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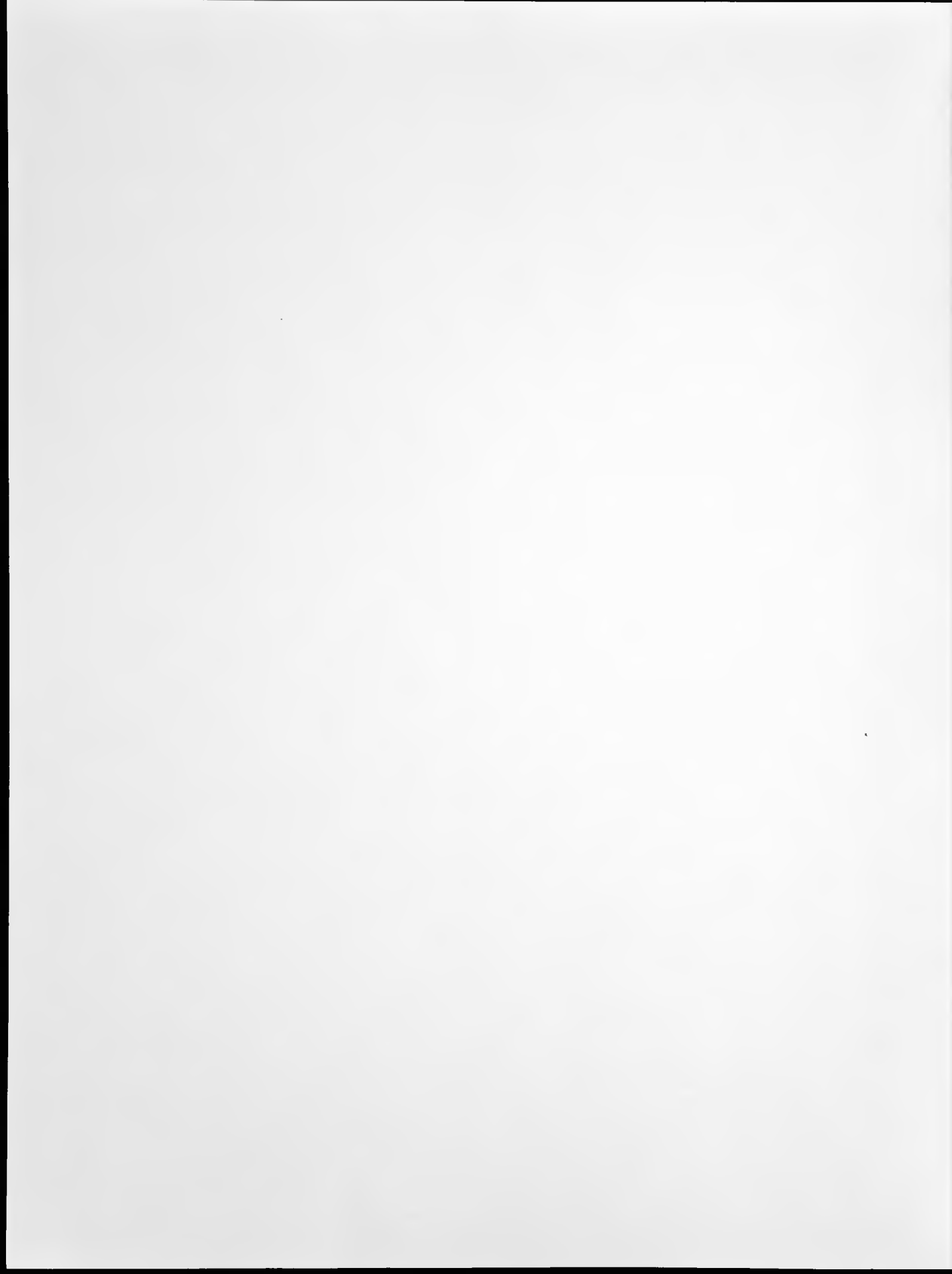
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Vol. 18 No. 1
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Delta Nu Alpha Transportation Fraternity



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The **Delta Nu Alpha Foundation** is a not-for-profit organization, with a sole purpose of supporting education in the fields of transportation, distribution and logistics. Since its inception in 1987, the Foundation has provided numerous scholarships, research grants, and the sponsorship funding for *The Journal of Transportation Management*, published by Georgia Southern University.



