold is considering moving the distribution function out of Rainier and keeping the plant as a production only facility. Darigold is still at the initial stages of considering the costs of such a move, alternative locations for a distribution facility, and other issues concerning such a move. Currently,

no decisions have been made on this issue. One potential location, casually mentioned, was Chehalis, a central location between the Seattle and Portland metropolitan areas.

### **Congestion and Infrastructure Issues**

Darigold's main strategy for minimizing the impact of congestion on its operations seems to be timing deliveries outside of normal rush hours, thus minimizing driver time on crowded freeways. Darigold also plans its routes to miss problem areas such as the Southcenter hill during peak times. In addition, Darigold uses different sizes of trucks for its different types of routes—supermarkets, food service businesses, and convenience stores—and varying degrees of congestion. The costs of these attempts to adapt to roadway congestion are not known by Darigold.

We interviewed two Darigold drivers for this study. One driver, with over 30 years experience at Darigold, currently makes intracity deliveries to the South Seattle industrial area and to West Seattle using a 28-foot truck. The other driver, with 14 years of experience at Darigold, makes deliveries to Sea Freeze and intercity deliveries with full-sized single-trailers or with trailer sets.

Both drivers commented on the tremendous increases in traffic volumes and congestion in the metropolitan region during their careers. However, their attitude seemed to be that this was "a part of the job" and that, with the exception of some specific areas, they were largely able to deliver effectively. Congestion on Rainier Avenue did, however, seem to be of special concern. Rainier Avenue is the only acceptable truck route between the Rainier Plant and both downtown Seattle and Interstate-5. Both drivers expressed frustration at even entering the roadway, and one suggested the installation of a traffic light at the plant to allow better truck access. Again, the costs of increased delivery times to the firm does not seem to be something that has been systematically considered.

Specific driver feedback included the following:

- Not enough enforcement in load/unload areas, especially in downtown Seattle. A specific complaint was that salespeople have permits and use loading zones, displacing vehicle delivery goods.
- There is a convention concerning the direction in which to enter alleys in downtown Seattle; i.e., alleys in downtown Seattle are essentially one-way. This idea should be extended to other areas to avoid truck conflicts in alleys.
- When asked about the idea of trucks using high occupancy vehicle (HOV) lanes on freeways, the inter-city driver felt that they would not work because trucks climbing hills would unacceptably slow other traffic. He also mentioned that HOV lanes on the left side of freeways were not optimal for trucks because of the difficulty of crossing lanes to exit.
- Roadways are not designed for truck movement. For example, freeway ramps are often too steep and freeway entrance chutes are too short for trucks to get up to a safe speed.
- Automobile drivers are poorly educated. For example, drivers do not understand that trucks cannot stop as quickly as cars and must take wider turns. Another example used was that many drivers do not pull fully into turn lanes, backing up traffic for everyone. A much better effort at education is needed.

We spent a limited amount of time with only two drivers, but it was evident that this is an extremely valuable and largely untapped source of information.

## **Inventory and Shipment Variability Issues**

Darigold's inventory is characterized by low value density, perishability, and seasonality. Ice cream is particularly seasonal, with demand peaking in summer months. Darigold also carries a large number of stockkeeping units, a consequence of its diversified product lines, which further complicates its forecasting, production scheduling, and shipping activities.

Shipment variability can be a critical issue for Darigold because its production flows are timed so precisely. A delay in receiving raw materials can force a switch in production plans or potentially stop production in part of the plant entirely. A delay in shipments to stores runs the risk of unsatisfied customer demand for Darigold's products and lost sales.

## **Labor Relations**

Darigold has different labor unions at its cultured products facility and at the milk packaging, ice cream, and distribution facility at Rainier (where employees belong to the Teamsters union). Mike Bevers, our principal informant, described the labor climate at the plant as generally good. Mr. Bevers felt that employees' loyalty to Darigold is very high, as many drivers have worked for the company for many years. He said that managers attempt to keep open lines of communication with workers.

When asked about freight delivery outsourcing freight operations, our informant discussed how Darigold as a union operation is under pressure in a market with increasing non-union competition (due in part to the deregulation of the trucking industry), but he questioned whether outsourcing would really save the firm money and stressed that it would also mean losing control of a critical business function. Because delivery drivers are the primary contact between the firm and customers, this issue is especially important at Darigold.

In the context of freight and congestion at the Rainier plant, Darigold's current contract with the union locks delivery drivers' shifts into three starting times. This means

that there are three peak periods during which many trucks are attempting to leave the facility, and this creates delays. Darigold would like to have more flexible driver start times to reduce this problem.

### **Energy and Environmental Issues**

Energy costs are very high for Darigold, as almost all of its products require refrigeration during warehousing and transport. Darigold continually searches for better cooling equipment and refrigerants to minimize these costs. The firm's truck fleet is also continually replaced to improve fleet efficiency. Delays due to traffic congestion are thus more expensive for the firm than for firms that transport non-refrigerated goods. Moreover, delays in shipping have an adverse environmental impact because of increased emissions. Darigold and most other firms do not quantify these additional costs; these issues may warrant further research.

### **CONCLUSION**

Darigold, Inc. offers an excellent example of the goods movement issues facing a large manufacturer and distributor in King County. The increasing congestion in the metropolitan Seattle area has impacted Darigold's operation in terms of higher costs due to longer delivery times and increased fuel consumption, but the firm does not seem to know the magnitude of these costs. Additionally, the firm is having some difficulty operating its Rainier facility in its present location because of space limitations, land use conflicts, and regulatory restrictions. This may create increased incentives for the firm to move, at least part of its functions, from this urban location.

**AVTECH CORPORATION,  
SEATTLE, WASHINGTON**

**GENERAL DESCRIPTION OF FIRM AND PRODUCTS**

Avtech Corporation is a privately held corporation that produces and repairs airplane components, primarily remote electronic units, indicator units, and lighting and sound systems. About half of the invoices processed are for repair and reconditioning of units that have already been in the field. Many parts and models are modified for individual customers.

The company's newest product is a fax machine intended for use in airplanes. The fax is an attempt by Avtech to broaden its product line and become less dependent on aircraft building business cycles.

The prices of Avtech products range from between about \$100 and \$15,000, with average prices in the \$300 to \$2,500 range. About 50 percent of the firm's receipts are with Boeing, 40 percent are with other firms within the United States, and about 10 percent of the firm's business is international.

**Size**

The company currently has about 215 employees, and last year (1993) grossed around \$15,000,000 in sales. Numbers of employees and sales vary with cycles in aircraft building, and these figures can vary considerably. While the firm has run up to three shifts, currently the firm is running one shift and processes about 800 to 1,000 invoices a month. Overall, the firm has been growing and is currently coming out of a slow business period.

**Facilities**

Facilities consist of a main building on the north side of 34th Street. A former "Grandma's Cookie" bakery, this building houses the firm's main offices, assembly plant, inventory storage, and shipping and receiving facilities. On the south side of 34th Street

Avtech owns several smaller facilities, including an additional fabrication facility and an engineering research and development facility.

The main facility was expanded six or seven years ago. The main lot has an employee "sports court" or recreation area, and an adjoining lot and house are owned by the firm. Both these areas could potentially be used for additional expansion or for additional parking. Our informant said that limited space for employee parking is the major difficulty with the current facility, but even this is not a major problem. The firm used to lease a lot across Wallingford Avenue for parking. This lot has now been developed as multi-family housing. Avtech has a Transportation Demand Management program that may partly compensate for this loss (see below).

### **WORK FORCE**

Avtech's work force is non-union. Employees have a benefits package that includes a computer purchase program, education assistance, a 401K plan, and an employee ownership plan. As Bob Hancock, the company's founder, prepares to retire, ownership of the company may change. One possibility is an employee buyout.

The work force is diverse, with "13 languages spoken, including sign." About 15 to 20 percent of the work force is involved in engineering and research. The bulk of the rest is in product fabrication and repair. Two people are employed in shipping, two in receiving, and five are in components preparation. An additional employee spends about half-time driving a truck to meet plant needs.

The firm is currently running one shift between 6:30 am and 3:00 p.m. The firm is also experimenting with some flextime and telecommuting for some of the professional positions.

## **GOODS MOVEMENT PATTERNS**

### **Transportation and Inputs**

The firm receives an approximate average of 40 boxes a day, each averaging about 5 pounds. Most of the boxes received contain electronic components that originate from outside of the Puget Sound region. Most goods come via UPS with twice daily delivery. Problems with receiving goods are minimal and not tied to location or facilities. Mostly they are typical problems, such as wrong deliveries, associated with any third party carrier.

The firm has a loading dock at the main plant, which is accessed through the main parking lot. This can be used for the "occasional" 35 to 40-foot truck that delivers larger components and supplies to the plant. The plant has a pallet lift, which is used only occasionally.

Dealers come in and stock many supplies that Avtech used to pick up. This includes office supplies, general shop supplies, and packaging.

Additionally, the firm has a small plant truck for running errands and picking up miscellaneous supplies. This requires about one-half of an employee's time. A trip log and spreadsheet are used to try to minimize trips. Weekly mileage has been reduced in the last few years from 250 to 300 miles per week to about 150 miles a week. Reductions have been achieved by running the truck to regular suppliers on a scheduled basis. For example, whereas the driver would previously run out to Costco whenever anyone had a request, usually every day of the week, scheduled trips are now made two days a week and orders must be placed before a run or wait for the next run. A cellular phone or beeper may soon be used to allow communication with the driver so that errands or stops can be added during a run, thereby further reducing total trips. Mr. Nelson, the manager of shipping and receiving, does not see congestion as a problem for running the plant truck. Peak traffic periods are simply avoided.