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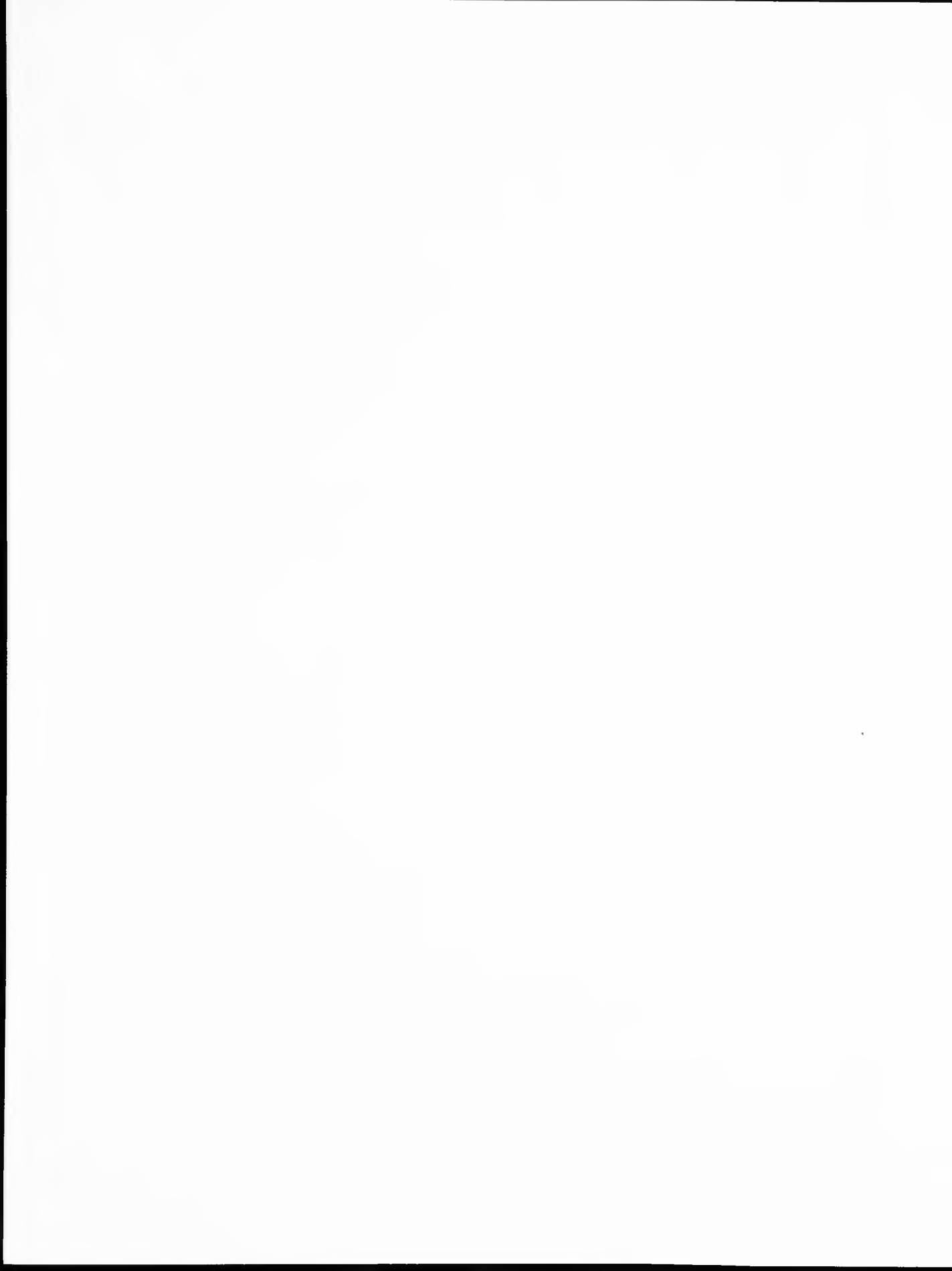
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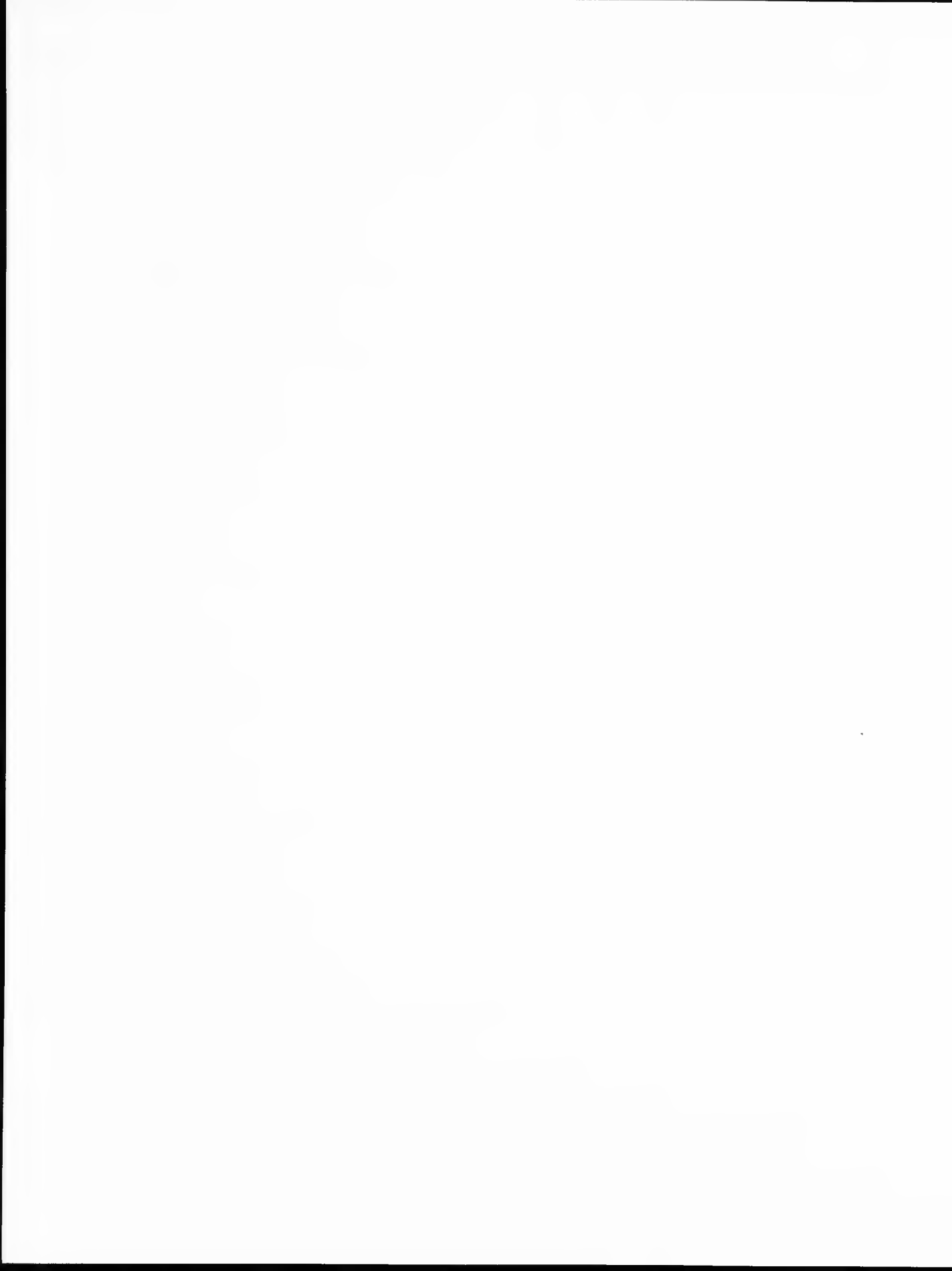