### **Transportation and Outputs**

Avtech fills 800 to 1000 invoices a month. Most invoices consist of a single piece, which is individually shipped. A typical shipment consists of a single 6 to 10-pound box.

About 50 percent of the firm's product goes to Boeing. Boeing picks up its own orders in its own trucks. A Boeing truck usually comes by daily.

Avtech supplies 450 to 550 customers worldwide other than Boeing. Most of these are domestic, and product is shipped by UPS. About 10 percent of sales are international, going to Asia or Europe, and these are shipped by UPS, Federal Express, or by whatever carrier the customer requests.<sup>6</sup> In almost all cases the customer specifies the carrier. Carriers come and pick up at the plant.

### **Transportation Demand Management Program**

Avtech has a transportation demand management system in place that includes a ride share coordinator, reserved carpool parking spaces near the building entrance, a guaranteed ride home program, bus passes paid for by the firm, and showers for bicyclists (the firm is located next to the Burke-Gilman bicycle trail). Mr. Nelson feels that this program is effective. Additionally, the firm has been experimenting with increased opportunities for some employees to telecommute or to use flextime work arrangements.

---

<sup>6</sup> This figure is an estimate by Mr. Nelson, but *Honor Roll of U.S. Exporters*, Business America, July 2, 1990, vol. 111, no. 13, p. 24, reports that 25 percent of Avtech's product is sold overseas, and the company hopes to "increase the percentage to more than 50 in the next five years."

## **FACTORS INFLUENCING GOODS AND FREIGHT MOVEMENT**

### **Inventory, Time Sensitivity, and Shipping Time**

Inventory of components for the building of finished products is controlled and maintained using a two-bin storage system. When the first bin has been exhausted, more components are ordered. The second bin contains enough components to supply the firm until new stock arrives. Most components are small, and storage space is not extensive.

Mr. Nelson describes Avtech as a high-mix, low volume manufacturer. Avtech forecasts demand for some products and pre-builds smaller pieces (such as lighting ballasts). The firm has built up a small amount of finished goods inventory that is stored on site. Much of the firm's product is also built to order. Many products have long lead times of up to three months. The firm's goal on turnaround time for product repair (about 50 percent of the business) is 10 days. Just-in-time delivery proved successful in one division and is being incorporated in other divisions as well.

Orders need to go out when promised, but most orders are not particularly time sensitive. The shipping department has made "a commitment" that orders will be shipped within three days of being completed. An exception is when there is an "aircraft on ground" (AOG), that is, an aircraft that needs an immediate replacement or back up part in order to be allowed to fly. In this case Avtech ships out the part within four hours. Occasionally an employee that drives near the airport or Boeing on his or her route home is used to deliver the part to speed up delivery.

### **Location**

The firm is located in the south part of the Wallingford neighborhood in Seattle. The area is just east of the Fremont "hub urban village" and just south of the Wallingford "residential urban village," as designated in the city's new comprehensive plan. Mr. Nelson describes access to I-5 via 45th Street as good except during peak traffic periods when 45th Street is very slow.

The 30-year-old firm has been in its present location for around 15 years. Before that it was on Nickerson in the Interbay area of Seattle. Mr. Nelson was not familiar with the history and reasoning behind relocating the firm.

The firm is located in a mixed-use area where commercial and industrial uses associated with the north side of Lake Union give way to predominately residential uses associated with the Wallingford neighborhood. In the last few years a significant amount of multi-family housing development has occurred around the firm. Multi-family development now directly abuts the firm's principal lot and faces the firm across two streets.

This has raised two principal issues for the firm. First, the firm has had to contend with the concerns of nearby residents. Residents have expressed concern over the use of chemicals in the plant and over noise, and some have expressed general interest in or fear of what goes on in the plant. The firm's strategy has been to "blend in" with the community and to work with residents by readily supplying information and inviting people in to see the plant when they express concerns. As an example of working with the neighborhood, Mr. Nelson described how the firm built a shed around an air compressor when a neighboring resident informed the firm that the compressor's noise was making it hard for her to work at home. Only a few small trucks deliver or pick up from the firm on an average day, and Mr. Nelson did not feel this caused any conflict with residents. In general, Mr. Nelson felt that the firm had good relationships with neighbors and that there have not been significant problems for the firm.

The second issue for the firm has been rising land values. The land the firm owns may now be much more valuable for residential development than for continued use as a plant. According to Mr. Nelson, the firm's capital equipment is fairly movable, allowing the firm to relocate fairly easily. While Mr. Nelson did not suggest that the firm is seriously considering such a decision, he did suggest that if the firm were to relocate, it would consider a more suburban location where land costs are lower and where there is

less regulation. Mr. Nelson stressed that the complexity of regulations in Seattle and the length of the permitting process are serious issues for the firm.

While relocation would affect employee's commuting patterns, Mr. Nelson suggested that employees already commute from all over the metropolitan area. Further information on commuting patterns would be useful, but this was not the focus of this study.

### **OTHER ISSUES**

When asked what research Washington State DOT could conduct, or what measures the DOT could take to help Avtech with its freight issues, Mr. Nelson stressed that freight was not a real issue for the firm. Instead, Mr. Nelson stressed simplifying state regulations that more directly affect the firm. In particular, he noted the Department of Ecology's hazardous materials regulations. Mr. Nelson discussed how Avtech tries to use non-toxic solvents and makes every effort to meet the regulations. However, Mr. Nelson also felt that, even with considerable amounts of legal advising, the regulations are much too complex to understand and are literally impossible for any firm to comply with fully. He believes this leads to unnecessary expense, and in the case of firms less responsible than Avtech, actually leads to illegal dumping of wastes.

### **CONCLUSION**

Freight movement seems to work well for Avtech. Freight volume for the firm is low, and most products are shipped via commercial carriers, or in the case of Boeing, are picked up by the customer directly. In general, the firm bears few freight costs, and this is not a determining factor of its operating in its current location within the City of Seattle. Location within a medium density residential environment seems to require some work with neighboring residents, but it does not seem to pose any major problems for the firm's goods movement. Mr. Nelson stressed increasing land value, permitting time for facility expansion, and the regulatory environment in Seattle as more likely to

affect a move out of the city if the firm were to make a new location decision. The cost of meeting regulations on all levels of government is of concern for the firm. The largest transportation cost related to the firm is the cost of employee commuting. Although the firm pays for a transportation demand management program, commuting costs are mostly borne by employees.

**THAW CORPORATION,  
SEATTLE, WASHINGTON**

**GENERAL DESCRIPTION**

Thaw Corporation is a manufacturing subsidiary of Recreational Equipment, Inc. (REI), which designs, manufactures, and imports sewn products, mainly apparel. Thaw has been in business since the early 1970s, when it was started to supply outdoor apparel to REI, which eventually acquired Thaw. In addition to selling most of its production to REI, Thaw has two other customers, West Marine and Lion Apparel (which provides apparel to the U.S. Forest Service and the Bureau of Land Management).

Thaw's main facility is located just south of the Kingdome on First Avenue in Seattle; this houses its offices, most of its cutting and sewing operations, and some raw materials and finished goods warehousing. Thaw has another production facility, opened in 1990, in Wenatchee, which cuts, sews, and has some finished goods warehousing. In addition, Thaw rents warehouse space in other locations in Seattle, in Interbay just north of Pier 91 for raw materials, and just south of the Sears building for finished goods.

**Production and Distribution**

Thaw's production strategy is to manufacture as much as possible domestically to take advantage of the shorter lead times, better communication, and the proximity of its production facilities to the REI headquarters in Kent and to the REI national distribution center in Sumner. Thaw has found that it can be very competitive with overseas sourcing in Gore-Tex and polar fleece apparel and in sleeping bags. (Part of the reason for this is that both Gore-Tex and polar fleece materials are only manufactured in the United States, and any overseas subcontractor would first need to import these materials.) Other product categories, such as down-filled outerwear, cannot be made domestically for a competitive price, and these Thaw subcontracts to Asian contractors.

Thaw decided to start its facility in Wenatchee because of the availability of labor there and because the cost of that particular facility was very attractive. Because Thaw's products are fairly lightweight for their value (a medium "value-density" category) and are not perishable, transportation considerations were less important in Thaw's decision to open the Wenatchee plant. There are about 200 employees (including the offices for all of Thaw's operations) in the downtown Seattle location, and about 100 in Wenatchee.

### **GOODS MOVEMENT PATTERNS**

Thaw subcontracts a relatively large amount of its goods movements. REI pays for its shipments of finished goods, which it contracts with Oak Harbor Freight Inc. Shipments of finished goods to REI can range from one or two 30-ft. trailers/week in the slower first half of the year, to two to four trailers/week in the last half of the year. Inbound raw materials (one to three 40-ft. containers/week) are shipped to the Interbay warehouse via contract carrier, either intermodal truck and rail or truck only, and Thaw ships raw materials from Interbay to Wenatchee (one 40-ft. container/week). Finished imported items come in containers by ship (about 30-40 ft. containers each year). They are first 100 percent inspected at the downtown facility, and then are either held in the warehousing area there or sent to the finished goods warehouse. Thaw has one 24-ft. company truck, which handles movements between its locations.

### **FACTORS INFLUENCING GOODS AND FREIGHT MOVEMENT**

#### **Land-Use Issues**

Thaw is currently looking for a larger facility to consolidate its cutting operations, raw materials, and finished product warehousing under one roof. It plans to keep the sewing facility in its current downtown location, expanding it to take up the space vacated by the cutting and warehousing functions, and hopes to accomplish the move by the first quarter of 1995. Wenatchee will also continue to sew, but not cut, its production. A factor in keeping the sewing production downtown, instead of consolidating the entire

company in one location, is to retain the highly skilled labor force in that department that it has built over the years. Thaw has been researching locations in the Kent and Tukwila areas because it will need a large facility (200,000 square feet) but will need to remain close to downtown so that all departments have fast and easy communication in the event of any emergencies or shortages.