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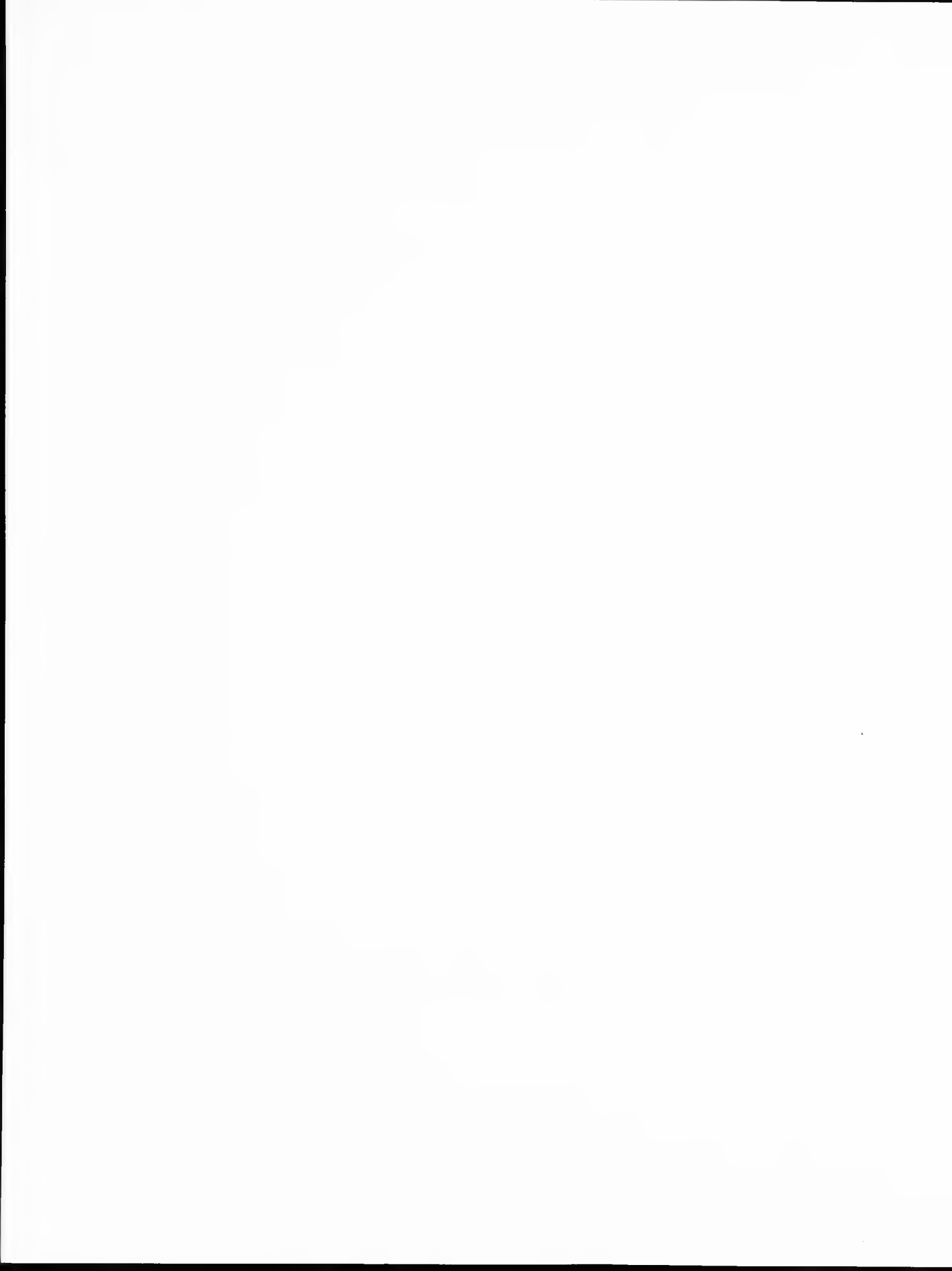
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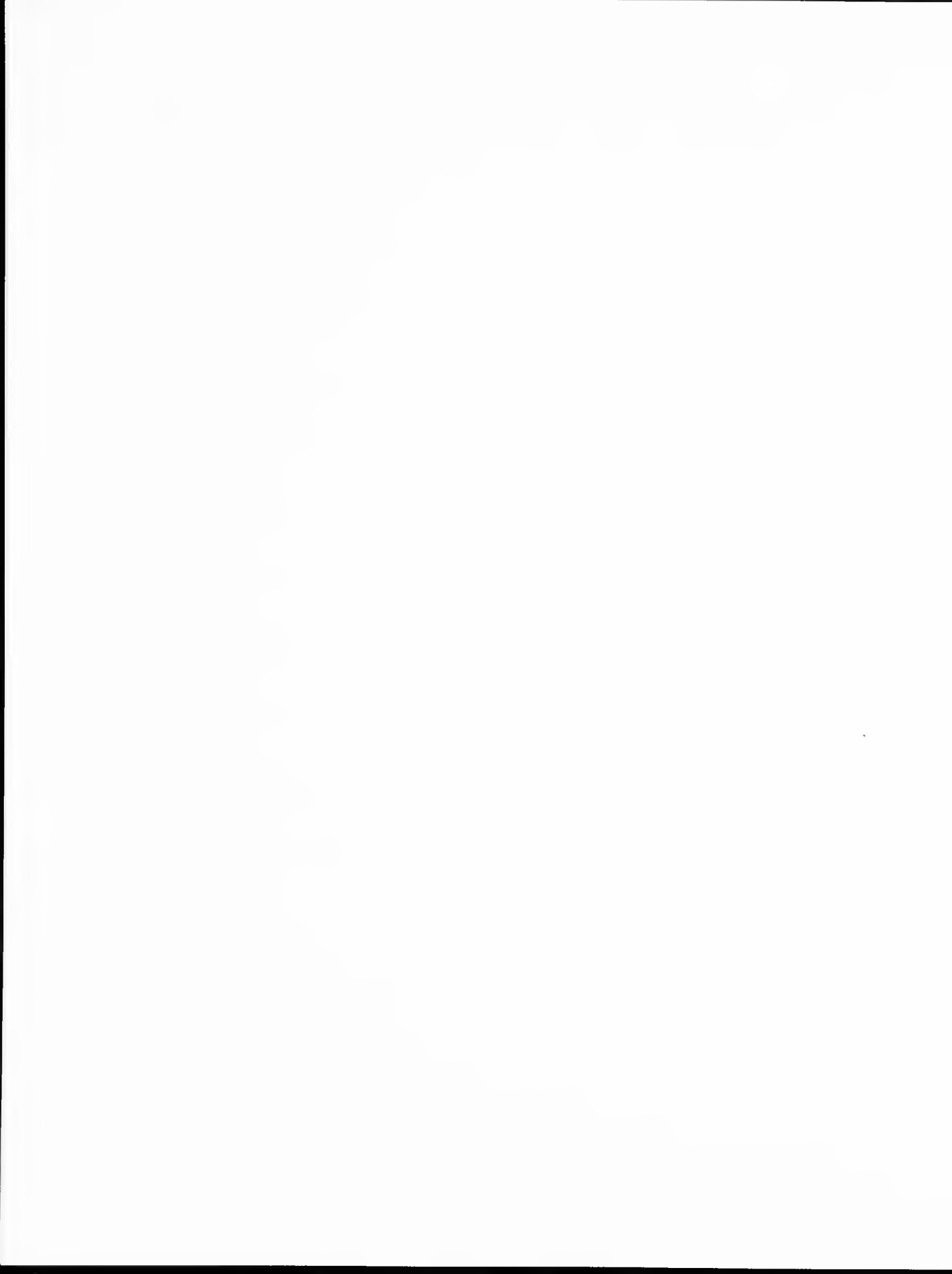
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Journal of Transportation Management

OBJECTIVES

Editorial Policy. The primary purpose of the *JTM* is to serve as a channel for the dissemination of information relevant to the management of transportation and logistics activities in any and all types of organizations. Articles accepted for publication will be of interest to both academicians and practitioners and will specifically address the managerial implications of the subject matter. Articles that are strictly theoretical in nature, with no direct application to the management of transportation and logistics activities, would be inappropriate for the *JTM*.

Acceptable topics for submission include, but are not limited to carrier management, modal and intermodal transportation, international transportation issues, transportation safety, marketing of transportation services, domestic and international transportation policy, transportation economics, customer service, and the changing technology of transportation. Articles from related areas, such as third party logistics and purchasing and materials management are acceptable as long as they are specifically related to the management of transportation and logistics activities.

Submissions from industry practitioners and from practitioners co-authoring with academicians are

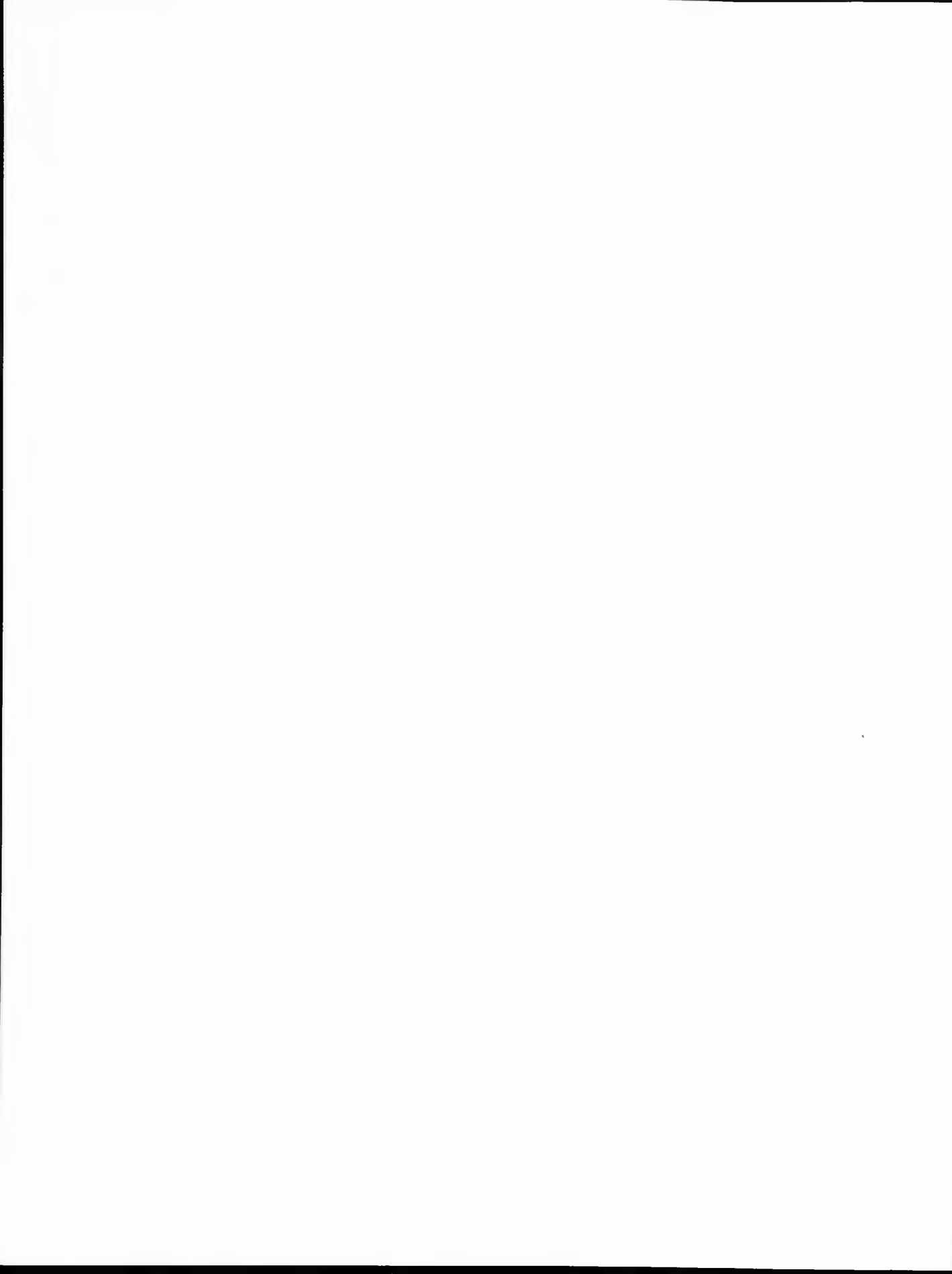
particularly encouraged in order to increase the interaction between the two groups. Authors considering the submission of an article to the *JTM* are encouraged to contact the editor for help in determining relevance of the topic and material.