### **Congestion and Infrastructure Issues**

Congestion does not have a major impact on Thaw's operations, partly because it is extremely close to all of its destinations, does not generate a large volume of trips, and does not actually transport most of its freight (and therefore does not have to directly manage the congestion or infrastructure difficulties in these movements). Additionally, Thaw has adjusted to its dense, mixed-use location by having its workday (one shift in all departments) begin at 7:30 a.m. and end at 3:30 p.m. Employees are therefore spared most of the worst traffic congestion, and the company truck makes otherwise problematic trips to the raw materials and finished goods warehouses outside of rush hours (generally either before or after the morning rush hour).

The major infrastructure issue that impacts Thaw is the narrow width of Occidental Avenue and the lack of docking room on the building premises. As its building adjoins Occidental Avenue directly, trailers must partially block the street access while loading.

### **Inventory and Shipment Variability Issues**

Variability in either receipts or shipments does not have a large impact on Thaw. None of its products are perishable, and it is close enough to the REI distribution center in Sumner to be able to ship product quickly. Raw materials are occasionally late, in which case Thaw asks the vendor to air freight that shipment and absorb the difference in cost. Thaw currently has a 2- to 3-month buffer in its raw materials inventory, which it hopes to reduce by moving toward a more just-in-time delivery schedule. However,

Thaw is concerned about the reliability of some of its suppliers and their ability to meet just-in-time requirements.

Because of the long lead times involved in overseas sourcing, Thaw at times also has a sizeable inventory of finished, imported goods. REI sets time windows in its orders for when it will accept goods, but to meet minimum quantity requirements and assure delivery through all of the bureaucracy and quotas involved with importing, Thaw must order its foreign production far (as much as several months) ahead of when REI will actually accept the merchandise.

### **OTHER ISSUES—LABOR RELATIONS**

Thaw enjoys an amicable relationship with its nonunion work force. Many employees have been with the company for years, building a pool of experience in this highly skilled industry. Employees enjoy REI's generous benefit package and "promotion from within" policy.

### **CONCLUSION**

In conclusion, Thaw sees its biggest costs and concerns to be those of facilities and people. Thaw's position as a medium value-density manufacturer, located near its primary customer, means that freight movement issues do not directly affect it to a great degree. By carrying a relatively large inventory in both raw materials and finished product, Thaw is also giving itself "buffer" (probably excessive buffer) from goods movement problems. It would be interesting to examine the indirect impacts of congestion, urban planning, and goods movement issues on businesses like Thaw—hidden costs or benefits (such as employee travel time) may very well be having a large impact on the company.

**WEYERHAEUSER RECYCLING DIVISION  
PUGET SOUND REGION, WASHINGTON**

**GENERAL DESCRIPTION**

Weyerhaeuser is a pulp, paper and timber company with headquarters in Federal Way, Washington. Weyerhaeuser is one of North America's largest producers of forest products and recyclers of office wastepaper, newspaper, and corrugated boxes. It employs approximately 39,000 people, and in 1992 Weyerhaeuser reported earnings of \$372 million on \$9.2 billion in sales.

**The Recycling Industry**

The recycling industry is changing rapidly. Mom & Pop operations are starting to fold as large operations such as Weyerhaeuser move in to this industry. The constantly changing regulatory framework keeps the paper manufacturers busy trying to meet the demands of different state and federal requirements regarding recycled content in paper products. Because of them, Weyerhaeuser either must "harvest" its own recycled products, or buy them from someone else. Harvesting has proved to be a more cost-effective method.

The nature of the industry is such that the price for recycled products varies daily. Foreign (Pacific Rim) firms will buy as much as possible for weeks or months, driving up the price. The price then plummets when they pull out of the market. Weyerhaeuser tries to keep its supply constant by banking on its reputation to pay, and by always being available to pick up, even during down times in the industry.

Freight costs can be 20 to 40 percent of sales, much higher than most manufacturing industries. Weyerhaeuser must be effective in controlling the large cost of transportation to remain competitive.

## The Recycling Division

The Weyerhaeuser recycling division is approximately 25 years old. Its headquarters are at the Federal Way facility, but there are recycling plants across the United States. The Recycling Division's primary purpose is to supply other Weyerhaeuser divisions with the needed pre-used paper products for manufacturing of paper products.

Weyerhaeuser divides its firm into separate business units. Each of the recycling facilities operates independently, with its own customer base, and makes its own marketing decisions.

All of Weyerhaeuser Recycling customer suppliers are industrial or commercial enterprises; Weyerhaeuser does not pick up from any residences. Weyerhaeuser Recycling also has customers that buy its excess waste paper. This case deals only with the customer suppliers that Weyerhaeuser collects paper from. The suppliers of Weyerhaeuser Recycling usually fall into the following categories:

- printers-converters
- stores
- office buildings
- financial institutions
- distribution centers (such as Fred Meyer, K-Mart)
- archives and records

The recycling division picks up all grades of paper. The paper that Weyerhaeuser itself does not use, the high grade paper and much mixed waste, are sold to other processors.

The recycling division trucks everything outbound under a certain mileage, but it will then consider rail transportation if it is cost effective. All inbound materials are collected by truck. It is occasionally able to use backhauls, but most materials are first

transported (by Weyerhaeuser or the customer) to a recycling facility, sorted, and then transported outbound to a Weyerhaeuser mill or some other customer.

### **Weyerhaeuser Recycling in the Puget Sound Region**

Weyerhaeuser Recycling has three plants in the Puget Sound Region, the Kent, Seattle, and Woodinville facilities. The Kent and Woodinville facilities both perform not only paper collection, but also sorting, baling, and shipping to the purchaser, whether internal or external. The Seattle facility is a collection point only. Paper is collected there, then trucked to the Kent facility for processing.

The Recycling Division owns its own fleet of collection vehicles but most outbound trucking is done by contract. All of its collection is done by truck. Under a certain mileage (about 400 miles) everything going out of the plants is trucked, but it will consider rail transportation if it is cost effective.

#### **The Kent Facility**

The Kent facility services the I-5 corridor between Olympia and Everett. This was the first facility in this region and is approximately 15 years old.

The Kent recycling facility is basically a collection, sorting, and baling point for waste paper. Paper is brought in by the truckload and is then sorted, baled, and shipped to paper plants for processing either here in the Puget Sound region, to other states, or to the Pacific Rim. Weyerhaeuser itself uses about 30 percent of the paper that comes through this facility. The rest is primarily sold to long-term partners (such as Sonoco) that purchase the excess supply. The volume tends to be constant throughout the year, with some increase at Christmas.

The Kent site was chosen on the basis of several criteria. Ease of access to I-5, a central location to the customer base (Everett to Tacoma), and land prices were also taken into consideration. As this is a 24-hour operation, it would not have been appropriate to locate near any residential areas.

The plant building in 55,000 sq. ft. on a 7 to 8-acre piece of land in the industrial sector of Kent. Weyerhaeuser wishes that this was a larger facility, as it has outgrown its inventory storage capabilities. The plant has five receiving docks for collection trucks, and two shipping docks for outbound materials. There are two buildings, a main building where the sorting and bailing take place, and another building for storage, dispatch, and maintenance offices.

The Kent facility runs three shifts a day, but only two for the drivers. It has 12 day drivers and two swing-shift drivers. The day drivers start at 6:00 am, and the swing drivers at 2:30 p.m. Weyerhaeuser Kent formerly had some accounts that only wanted Saturday collections, but currently it does not employ a Saturday driver.

### **The Seattle Facility**

The Seattle facility is a warehouse in the southern industrial section of the city. It acts as a transfer facility to the Kent plant. Small box vans are operated in the downtown area. These vans drop their loads into a semi-trailer parked at the Seattle facility for hauling to Kent.

Two years ago (1992), Weyerhaeuser rented this warehouse space in the industrial section of south Seattle. Previously, Weyerhaeuser had had to run small trucks, capable of negotiating the difficult downtown conditions, back and forth to Kent. Weyerhaeuser determined that it would be more cost effective to base the trucks in Seattle and transfer the loads by semi-trailer to Kent. This location was chosen on the basis of availability of the required space, access to downtown Seattle, and price. The location is considered excellent by the drivers because of the easy access to I-5 and Highway 99 and the availability of alternative routes when there are traffic problems on the major routes.

The Seattle facility has three drivers, three box vans, and one roll-on roll-off. Each truck makes between two and four stops per run, and about four runs a day. The crew works from about 6:00 am to 2:00 p.m. They average approximately 46 to 48-hour

work weeks. The drivers have the authorization to complete a run even if they will have to work overtime to service the customer.

The Seattle facility fills three to four semi-trailers a day. A Kent driver will come up to make the rig swap. The Kent driver will also bring paper containers, as the Seattle facility does not store enough to make it through a full day of operations.

This facility receives its schedules for the following day with a delivery from the Kent swing-shift driver. The drivers only have their first trip out scheduled. After that, the first driver back takes the longest route that is available on their next trip out. The drivers work cooperatively by having discussions first thing in the morning and during the day to make their collections as efficient as possible by communicating information.

Weyerhaeuser has separated its drivers into specialty areas, those who prefer and drive better in the congested downtown streets, and those who prefer suburban driving. Maneuvering effectively under the different driving conditions requires different sets of skills. Seattle drivers need to be "cool cucumbers." The drivers must also be good around pedestrians.

### **The Woodinville Facility**

This facility, located in an industrial section of Woodinville, is a smaller version of the Kent facility. It operates as an independent agency from Kent, and therefore there are some differences in its everyday operations.

This facility serves Snohomish county and the east side of lake Washington, but it does have some accounts in Seattle.

The Woodinville facility was opened in 1988. This facility location was chosen on the basis of the central location to its service area and price of land. Weyerhaeuser recently considered moving, as the business has outgrown the facility, but the location is good enough to justify expanding the existing plant.

The Woodinville facility's plant, on about 2.5 acres of land, is approximately 15000 sq. ft. and is in the process of being doubled. There is essentially no storage

facility here, so the paper is moved out fast. The facility runs 24 hours a day, 5 days a week.

This facility has about 250 customer/suppliers. About 10 percent of the paper is purchased by Weyerhaeuser mills, the rest is sold to domestic partners or overseas.

Woodinville has a total of five trucks, one roll-on roll-off, one straight van, and three semis with a variety of trailer sizes. Each truck makes approximately three to five round trips a day. The trucks are not equipped with cellular phones, only radios for communication with the dispatcher.

Woodinville employs six drivers, one of whom drives swing shift, and one who drives Tuesday through Saturday to accommodate customers who prefer Saturday collections. Customers are encouraged to use off-peak hours collection times to lower driving times. The day drivers work from 6:00 am until 2:00 p.m.

## **GOODS MOVEMENT PATTERNS**

### **The Kent Facility**

About 90,000 tons of paper come through this facility every year. About 36 percent of this is bulk cardboard and 39 percent high grade paper. The papers are sorted into 24 grades. The paper is then sold to either Weyerhaeuser (about 30 percent), to domestic partners (about 56 percent), or exported (about 18 percent). The paper that is exported is shipped via container from the Port of Seattle.

Out of the Kent facility, Weyerhaeuser runs four semis, five box vans (24 feet) and one roll-on roll-off. Each of these makes approximately three trips in and out of the facility each work day. The Kent and Seattle facility combined travel about 400,000 truck miles a year in the collection of waste paper.

The majority of the customers of this facility keep large metal hampers or bins at their places of business to put their waste paper in. When these fill up, they are either picked up as a regularly scheduled pick up, or the customer calls Weyerhaeuser to request

a pick-up (usually as soon as possible). The drivers then arrive and load the hampers into their trucks and drop off empties. These hampers are about 4 feet x 4 feet. In some locations, the drivers are required to physically load the hampers out of smaller, portable bins.

### **Trip Scheduling**

Out of 700 or 800 regular customers (Kent and Seattle combined), approximately 50 percent are on a regularly scheduled pick-up. The rest are phone-in customers that request pick-up as soon as possible. There are approximately 60 to 70 pick-ups a day between the two (Kent and Seattle) facilities. Because of this uncertainty in daily demand for drivers, each route is rescheduled each day. This is basically done in the head of the dispatcher. The trucks from Kent average about three full loads a day.

The first schedules of each day are generally divided up by seniority, the "best" routes (those requiring the least physical labor) are given to the most senior drivers. The rig swaps, dropping off an empty/full trailer and bringing back another, is considered the easiest. After the first route, all bets are off as the dispatcher tries his best to make the most efficient use of drivers and trucks in scheduling pick-ups as they are called in. The dispatcher must know the requirements of each particular customer to know which type of truck to send.

Weyerhaeuser Kent has recently installed cellular phones in its truck fleet. With these, the drivers can now call a customer if they are going to be late for a pick-up, are stuck in an alley, or cannot find someone to open the loading dock door. Previously, if drivers needed to contact a customer, they would have to call to the dispatcher on their radio, then wait for instructions while the dispatcher called the customer. They can also call in to the dispatcher for another stop if they have extra room or are too full to make a scheduled stop.

Although most drivers deal with less congestion than the Seattle facility, there are longer distances between stops. When scheduling, Weyerhaeuser tries to keep the drivers

out of congested areas during peak hours. The dispatcher tries to schedule more accessible stops during peak hours and avoids the freeways. The swing shift drivers usually make the local runs first, then after rush hour (5:00 to 6:00) they make runs to Seattle (the warehouse in Seattle is only open during daytime hours)

### **Outbound Shipping**

The majority of the outbound trucks from this facility are contract or customer trucks, but Weyerhaeuser does have a few of its own larger trucks it uses for hauling. Most of the trucks outbound are 45- to 54-foot semis. The pick-ups only occur during the day between 8 a.m. and 4 p.m. There are approximately eight pick-ups a day, of which approximately two are by Weyerhaeuser trucks. It does not ship the waste paper by rail, as it is not cost effective. Most of the waste paper is consumed somewhere in the Pacific Northwest.

### **The Seattle Facility**

This facility moves about 900 tons a month. The trucks out of this facility tend to make more stops and haul in more full truckloads (about four) in a day than the Kent facility. The distance between stops is shorter, but the time can be just as long because of congestion.

This Seattle facility has allowed Weyerhaeuser to not have to dispatch smaller trucks all the way from Kent to Seattle with each load. This lowers costs in the form of driver time and also in truck costs. Weyerhaeuser has reduced truck mileage by approximately 15,000 miles a quarter by opening the Seattle facility.

The low clearance requirements of many of the downtown buildings require Weyerhaeuser to use appropriate trucks. These trucks carry smaller loads and require more frequent unloading.

## FACTORS INFLUENCING GOODS AND FREIGHT MOVEMENT

### The Kent Facility

#### Customer Requirements

Weyerhaeuser Recycling works to make collections when the customer prefers them. They frequently want to be part of the first run of the morning and also want to know the exact time Weyerhaeuser will arrive. Given scheduling demands, it is impossible to pre-determine exactly when a truck will reach a particular destination. A few customers prefer swing-shift pick-ups, which is why the Kent facility has two swing drivers.

Some customers prefer to deliver their own paper. Weyerhaeuser pays a higher price for the paper that is delivered to them, depending on the quantity being delivered. A customer that has its own fleet of trucks with idle capacity is a typical customer that would prefer to make its own drop-offs.

#### Costs

Weyerhaeuser Recycling pays between \$0-300 a ton for the paper that it collects. This does not include the paper that is collected for its shredding service, for which it is paid by the customer. The price per ton that a customer receives for its collected paper is dependent on the time for collection, the distance to the facility, and the volume of paper collected on each visit. Weyerhaeuser makes the highest profit margin on higher volume accounts because of the lower time requirement per ton for collection.

Weyerhaeuser estimates approximately \$1.04 a mile for truck travel not including labor. The labor costs are approximately \$20 an hour. The total cost to truck inbound is about \$20 per ton of paper.

## **DRIVER INTERVIEWS**

### **The Seattle Facility**

#### **Interview**

The driver interview was performed on a round-trip collection to Downtown Seattle and surrounding areas. This driver had been driving with Weyerhaeuser for approximately 1 1/2 years, but had been driving professionally for about 7 years. He likes downtown driving and felt that he would get bored with a route in Kent or Woodinville.

Usually, the collection points are very close to each other, about 10 minutes apart. Drivers spend about half of their days driving.

Traffic is a daily occurrence that is dealt with. If drivers get into particularly bad traffic, they will call the other drivers and warn them of the situation. Becoming familiar with a collection site and the area helps to speed up driving, as drivers can take alternative routes when necessary.

Their major problem appears to be accessibility. There is often a line to get to a building's loading dock (which is usually poorly positioned to begin with), or they get held up in alleys by other truckers. Also, vehicles parked illegally in truck zones cause many delays or hassles.

Pedestrians do not appear to pose much of a problem, except at lunch time.

Because of the rolling cages, they do not park on any hill facing upwards. It would be impossible to remove one of the rolling cages without the rest coming out also.

The Weyerhaeuser trucks can not use the carpool lanes through downtown Seattle, but one commented that it would be nice if they could.

This driver said that only a few accounts are actually good to pick up from. Most of them have some kind of problem because of lack of consideration for freight needs in the design of the facility.

### Specific Collection Descriptions

We left the Seattle facility at about 6:50 am. There was traffic, but nothing that slowed us down.

The first stop was a truck zone beneath a large office building. There was only one loading dock, and because it was on a downward sloping incline (for no apparent reason), the driver parked several feet away from it. This stop would have been much faster if the driver could have backed right up to the dock.

The loading zone was accessed from one side of the building, and the trucks exited on the other side. The access was extremely tight, and while we were there another truck pulled in and was forced to sit and wait for us to finish (about 10 minutes) before being able to unload.

The next stop was in an alley. The access here was also extremely tight because of the dumpsters parked next to the buildings. Alleys are also prime spots for getting blocked in by other trucks making deliveries. This business had forgotten to bring down its paper, so we did not sit long. If drivers are going to be blocked in for more than 10 or 15 minutes (determined by checking with the other driver) they will call in.

The next stop was Seattle University. This was a flat, easily accessible area.

Because one of the stops did not have anything, the driver was able to phone in and coordinate to take a different collection. This one was at a printer's off of Lake Union. The access was not difficult for this size of truck, and we were able to back up to the loading dock.

Usually the drivers try to make their downtown stops early because of the traffic and the other trucks (UPS, mail, etc.) trying to make deliveries. By 8:00 a.m. in our trip the traffic volumes had changed considerably. There was definitely more time sitting in traffic trying to get through lights or make turns.

## The Woodinville Facility

### Interview

The driver interview was performed during a collection round trip. The driver had been with Weyerhaeuser Recycling since June 1994 and was the Tuesday to Saturday driver. The straight (box) van was used.

This particular driver was given a schedule at the beginning of the day with his four round trips already planned. This trip was a collection in Seattle, a small printing operation by Greenlake, and to GTE in Everett, close to Paine Field. The driver mentioned that collections spaced this far apart are more common. The drivers usually make two stops per round trip. During the trip, the driver keeps track of the travel time between each stop and also the unload/load time required.