The opinions expressed in published articles are those of the authors and do not necessarily reflect the opinions of the Editor, the Editorial Review Board, Delta Nu Alpha Transportation Fraternity, or Georgia Southern University.

PUBLISHING DATA

Manuscripts. Submit the manuscript, along with all tables, figures, and references to the editor by email attachment to jwwilson@georgiasouthern.edu. Manuscripts should be no longer than 25 double-spaced pages. Guidelines for manuscript submission and publication can be found in the back of this issue.

Subscriptions. The *Journal of Transportation Management* is published twice yearly. The current annual subscription rate is \$50 domestic and \$65 international in U.S. currency. Payments are to be sent to the editor at Southern Center for Logistics and Intermodal Transportation, Georgia Southern University, P. O. Box 8154, Statesboro, GA 30460-8154.



From the Editor...

I begin this issue with an apology. I received an email from an irate reader (identified only as Liz) calling me to task for the title of the lead article in the Fall 2006 issue. Liz correctly pointed out that the usage of "first annual," according to the *Associated Press Stylebook*, page 17, is incorrect. Liz states that, "This error degrades your journal, the article's authors and the journal's editors." While I do not feel degraded, the rest of you may feel free to do so! Thank you, Liz, for noting this "egregious" error.

An excellent set of articles awaits you between these covers. The first article in the issue, by Robert Cook and Brian Gibson, reports the results from a survey of purchasing executives concerning outsourcing and offshoring practices. In the second article, Stanley Griffis and Thomas Goldsby compare the experiences of adopters and non-adopters of transportation management systems. In article three, Harry Sink addresses the need for a standardized curriculum in training entry-level commercial drivers. Maciek Nowak and Alan Erera assess the risks and benefits of expanding a satellite based mobile communications tracking system in article four. In the final article of this issue, Hokey Min, Hyun-Jeung Ko and Chin-Soo Lim describe a shortest-path, model based decision support system they developed for an inland logistics network configuration in China. I think you will find all of the articles interesting.

Please remember that we cannot survive and continue to publish without reader support. Join or renew your membership in Delta Nu Alpha International Transportation Fraternity today and subscribe to the *Journal of Transportation Management*. Remember that, if you join DNA at the Gold level, a subscription to the *JTM* is included in your membership! That is a deal that is hard to beat!

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U.S. FIRM OUTSOURCING/OFFSHORING PRACTICES AND PLANS: AN UPDATE

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ABSTRACT

A study of U.S. firm outsourcing and offshoring practices and future plans regarding supply chain activities provides an update for supply chain managers. Specifically, the reported information provides supply chain managers of manufacturing/merchandising firms with a competitive benchmark; facilitates third party logistics manager strategic planning efforts and provides an input to U.S. transportation planners who determine future transport and infrastructure requirements. The study reports the responses of 151 Chief Purchasing Officers from U.S. firms. Firms are benefiting from outsourcing logistics and production activities and over one-third of the firms plan to increase outsourcing spend. In addition, 60 percent of firms outsource offshore, and of these firms, 41 percent will increase their offshore spending, some by more than 50 percent.

INTRODUCTION

To remain competitive in the global marketplace, U.S. firms continue to outsource supply chain activities to improve supply chain efficiency or enhance supply chain effectiveness in serving emerging global markets (Trent, 2004; Langley, van Dort, Ang, and Sykes, 2005). In fact, most recent studies indicate that outsourcing spending is continuing to increase 15-25 percent per annum (Patton, 2003). Outsourcing is defined as “the transfer of responsibility to a third party of activities which used to be performed internally” (Ellram and Maltz, 1997). A major portion of recent outsourcing activity involves “offshoring”—the practice of U.S. firms outsourcing business activities to providers overseas (LaLonde, 2004). The McKinsey Global Institute estimates that the volume of

outsourcing offshore will increase 30-40 percent per year for the next five years (Drezner, 2004).