The box van can accommodate 10 of the bins Weyerhaeuser uses for collections. Because of its smaller size (compared to the semi's) it is more maneuverable and takes less travel time, but not as much can be carried.

When questioned about the easiest collections, the driver replied that only places that were planned with trucks in mind are easy to access.

A problem mentioned with the outbound materials that Weyerhaeuser trucks to the Port of Seattle is that the facility closes for lunch from 12:00 to 1:00, and there are usually very long lines to make drop offs.

Traffic congestion did not appear to pose a serious problem to the drivers. Traffic can usually be avoided, but when it cannot they just put up with it. Travel times tend to decrease as a driver becomes familiar with a particular collection point and the traffic patterns surrounding it.

When questioned about some of the problems met on the roads, the strongest reply was the lack of passenger car understanding of trucks, such as turning radii, stopping distances, and visibility of cars to the driver. It was suggested that better driver education in this area would make traveling safer for all involved. Another problem is

that there is no standard loading dock. They are all different, some are on hills or have to be backed into. Some other problems listed were as follows:

- bushes around corners and curbs (obstructing vision)
- few wide, planned turning areas
- improperly planned merge lanes on highway entrances; they are often too short, or there is exiting and entrancing traffic merging together (such as the I-5 and I-405 interchange)
- a truck-only lane would be nice, but not that useful
- having load/unload zones on flat surfaces would increase speed of transfers.

#### **Specific Collection Descriptions**

The first stop was at a printer's on 5th NE in Seattle (near Greenlake). Although situated in a mixed residential/industrial area, this collection was fairly easy. The truck double parked on a residential street with little traffic. Because the street was flat, this was fairly easy to do. Although a truck loading area was in back of the building, the sidewalk had fresh cement so that the truck was not able to cross into it.

The bins were wheeled across the street to make the transfer. Once again, since it was a flat surface, this was reasonably easy, but given the weight of the bins, an incline would have made this a difficult operation. Total load/unload time was about 25 minutes. Total driving time was about 20 minutes to the facility.

Our next stop, in Everett near Paine field, had no loading dock facility or load/unload zone for trucks. This is apparently a typical situation. The truck parked in a no parking area of the lot. Once again, it was a flat area. The driver was required to take the bins in and out of the front door, and also to use an elevator to remove bins from the upper floor of the building. Total load/unload time was about 1 hour. Driving time to the

facility was about 35 minutes, time to return to the Weyerhaeuser facility was about 20 minutes. Total driving time was approximately an hour and 15 minutes.

## **BOEING LICENSED TRANSPORTATION PUGET SOUND REGION, WASHINGTON**

### **GENERAL DESCRIPTION**

Boeing develops and manufactures commercial transportation equipment, including passenger and cargo jetliners, as well as military aircraft. In 1993, Boeing had annual sales of \$25,438,000,000. It has five major facilities in the Puget Sound region and employs approximately 90,000 people. The facilities are listed below from largest to smallest:

- Everett (Final Assembly)
- Auburn (Fabrication)
- Renton (Final Assembly)
- Seattle (Engines, R&D)
- Kent (Warehouse and Supplies, Defense and Space)
- Bellevue (Computer Services)
- Fredrickson (Vertical Tail Section).

Boeing has several internal organizations that are responsible for different types of freight movement. Traffic, which handles shipments of parts and supplies into and out of the Puget Sound region; Material Handling, which handles inter-plant movement of materials; and Licensed Transportation, which handles movement of goods and people within the Puget Sound region. For the purposes of this case study, we focused on the Licensed Transportation group.

### **The Licensed Transportation Group**

The Licensed Transportation (LT) group manages and operates any vehicle that Boeing owns in the region with over-the-road plates. It has approximately 700 motorized vehicles and about 250 trailers. Any item being sent out of state is handled by the traffic organization and is normally sent by outside vendor.

LT operates 54 semis, about 40 passenger vans for a taxi service, and about 200 small freight vehicles for mail and small packages (like an internal UPS). For the taxi service it has approximately 200 customers at a time in town for training or sales, and it

provides transportation for these people wherever they need to go. Boeing has approximately 150 miscellaneous mid- to large-freight vehicles. The rest of its vehicles are cars.

### **Facility Location**

The LT is headquartered in Plant 2 (Seattle); it totals 25 people in administration, five dispatchers, and 46 trucks. This is also the location of the major maintenance facility and of the main hub for transportation. The trucks and drivers are spread out among the different locations, and minor repairs are performed on site. The vehicles are allocated as follows among the facilities:

Seattle	110
Auburn (+Fredrickson)	41
Kent	37
Renton (+Bellevue)	56
Everett	48

The vehicles have been allocated according to historical and customer needs. The decision to base a vehicle at a certain plant is related to several criteria, including the following:

- major customer location
- distributing vehicles between plants

### **GOODS MOVEMENT PATTERNS**

Freight into, around, and out of Boeing moves by several modes. Freight coming from out of state can come by train, truck, air, or intermodal. Freight moving from one Puget Sound facility to another generally moves by truck. As the Boeing facilities are so large, there is also freight that moves within a facility. This is done by jitney or a non-licensed vehicle.

The teamster driven trucks and cars drive about 8,000,000 miles a year, out of which approximately 5,000,000 miles are logged by the light vehicles. In 1992, Boeing hauled 137,00 trailer loads. Boeing does not keep track of tonnage, only the hours and miles traveled.

A typical freight movement for the Licensed Transportation group is subassemblies or fabrication parts to Everett or Renton from Auburn. Kent ships to all of the other facilities, as it is the warehouse for the entire region. Everett and Renton typically do not ship much to the other plants, as they are final assembly points and their product flies out.

Boeing's freight movement within the Puget Sound Region is only performed by truck. Rail is used to bring in some larger assemblies to Renton and Everett from Boeing's out of state facilities. Boeing has studied the use of rail to move oversized shipments, but has determined that it does not meet Boeing's transportation time constraints. The transportation group has a commitment to transport goods in a certain time frame and the railroad has found it impossible to deliver the goods within those limits.

The major routes that Boeing drives are I-5, SR167 and I-405. Both SR167 and I-405 have bottlenecks at rush hour. Boeing tries to not schedule trucks on these routes during rush hour, but it is limited in that it has to haul when the internal customer requires it. Freight transportation usually occurs during the day, as this is when the majority of the company works. There is also a substantial amount of driving done during swing shift, but only a skeleton crew on third shift.

### **Passenger Movement**

For passenger movement, Boeing uses a computerized dispatch system. The passenger system is real-time trip planning. The computer analyzes the current vehicle location and destination, plans for current traffic patterns, then proposes the next stop.

The passenger vehicle dispatching system is run on a mainframe computer. The dispatcher receives a call from a customer who requires transportation. The dispatcher then enters this information into the system, and the person is added to a queue.

When drivers arrive at work, they log into their mobile data terminal in their vehicles. The computer then registers their employee ID numbers and ties a particular person to a particular vehicle for the remainder of the day. The drivers tell the computer which zone they are in (Boeing breaks up the region into zones, similar to what Metro does). The computer then assigns drivers to a person(s) to pick up and deliver to their destination. The computer knows the drivers' locations, and schedules pick-ups to make optimal use of driver time and mileage. The computer system uses the travel time from the last 10 times a route was traveled to predict today's time requirements.

Driver's notify the computer (through the mobile data terminal) when a pick-up has been made. When drivers approach a destination (within 10 minutes), they push a "soon to clear" button on their terminal, which alerts the computer. When the delivery has been made, the computer is again notified, and at that time gives drivers their new assignments.

This dispatching system uses as its first priority "never late," then adjusts with many other parameters, such as never hold a driver for more than a certain amount of time. The dispatcher also monitors the computers assignments and can override if necessary because of information unavailable to the computer.

By using this computerized system, Boeing is constantly able to update travel time between zones. Boeing can predict the traffic density that will be on any given route depending on the day of the year (such as the Friday before a holiday) or the hour.

All taxi drivers have their own favorite routes. They are able to take whichever way appears the best for them at the time. The drivers also have two-way radios in their vehicles and will have an announcement made if they run into bad traffic to warn other drivers.

### **Light Vehicle Dispatch**

Light vehicles are dispatched using several methods, depending on the type of freight and time requirements. Some of the light vehicles are on set schedules. Of the vehicles on set schedules, some of these are covering the same route maybe 10 or 12 times a day between two facilities. Others are dispatched and use a hub and spoke method of goods movement, and others are dispatched as special delivery to take an item immediately from one facility to another. The dispatcher uses the needs of the customer to determine the type of delivery system to be used for a particular item.

The dispatcher receives a request from the customer for a goods movement. The dispatcher then uses his or her own knowledge and experience to assign a driver to a particular collection. Drivers usually cover a particular part of the Puget Sound Region. The drivers are sent out in loops if they are using a modified hub and spoke method of collection. The drivers will make their collections, then bring the packages back to the main facility for sorting and delivery.

For items that need to be at their destination immediately, the dispatcher will send a dedicated driver to collect and deliver the item.

### **Heavy Vehicle Dispatch**

For heavy vehicles (semi-tractors) the dispatcher receives a call that a load is ready for moving. He/she then calls a tractor by two-way radio and give it instructions on where a trailer is and where it needs to go. This is a manual system for which the dispatcher keeps a large spreadsheet of tractors and locations coded with numbers and colors for tracking truck location. Drivers call the dispatcher when a drop off is made, and the dispatcher gives them their next jobs.

There are also semis that drive scheduled routes such as to Portland every day. Another scheduled route is for two trucks from Spokane and two from the Puget Sound region to meet each other in George, Washington, for a trailer swap. By doing a halfway

swap, drivers do not have to stop for the night en-route (because of federally mandated time restrictions on hours driven per day).