Examples of recent offshoring practices include the following: U.S. electronics original equipment manufacturers have outsourced a significant portion of component purchasing and production to electronic manufacturing source (EMS) companies, many of whom have facilities located offshore (Zetter, 2003); U.S. automakers and parts suppliers continue to move manufacturing operations offshore to Southeast Asia, Central and South America and Eastern Europe (A.T. Kearney, 2005); and as U.S. companies expand their global reach, they are increasingly using global third party logistics (3PL) providers such as DHL, Kuehne & Nagel, Panalpina and UPS Supply Chain Services (Harps, 2004).

The growth in offshoring of U.S. firm supply chain activities is fueled by three primary factors. First, the internet enables chief purchasing officers (CPO's) to utilize providers of supply chain activities from all parts of the globe (Gododia et al., 2004). Second, there is a considerable gap in direct labor rates that favors emerging countries such as China, Brazil, Vietnam and Ukraine over the United States (Carbone, 2004). Third, 3PL's focus on border crossings and improved international trade software has facilitated the flow of international shipments (Forrest, 2004).

Firms should continue to take advantage of the significant opportunities afforded by outsourcing/offshoring (Doblar and Burt, 1996; Leenders and Fearon, 1997; Monczka et al., 1998; and Petersen et al., 2000). As Bud LaLonde (2004) stated in an offshoring editorial, "Longer supply chains crossing countries, cultures, and time zones increase the risk but also increase the payoff to the business enterprise." The purpose of this article is to provide supply chain managers with an update regarding U.S. firm outsourcing and offshoring practices and future plans.

Specifically, the reported information provides supply chain managers of manufacturing/merchandising firms with a competitive benchmark, facilitates third party logistics manager strategic planning efforts and provides an input to U.S. transportation planners who determine future transport and infrastructure requirements. The research focuses on supply chain activities involved in purchasing, production and logistics.

BACKGROUND

Outsourcing Supply Chain Activities

During the last decade, U.S. firms have outsourced a number of supply management activities (Karoway, 1995; Purchasing, 1995). While strategic purchases and supply management activities that are a corporate core competence or provide a strategic advantage

have experienced limited outsourcing (Monczka and Trent, 1995; Burt and Pinkerton, 1996; and Maltz and Ellram, 1999) non-strategic purchases and activities have been increasingly outsourced (Karoway, 1995; Ellram and Maltz, 1997). Supply management activities most often outsourced include MRO buying, capital equipment buying, short life cycle technology buying, offshore buying, services buying, order management, storeroom operations, quality inspection/compliance, non-strategic (indirect) material contract administration and supplier management, and surplus/obsolete material and equipment recycling/disposal (Maltz and Ellram, 1999; Patton, 2003).

The outsourcing of production by U.S. firms continues to grow (Zetter, 2003; Zsidisin, 2003). Approximately two-thirds of all production outsourcing involves non-core parts and products manufactured with low, readily available, established technology while the remaining one-third involves strategic parts and products (Ehic, 2001). The primary production activities outsourced by U.S. firms are manufacturing, assembly and information systems/technology. Other production activities outsourced on a smaller scale include process and product engineering and R&D (Porter, 2000; Ehic, 2001; Patton, 2003).

Logistics outsourcing by U.S. firms has increased dramatically. In 2005, American manufacturers using 3PL services reported spending 40 percent, on average, of their total logistics budgets (compared to 20 percent in 2000) to support 3PL services (Gooley, 2000; Knemeyer and Murphy, 2004; Leib and Bentz, 2005). Logistics activities most commonly outsourced include warehousing, freight bill payment, customs brokerage, transportation, consolidation, logistics consulting and logistics information services (Murphy and Poist, 2000; Lieb and Miller, 2002; Maloni, 2006).

Offshoring Supply Chain Activities

Global sourcing continues to grow as U.S. firms realize benefits such as material unit price reductions (Trent and Monczka, 1998; Peterson,

Frayner, and Scannel, 2000) and enhanced technical capabilities (Ettlie and Sethuraman, 2002). For example, after three years of global sourcing experience and nearly 100 global agreements in place, Air Products realized an average cost savings of 20 percent (Trent and Monczka, 2003).

Contract manufacturing offshore is growing rapidly as evidenced by recent findings. The share of foreign-sourced goods in total manufactured inputs almost doubled—from 12.4 percent to 22.1 percent in U.S. manufacturing between 1987 and 2002 (Burke, Epstein and Choi, 2004). Industry groups with the highest share of foreign-sourced manufactured inputs were computer/electronics, apparel/leather and motor vehicles. In these three industries, imported inputs represented about one-third of all manufactured inputs in 2002 (Burke, Epstein and Choi, 2004).

As global sourcing and contract manufacturing offshore have accelerated, the demand for 3PL service providers that span the globe has grown as well. While overall 3PL revenue growth rates are averaging 10 to 15 percent per year, revenue growth rates for providing services to emerging markets such as India and China are estimated to be 20 to 30 percent per year for the next few years (Foster, 2004).

Given the rapid growth and change in outsourcing/offshoring practices, a study updating supply chain managers regarding outsourcing/offshoring practices and future plans of U.S. firms is clearly warranted.

RESEARCH METHODOLOGY

To provide an update, the research focused on two areas:

1. Outsourcing—extent of practice and activities involved now and in the future; primary reasons for outsourcing and resulting benefits.

2. Offshoring—extent of practice now and in the future; locations and factors impacting offshoring.

Data Collection

A mail survey instrument was developed to collect data regarding U.S. firm outsourcing/offshoring practices and plans. The ten-question, 185 item survey was pre-tested by six CPO's. Survey modifications were made to provide a more understandable survey.