### **Customer Requirements and Service Guarantees**

The LT guarantees freight and passenger delivery. The time frame of the delivery depends on the type of freight being moved. Passengers are guaranteed on time service. Freight that is moved by heavy vehicle (semi-trailer) is guaranteed to be at its destination within one manufacturing day. The light vehicle guarantee ranges from 4 hours after the call is placed to the dispatcher, to 8 or even up to 24 hours after.

Occasionally, a customer needs a package moved immediately. To service this need, Boeing has a crew of 25 special delivery people. Each truck is equipped with a cellular phone, and when drivers get close to a delivery/collection point, they can call the receiver/sender and have them meet them at a specific place for immediate transfer.

## **FACTORS INFLUENCING GOODS AND FREIGHT MOVEMENT**

### **Trucking Deregulation**

The new intra-state trucking deregulations would not directly affect the LT at Boeing, except that deregulation could make in-state trucking companies more competitive.

### **Labor**

The Licensed Transportation group employs approximately 271 Teamster drivers. There are only certain windows during which shifts can start or stop, although under the most recent union contract the windows are fairly wide, and there are only a few hours in the middle of the day when drivers cannot be started.

### **Difficulties in Freight Movement**

Construction causes many time delays in the freight movement of Boeing. It is difficult to plan ahead for delays, and this makes its service less consistent.

The low overhead clearances (many only 14 feet) are also a cause for concern. Boeing often hauls large loads that do not fit under these low clearances. Because of low clearances, Boeing must know which streets are not passable with a high load. It has developed designated routes so that drivers who drive overload trucks almost always take the same route that is safe for oversized loads when traveling between facilities, even when not driving an oversized load. This means that the drivers drive the same route, even if it is not the most efficient in time or distance, so that they do not make a mistake and take an oversized load down a street that is inappropriate.

Another adjustment Boeing has made to deal with low clearances is to have special trailers constructed to haul its 777 engines. These engines currently arrive by air at Boeing Field. The engines must then be transported by truck to the Kent facility, where assembly is completed and then trucked to Everett. Because of the engine height and of the low overhead clearances the engine is required to clear, a special trailer had to be designed with an inset for the engine so that it rides only 9 inches above the ground.

The window of time that oversized loads are allowed to travel on the freeways is getting narrower and narrower. This makes it harder for Boeing to meet its delivery schedules and could increase costs.

Boeing knows when the peak traffic periods are; what it does not know is exactly where the next big accident will be. An immediate response to accidents and breakdowns to remove them from the road would help its planning capabilities. Clearing the road faster would help to smooth the time requirements of moving around the region. Travel time between facilities has increased because of the increased congestion on the major roadways.

Boeing uses vans and buses to support its passenger service requirements. These vehicles are occupied by only the driver when enroute to pickup customers. Traffic congestion frequently requires an increase in the number of vehicles dispatched to meet

scheduled pickups. A plan to allow permits for the use of HOV lanes when performing HOV type work while occupied by a single driver would reduce vehicle trips.

Boeing has made slight changes in routing around facilities because of congestion around new buildings, such as near the Auburn shopping center. The shopping center is at the north end of Boeing's facilities. The trucks are now routed out of the south end of the facility to avoid congestion.

### **Integrated Transportation**

Boeing is integrating its transportation between the licensed vehicles and the non-licensed (internal facility vehicles). To do this, it is forming connector routes at all of its major delivery sites. A package is delivered by the licensed vehicle to a particular point at a facility. The package then will be picked up by an internal driver to be delivered to the specific person/location.

Boeing schedules these drop offs and pick ups so that they coincide and are on a regularly scheduled basis. This has reduced trips because customers know when an item will be moved, so they do not request special delivery. Under the new system, customers will be able to look at a schedule and be reasonably certain of delivery times. The uncertainty is what causes groups to request a dedicated driver and vehicle for their delivery, resulting in increased costs and vehicle trips.

Currently 271 drivers are employed by LT. It hopes to be able to reduce the dedicated driver positions (see customer requirements, above) by 30 to 35 and reduce other positions to reach a total of about 230 drivers by implementing the integrated system.

Boeing expects its new integrated transportation to save the company money by reducing mileage, fleet size, and drivers. This also means fewer vehicle emissions. This new scheduling will also enable Boeing to move into larger vehicles, which are more efficient in emissions for tonnage hauled, drivers, and mileage.

One difficulty encountered while integrating the transportation systems is the inability to predict traffic patterns so that Boeing knows when to send a driver to arrive at a specific point at a specific time. Boeing has internal information on traffic patterns and schedules more travel time during peak hours.

**SAFEWAY STORES INC.,  
BELLEVUE, WASHINGTON**

**GENERAL DESCRIPTION OF FIRM AND PRODUCTS**

Safeway is one of the largest grocery store chains in the nation. In terms of market share, Safeway is the largest such chain in the Puget Sound area, and it is the second largest employer in Washington state, next only to the Boeing Company.

Safeway owns two finished-product distribution centers, in Bellevue and Spokane. These serve Washington, Alaska, Idaho, and Montana. The Bellevue distribution center, the focus of our study, is located near the 124th N.E. interchange of SR 520 and was built in 1959. It serves 138 stores in western and central Washington, 85 percent of which are in the Seattle metropolitan area, and 12 stores in Alaska. It also ships products to the Spokane center for warehousing and distribution.

An industry source, Grocery Marketing, in its May 1993 issue said that Safeway often has the number 1 or number 2 position in terms of market share in its markets, and that its stores are situated in some of the choicest locations nationwide. Safeway also operates the world's largest grocery chain distribution center in Tracy, California.

**GOODS MOVEMENT PATTERNS: THE BELLEVUE FACILITY EXAMPLE**

The main Bellevue facility has separate warehouses for grocery products (generally boxed, canned, or bottled items), produce, meat, frozen foods, and non-food items such as cosmetics and stationery. Safeway also contracts warehouse space in Kent for its bulky items—generally paper products and pet food. Safeway manufactures a variety of products for its stores at the Bellevue site as well—a dairy and ice cream plant, a bakery and bread facility, and a bottling plant are all on or adjacent to the distribution center.

Safeway ships about 17,000 tons of goods within the Puget Sound area per week by truck from either the Bellevue center or the Kent distribution facility, according to Mr.

Lindsley, Safeway Trucking Manager at the Bellevue location, who was interviewed for this report. Stores place their orders via modem into a mainframe computer system at the Bellevue center. Each store calls in its orders at a specific time each day.

Safeway's cost of transporting goods is typically \$18/ton, with some variation based on delivery location and product.

The Bellevue center employs a computer program named "TRUCKS," which optimizes total distance traveled, total time spent, average payloads per customer, and other factors, and determines the least-cost route/load configuration for each day's deliveries. Among the objectives is to make sure that trucks do not leave half-filled and that each store is able to get its orders delivered with the minimum disruption.

As some examples of shipped-out volume up to 900 trips per week (average 800 to 900) depart the Bellevue center, with each truck averaging a 40,000—pound payload. This adds up to an approximate weekly total of 17,000 tons; all but 800 tons per week go to western Washington and Alaska.

Manufactured products trucked from Bellevue to other places in the Puget Sound region are meat, produce, and some slower moving products, usually non food items. Shipments to Alaska average 70 loads per week, with an average weight of 44,000 pounds per trailer. The mode used in this case is Sea-Land container ships. Alaska deliveries take about six days.

Safeway follows the strategy of trying to keep like items together—dry with dry, refrigerated with refrigerated; this is cost effective both for product maintenance and unloading effectiveness.

Today's typical trailer size is 46 to 56 feet. Safeway tries to minimize labor costs by using larger trailers. This is especially critical to cost reduction, as all of safeway's drivers are unionized with full benefits.

Seattle area delivery turnaround time—i.e., time from order placement to product delivery at the grocery store—is 12 to 16 hours for most items except produce, which has

a turnaround time of about 24 hours. One major objective is to make the least number of trips to each store, and this sometimes means contracting with an outside supplier such as Langendorf Breads to supply directly to the Safeway store.

Safeway ships almost entirely by truck. Very little rail is used. Trucks leave 24 hours a day, 7 days a week, with fairly well-balanced (regular) shifts, except on Saturday afternoon and Sunday before noon, which are the comparatively slow times. Monday afternoons (recovering from the weekend) and Fridays (gearing up for the weekend) are usually the busiest.

The grocery business is categorized by heavy traffic in perishable goods, intense competition, and therefore low profit margins. One trailer can serve up to five stores, but bread routes serve as many as 13 stores daily because of the product's perishable nature. This suggests that Safeway utilizes a hierarchy of shipment scheduling by product perishability and trucking economy. Long shelf life goods, such as baby diapers, need not be delivered to stores on a daily basis. Perishables are given a higher delivery priority, and products with a long shelf life are delivered as needed.

The Kent warehouse was initially utilized as a receiving facility for bulky items such as paper towels and pet food, which were then trans-shipped to the Bellevue distribution center as needed. Increasingly, the Kent warehouse is delivering these items directly to stores in the Kent Valley and south King County areas, saving internal shipping costs.

## **FACTORS INFLUENCING GOODS AND FREIGHT MOVEMENT:**

### **Residential and Mixed-Use Location**

Safeway stores are located near their customers, i.e., in or near residential areas, shopping centers, and mixed-use urban village prototypes. Local community zoning and land use regulations can impact Safeway's transportation patterns and costs. For

example, night delivery is an excellent congestion avoidance strategy, but some communities object to or restrict nighttime truck deliveries.

New store locations can be influenced by additional costs of noise abatement, beautification, and parking requirements, but design constraints are easily met if the customer base will provide a profitable bottom line. Safeway's Jefferson Square store in West Seattle is an example of an urban village prototype development occupying the ground floor in a high rise, mixed-use residential, office, and commercial building situated atop a hill. Truck access is via a narrow winding road that is identified by drivers as a challenge for a large tractor trailer to navigate. These design constraints are outweighed by high sales and profitability at this location.

### **Congestion Issues**

Safeway compensates for potential delays from congestion by allowing more time for deliveries or by scheduling deliveries when the congestion is expected to be less. Safeway's policy is to send the smaller, 46 foot trailers to the most congested areas.

Safeway does internal analyses to minimize delivery costs. It pursues scheduling and scale congestion avoidance strategies, such as staggering shift start times, dispatching furthest shipments first, and using smaller trailers for stores in denser urban areas. Thus it is still affected by the prevailing congestion environment. It would like to be able to use the high occupancy vehicle lanes for freight operations.

One reason Safeway schedules round-the-clock deliveries is to avoid congestion as trucks leave and exit the Bellevue facility. The Bellevue location itself provides excellent freeway access with SR 520, I-90, and I-5, all conveniently located. The major difficulty in Safeway's deliveries is the overall congestion in the urbanized residential areas in which many Safeway stores are located.

## **Crime**

In some areas, Safeway will not make store deliveries at night—generally between 10 p.m. and 6 am for crime reasons. The corporation is concerned with adequate night lighting and asks drivers to report burned out lighting in store delivery areas immediately. It also has a security routine for all stores, a policy of, "if the driver feels uncomfortable, do not pull into the store." However, Safeway has maintained its locations in high crime areas as long as stores have stayed profitable. In addition to increased lighting, it provides extra security at certain stores.

## **Labor Practices**

Safeway no longer has the 50 percent market share it once enjoyed in many markets in Washington state. It used to offer very generous labor contracts, but it is now tightening up and seeking to cut costs. For instance, it cut 66,000 trucking hours last year (1993) while still maintaining or increasing tonnage movement. The "TRUCKS" routing software program has resulted in increasing average loads from 5 to 17 tons per truck. It is possible that an outcome of such computer programs will be to reduce the number of high wage, unionized jobs. There are many such changes that drivers see as threats, but the general attitude is to "adapt or lose." Safeway's operating costs remain higher than some of its competitors', such as those of Albertsons, which is non-union in many locations. However, this cost spread is closing. Safeway's current ratio of operating expenses to sales is 24.4 percent compared with an industrywide average of 20.4 percent.

## **Trends for the Future**

One industry trend affecting Safeway is the move toward bigger stores; typically up to 50,000 square feet today. Another trend is toward larger delivery trucks, such as the 46 to 56 footers common today.

Safeway periodically compares its trucking costs with those of subcontractors. To this moment such vendors have been unable to demonstrate how they could save Safeway

money by outsourcing trucking operations, but it is likely that in the future some trucking may be handled by independent contractors. Outsourcing of logistics activities is another widely recognized industry trend.

As the operations expand and the Bellevue center finds itself increasingly hard pressed to coordinate shifts, the trend may be towards a Tracy, California-like super distribution center. Safeway may combine the Portland, Seattle and Spokane centers with a possible location being south of Seattle on the I-5 corridor.

Another possible trend may be toward subregional centers, each such center located in a fast-growing area, such as in South King or Snohomish county.

### **DRIVER INTERVIEWS**

The project team briefly interviewed two drivers at the Bellevue center. Based on these interviews, it seemed that the biggest problems facing drivers were the general level of urban traffic congestion and the noise-related issues related to nighttime deliveries. Next, drivers suggested that freeway design signage was imperfect. Exit signs were sometimes hard to see at sufficient distances from the exit ramp. While Safeway drivers are fully familiar with their routes, automobile drivers often dart in front of the delivery trucks because they see the exit sign at the last minute.

Cities, it was suggested, should paint arrows on pavements to indicate the direction of alleys, for instance in Seattle's University District around Brooklyn Avenue and 50th street and near the Stone Way store in Wallingford. Private cars often park on the street uncomfortably close to freight-only zones, making it difficult for trucks to deliver. Some "worst stores" from a delivery viewpoint:

Worst:	Queen Anne lower and upper stores, Seattle
	Roxbury and 35th store, Seattle

Not as bad, but still difficult  
delivery locations:

White Center store-4011 S. 164th, Seattle

Burien store-120 S.W. 148th

University District store-4732 Brooklyn Avenue  
N.E., Seattle

Wallingford store-3920 Stone Way N., Seattle

West Seattle-9650 15th S.W., Seattle

Greenwood-8704 Greenwood Ave. N., Seattle

These stores have some common characteristics. First, they are in dense urban locations where the competition for the land and road space is acute. Next, many of them are located on streets that were completed well before today's truck size became typical. Although many have plentiful on-site customer parking, with increasing truck sizes, it is likely that freight deliveries at these locations will only become more difficult.

## ACKNOWLEDGMENTS

This research depended on the active cooperation and participation of businesses in the metropolitan King County area. We particularly want to thank the key personnel, including public affairs directors, transportation managers and truck drivers, who gave of their time and experience to make this study possible.

These individuals include John Ficker, regulatory and contract support manager, and Pamela Summerville, Weyerhaeuser Company; Jim Cross, CEO, and Dave Olson, scheduling manager, Thaw Corporation; Dave Nelson, shipping and receiving manager, Avtech; Chuck Lindsley, trucking manager, Safeway Stores; Bill Knox, public affairs manager, and Michael Minor, United Parcel Services; Mike Bevers, transportation manager, Darigold Inc.; and Gene Questad, licensed transportation division manager, Boeing Company.

The Puget Sound Regional Council readily made available to us information about regional freight movement gathered through the Regional Freight Roundtable, a joint PSRC and Economic Development Council project. Project manager Peter Beaulieu and consultants Paul Roberts, Tom Harvey, and Gary Moulineaux provided us important information.

Our Advisory Group of Amy Arnis, Mike Bevers, Peter Beaulieu, Mike Quinn, and Martha Choe provided essential guidance and counsel. Funding for this report was provided by Washington State Department of Transportation.

**APPENDIX A**  
**THE MAX DIVERSITY PROBLEM**

# **The Max Diversity Problem**

by

**T.D. Klastorin**

**Mark Cutler**

126 Mackenzie Hall DJ-10  
Department of Management Science  
School of Business Administration  
University of Washington  
Seattle, WA 98195

*January, 1995*

*This paper is a working paper only and should not be quoted, referenced, or reproduced in any way without the express written consent of the authors. Comments on the paper are welcome.*

# The Max Diversity Problem

## *Abstract*

Given a population of  $N$  entities, we want to select a subset of these entities which will be used to design a questionnaire to be sent to all entities. To insure that we would be most likely to observe relevant issues and questions, we want to select a subset of entities which are most dissimilar to each other. Assuming that each entity is described by a vector of characteristics, the dissimilarity between each pair of entities is described by some metric. The problem is then to select the sample with the greatest sum of the intergroup distances. In this paper, we pose this problem as the max diversity problem and, while the problem is NP-complete, show that an effective algorithm can be developed for large scale problems. The methodology is based on a lagrangian relaxation heuristic and a depth-first branch-and-bound algorithm.

# The Max Diversity Problem

## *1. Introduction*

In a recent study conducted at the University of Washington, we were asked by the Washington state Department of Transportation (WSDOT) to find and report on the range of problems which companies encounter with both inter-regional and intra-regional freight movement in the Puget Sound region. To determine these problems, we needed to identify a subset of companies for detailed case studies (which included interviews with truck drivers, logistics managers, etc.). The issues identified in these case studies would then be used to form a questionnaire which would be sent to all companies in the region; this would allow us to gauge the magnitude of the problems identified in the case studies. Given a limited budget, we were limited to a maximum of five or six companies for these case studies.

Initially, each company was described by a vector of characteristics which included such measures as size, manufacturing/service dimension, location of primary manufacturing facilities, etc. To maximize the likelihood that we observed the full range of possible problems, we wanted to find the group of companies which were most dissimilar to each other with respect to these characteristics. Since we were not testing hypotheses in this part of the study (but rather formulating hypotheses), a random sample of companies would not have been appropriate.

After using principal components analysis, the factor scores were used to compute a metric which represented a measure of dissimilarity,  $s_{ij}$ , between the  $i^{\text{th}}$  and  $j^{\text{th}}$  companies.<sup>1</sup> The problem was then to select the  $m$  companies which maximized the sum of the intragroup distances. We refer to this problem as the maximum diversity problem.

---

<sup>1</sup> While the squared Euclidean distance was used here (which was equivalent to the Mahalanobis distance), any metric could be used.

## 2. Problem Statement

Given  $N$  companies or objects with dissimilarity measures  $s_{ij}$ , the problem of finding the maximally diverse sample of  $m$  objects, is simply

$$\text{Max } z_o = \sum_{i=1}^{N-1} \sum_{j=i+1}^N s_{ij} y_i y_j \quad \text{s.t.} \quad \sum_{i=1}^N y_i \leq m \quad (\text{P1})$$

where

$$y_i = \begin{cases} 1 & \text{if } i^{\text{th}} \text{ object is selected} \\ 0 & \text{otherwise.} \end{cases}$$

To restate problem (P1) as a linear programming problem, we can define variables  $x_{ij} = y_i y_j$ . The problem becomes:

$$\text{Max } z_o = \sum_{i=1}^{N-1} \sum_{j=i+1}^N s_{ij} x_{ij} \quad (\text{P2})$$

s.t.

$$\begin{cases} x_{ij} \leq y_i \\ x_{ij} \leq y_j \end{cases} \text{ for all } i < j$$

$$\sum_{i=1}^N y_i = m$$

$$x_{ij} \geq 0$$

$$y_i = (0, 1)$$

Problem (P2) states the max diversity problem in a form which indicates a similarity to a number of well known problems, including the  $p$ -median problem (Mirchandani and Francis, 1993), the knapsack problem (Martello and Toth, 1990), and the "prize collecting" travelling

salesman problem (TSP) (Balas, 1989; Mittenthal and Noon, 1992) where the salesman wishes to visit a subset of  $m$  cities to maximize rewards available at each city (e.g., frequent flyer mileage). The max diversity problem, however, differs from these problems in the important aspect that the total value gained is a function of the interaction among all  $m$  objects selected (e.g., the  $p$ -median problem and the “prize collecting” TSP consider only the chain of  $m$  selected cities in the objective while the max diversity problem considers all  $\binom{m}{2}$  values of  $s_{ij}$  when evaluating a sample of  $m$  objects).