The mailing list consisted of the highest ranking procurement officer for each firm represented in the Institute for Supply Management membership database. A total of 3,452 surveys were mailed, with 151 completed surveys returned. While the response rate was very low, the large sample size enabled the researchers to collect information regarding outsourcing/offshoring practices and plans from over 150 U.S. firms. The total number of responses was acceptable given the extended length of the questionnaire and the time sensitivity of the potential respondents. Table 1 highlights the balanced cross-section of participating organizations based on their annual sales revenue and type of business. Additionally, responses were received from a broad cross-section of industries: consumer goods (16%), pharmaceutical (9%), transportation (9%), electronics (8%), chemicals (7%), financial services (7%), construction (5%), energy (3%), media (3%) and agriculture (2%).

Data Analysis

Given the exploratory nature of the research and low response rate, the researchers focused on reporting overall results using descriptive statistics. The completed surveys were coded, entered into a personal computer and analyzed using Microsoft Excel XP and SPSS Release 11.5 for Windows. Standard statistical tests (e.g., percentages, cross tabulation and Pearson Chi-Square tests) were used for descriptive analysis.

TABLE 1
RESPONDENT PROFILE

Company Type	Annual Sales		
	< \$500K	≥ \$500k	Not Indicated
Manufacturer	27.8%	21.2%	0.7%
Non-manufacturer	28.5%	19.2%	2.6%

RESEARCH RESULTS

Data analysis yielded a number of results regarding U.S. firm outsourcing practices and future plans. In addition, results were tabulated concerning U.S. firm offshoring practices and future plans.

Current Outsourcing Practices

The initial survey questions focused on the current outsourcing practices of the respondents for 28 different supply chain activities. The analysis indicated that the vast majority of respondents (90.7%) rely on external providers for at least one activity, with 4 activities being the median number outsourced (see Figure 1). In fact, nearly one-quarter of the respondents outsource 7 or more activities while only 9.3% of the respondents maintain all 28 activities in-house.

The most widely outsourced activities focus on logistics and production activities. Table 2 reveals that transportation, reverse logistics, and warehousing account for five of the top ten and are among the longest outsourced activities. Producing materials/products plus engineering account for four of the top ten and are among the longest outsourced activities. In fact, more than one-third of the respondents outsource production of direct materials and finished products. Interestingly, information systems are also in the top ten despite being a relatively young candidate for outsourcing with a median of three years outsourced.

In contrast, procurement and planning activities tended to be kept in house, with less than 15 percent of the respondents turning these responsibilities over to external providers. Likewise, inventory management activities were among the least frequently outsourced processes.

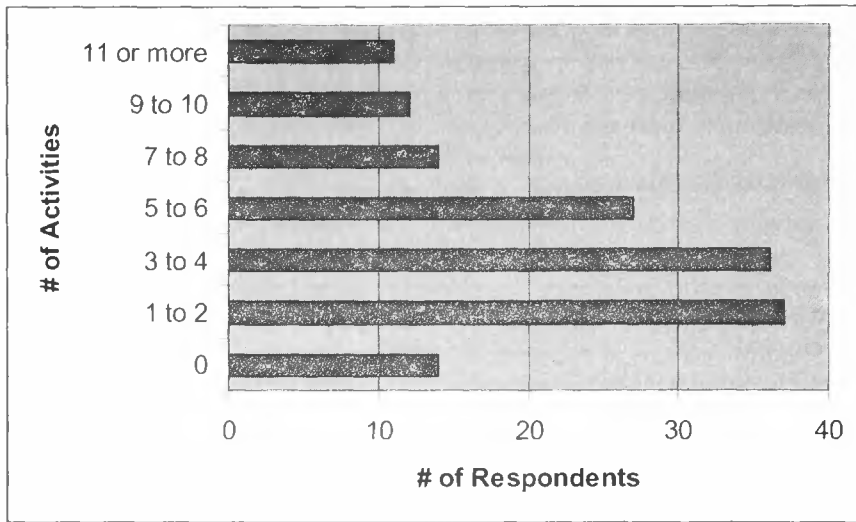
As a percentage of revenue, spending on outsourcing tends to be moderate. Figure 2 reveals that 44 percent of the respondents spend more than five percent of revenue externally on these services, with 16 percent spending more than 20 percent of total revenue on outsourced services. The activities with the highest cost proportion outsourced include reverse logistics, outbound transportation, inbound transportation, production processes, and purchase of finished goods. These results suggest that spending increases as outsourcing experience and trust are gained.

Future Outsourcing Intentions

While it is plausible to assume that the historical growth of outsourcing will continue into the foreseeable future, such assumptions should be investigated. The researchers addressed two aspects of growth—outsourcing activity expansion and spending level escalation.

The respondents' were asked to provide information regarding their outsourcing intentions over the next three years for activities currently performed in-house. From this perspective, the future growth of outsourcing appears to be very good for two activities and