A similar problem, the min diversity problem, was considered by Glover *et al* (1994) who pointed out that the min diversity problem was NP-complete and developed several heuristics for the problem. In contrast to the work by Glover *et al*, however, we develop an optimal algorithm for the problem which is effective for reasonably large problems.

### 3. Lagrangian Relaxation Heuristic

We initially developed a heuristic algorithm based on an alternative formulation of problems P1 and P2; we denote this formulation<sup>2</sup> as problem (P3). Problem (P3) is based on defining variables  $w_i$  ( $i = 1, \dots, N-1$ ) which equal the values of  $s_{ij}$  for which  $y_i = 1$  and  $y_j = 1$  ( $j > i$ ) (clearly,  $w_i = 0$  if  $y_i = 0$ ); this problem is stated as follows:

---

<sup>2</sup> A similar formulation was used by Glover *et al*.

$$\text{Max } z_o = \sum_{i=1}^{N-1} w_i \quad (\text{P3})$$

s.t.

$$w_i \leq \left( \sum_{j=i+1}^N s_{ij} \right) y_i \quad \forall i = 1, \dots, N-1 \quad (\text{P3-1})$$

$$w_i \leq \sum_{j=i+1}^N s_{ij} y_j \quad \forall i = 1, \dots, N-1 \quad (\text{P3-2})$$

$$\sum_{i=1}^N y_i = m$$

$$y_i = (0, 1).$$

We can formulate a Lagrangian relaxation of problem (P3) by relaxing constraints (P3-1) and moving them into the objective function; the dual variable  $\lambda$  ( $\lambda \geq 0$ ) indicates the penalty for not satisfying constraints (P3-1). The objective function becomes:

$$\hat{z}_o = \sum_{i=1}^{N-1} w_i - \lambda \sum_{i=1}^{N-1} \left[ w_i - \left( \sum_{j=i+1}^N s_{ij} \right) y_i \right] = (1 - \lambda) \sum_{i=1}^{N-1} w_i + \lambda \sum_{i=1}^{N-1} \left[ \left( \sum_{j=i+1}^N s_{ij} \right) y_i \right].$$

Since we want to maximize  $\hat{z}_o$ , an optimal solution will result in constraints (P3-2) being satisfied at equalities; that is,  $w_i = \sum_{j=i+1}^N s_{ij} y_j$ . Substituting these values of  $w_i$  into the modified objective function, we get:

$$\hat{z}_o = \sum_{i=1}^N y_i \left[ \lambda \left( \sum_{j=i+1}^N s_{ij} \right) + (1 - \lambda) \left( \sum_{k=1}^{i-1} s_{kj} \right) \right]. \quad (1)$$

Given a value of  $\lambda$ , the optimal solution to this modified version of problem (P3) is available by inspection. Letting  $c_i = \left[ \lambda \left( \sum_{j=i+1}^N s_{ij} \right) + (1 - \lambda) \left( \sum_{k=1}^{i-1} s_{kj} \right) \right]$ , we order the values of  $y_{[i]}$  ( $i = 1, \dots, N$ ) such that  $c_{[i]} \geq c_{[i+1]}$ , and set  $y_{[1]} = \dots = y_{[m]} = 1$  and  $y_{[m+1]} = \dots = y_{[N]} = 0$ .

To find the value of  $\lambda'$  which maximizes  $\hat{z}_0$ , we search<sup>3</sup> over the interval (0,1); however, we only need to evaluate a finite number of values (e.g., those that result in  $c_{[i]} < c_{[i+1]}$ ). The rankings resulting from  $\lambda'$  will be denoted by  $[i']$ ; the value of  $z_0$  corresponding to  $\lambda'$  will be denoted by  $z'_0$  and is used to define a lower bound in the branch and bound algorithm.

#### 4. Branch and Bound Algorithm

The branch and bound algorithm is based on Problem (P2) and the following lemma which indicates the optimal solution to problem (P2) when we relax the integrality requirement on values of  $y_i$  (and therefore on  $x_{ij}$ ).

**Lemma 1:** Relax the integer requirements on  $y_i$  in problem (P2) such that  $0 \leq y_i \leq 1$ . Then, for any optimal  $z_0^*$ , the corresponding values of  $\{y_i^*\}$  will be members of set  $K_0$ ,  $K_1$ , or  $K_2$ ; where

$$K_0 = \{i \mid y_i^* = 0\}$$

$$K_1 = \{i \mid y_i^* = 1\}$$

and

$$K_2 = \left\{ i \mid y_i^* = \frac{m - |K_1|}{N - [|K_0| + |K_1|]} \right\}$$

where  $|x|$  represents the cardinality of set  $x$ .

<sup>3</sup> Note that not every solution to problem (P3) corresponds to a unique value of  $\lambda$ .

Proof: Assume that for all  $\{y_i^*\}$ ,  $i \in K_0 \cup K_1$ . Then, from problem (P2), it is evident that  $x_{ij} = \min(y_i, y_j)$  and the objective function is equal to  $\sum_{(i,j)} s_{ij} \min(y_i, y_j)$ . Assume that all values of  $y_i$  (and, therefore,  $x_{ij}$ ) are initially equal; that is,  $y_i = x_{ij} = \frac{m}{N}$ . Clearly, the objective function can only be increased if there exists some set  $K_1 = \{r,t\}$  such that

$$\left(1 - \frac{m}{N}\right) s_{rt} \geq \left[\frac{m}{N} - \left(\frac{m-2}{N-2}\right)\right] \sum_{\substack{i < j \\ (i,j) \neq (r,t)}} s_{ij}$$

which simplifies to

$$s_{rt} \geq \left(\frac{2}{N-2}\right) \sum_{\substack{i < j \\ (i,j) \neq (r,t)}} s_{ij}.$$

Since the objective function increase is monotone with  $y_i$ , we would set  $y_r = y_t = 1$  and reduce the values in  $K_2$  accordingly; that is, set  $y_i = \frac{m-2}{N-2}$  for all  $i \in K_2$ .

This argument also holds for a set of variables  $\{k\} \in K_1$ ; that is, we would set  $y_k = 1$  for all  $k \in K_1$  iff

$$\left(|K_1| - \frac{m}{N}\right) \sum_{(r,t) \in K_1} s_{rt} \geq \left[\frac{m}{N} - \left(\frac{m - |K_1|}{N - |K_1|}\right)\right] \sum_{(i,j) \in K_1} s_{ij}.$$

A similar argument holds for reducing values of  $y_k$  to zero.

*Q.E.D.*

Using this lemma, we have been able to construct an efficient depth-first branch and bound algorithm for the max diversity problem. We begin by setting all  $y_i = x_{ij} = \frac{m}{N}$ . Each value of  $y_i$  ( $i=1, \dots, N$ ) is considered in the order  $[i']$  found by the lagrangian relaxation heuristic (using  $\lambda'$ ) described in the previous section. At each node, the corresponding value of  $y_i$  is set to 0 or 1; all free values (i.e., all  $i \in K_2$ ) of  $y_i = \frac{m - |K_1|}{N - [|K_0| + |K_1|]}$ . The solution at each

node is compared to the lower bound found from the optimal lagrangian relaxation heuristic and the node is fathomed if the solution is less than the lower bound.

### *5. Conclusion*

The algorithm developed in this paper has proven useful for finding maximally diverse subsets of entities or objects. We are currently testing the algorithm in order to analyze the size of problems which can be solved efficiently. Computational tests currently underway indicate that reasonably sized problems can be efficiently solved on a PC.

We are currently considering extensions of this algorithm to the minimum diversity problem addressed by Glover *et al.* as well as other related problems. Preliminary tests indicate favorable results.

*Acknowledgements*

This research was supported in part by a grant from the Washington State Department of Transportation. The first author also acknowledges the support of the Burlington Northern/Burlington Resources Foundation; additional support was provided to both authors by the School of Business, University of Washington. The authors also acknowledge the assistance of R. S. Klastorin.

*References*

- Balas, E., 1989. "The Prize Collecting Travelling Salesman Problem", *Networks*. Vol. 19, pp. 621-636.
- Glover, F., C. Kuo, & K. Dhir, 1994. "An Integer Programming Approach to the Minimum Diversity Problem", *Proceedings of the Twenty-Third Annual Meeting of the Western Decision Sciences Institute*, Wailea, Maui, Hawaii.
- Martello, S. and P. Toth, 1990. *Knapsack Problems: Algorithms and Computer Implementations*. John Wiley & Sons, Ltd., West Sussex, England.
- Mittenthal, J. and C. Noon, 1992. "An Insert/Delete Heuristic for the Travelling Salesman Subset-Tour Problem with One Additional Constraint", *Journal of the Operational Research Society*. Vol. 43 (No. 3), pp. 277-283.
- Mirchandani, P. and R.L. Francis, 1993. *Discrete Location Theory*. John Wiley & Sons, Inc., New York, N.Y.