**FIGURE 1
LEVEL OF OUTSOURCING INVOLVEMENT**



**FIGURE 2
COST OF OUTSOURCED ACTIVITIES AS PERCENT OF SALES**

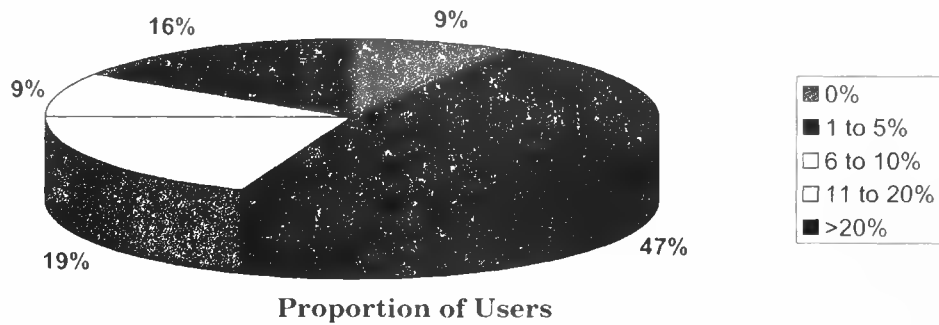


TABLE 2
OUTSOURCED ACTIVITIES

Activities	% of Respondents	Median # of Years
Outbound transport	38.4	10.0
Inbound transport	37.7	8.0
Scrap, recycling, waste disposal	37.1	6.0
Producing finished products	36.4	5.0
Producing materials (direct materials)	35.1	9.0
Information systems	26.5	3.0
Engineering	24.5	6.0
Inbound storage(warehousing)	21.9	5.0
Outbound storage(warehousing)	19.2	6.0
Producing MRO (indirect materials)	17.2	10.0
Packaging	15.2	5.0
Buying finished products	14.6	5.0
Buying MRO (indirect materials)	11.9	3.0
Purchasing research	11.9	3.5
Buying materials (direct)	10.6	5.0
Buying capital assets	9.9	3.0
Buying services	9.9	2.5
Manage material inventories	9.9	3.0
Product repair, returns	9.9	3.0
New product development	9.3	4.0
Supplier quality assurance	7.9	2.0
Customer service	7.9	3.0
Outsourcing/sourcing/value analysis	7.3	2.0
Pre-production kitting	7.3	5.0
Human resource management	6.6	2.0
Manage work-in-process inventories	6.0	7.0
Manage finished inventories	5.3	10.0
Production scheduling	1.3	2.5
Other	15.9	0.0

good for ten activities of the 28 activities studied. Leading the anticipated outsourcing growth are information systems (9.9 percentage point gain) and human resource management (9.3). Ten activities are expected to gain 4-5.3 percentage points. Of these activities four are already among the top ten outsourced activities: reverse logistics (5.3), producing finished product (5.3), inbound storage (5.3) and outbound storage (5.3). The remaining growth activities are: buying MRO materials (5.3), buying services (4.7), purchasing research (4), managing material inventories (4), supplier quality assurance (4) and pre-production kitting (4). Table 3 highlights the expected outsourcing leaders three years hence and the expected growth rate in outsourcing for each activity.

When analyzed from a spending perspective, the results indicate a strong intention to outsource. The respondents were asked about their expected financial outlay over the next three years (increase, no change, decrease) for each of the 28 activities that they currently outsource. Nearly 61 percent of the responses indicated stable spending plans, 34 percent planned to increase spending levels and only 5 percent planned to decrease spending levels.

Figure 3 highlights the proportion of respondents planning to increase spending for the 28 activities. The three top candidates for increased spending include: buying MRO indirect materials (50 percent of current outsourcers), human resource management (50%) and information systems (48%).

The combined analysis of the two future focused questions provides some insight into the source of outsourcing growth. In all but two instances, the number of current users planning to expend additional dollars on an outsourced activity exceeds the number of nonusers planning to begin outsourcing that activity. Thus, the results suggest that outsourcing growth will come primarily from current users rather than new users.

Outsourcing Impact

The perceived success or failure of an outsourcing initiative is often impacted by the expectations of an organization going into the process. Given the respondents' future intentions to expand outsourcing, it appears that their expectations have been met. However, it is useful to identify these initial considerations and the specific benefits achieved. The final outsourcing questions addressed these issues.

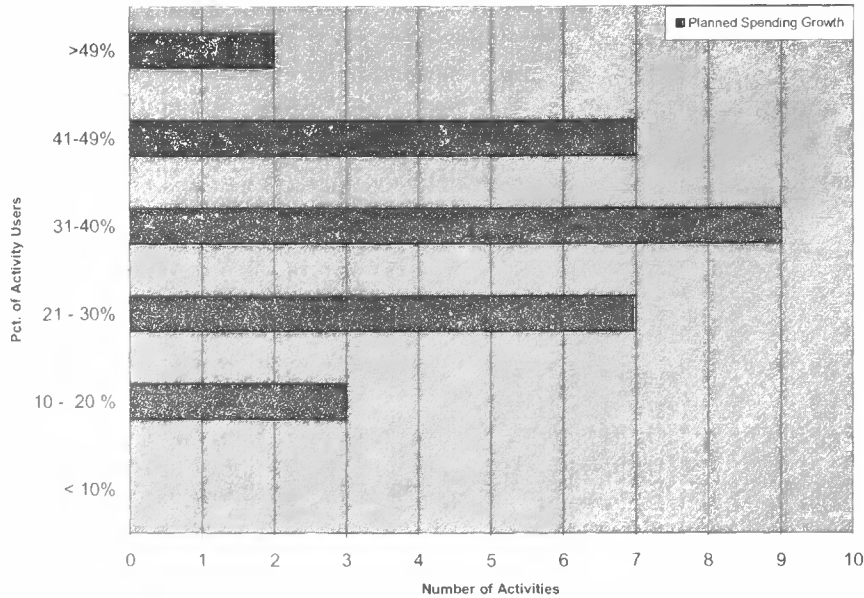
The primary factors considered by the respondents when making a go/no go decision to outsource are largely financial in nature. Of the 404 factors listed by the respondents in this open-ended question, 37 percent focused on cost savings (reduction of capital expenditures, labor costs, overhead fees, cost of ownership, and related issues). Another 18 percent of the responses centered on quality issues—meeting standards and customer satisfaction. Close behind at 17 percent was the core competency factor—internal versus external capabilities, expertise, and activity strategic fit. Additional factors included capacity issues, delivery capabilities, and geographic challenges.

It appears that the results to date have been positive, though not exceptional. Table 4 reveals that each benefit has received ratings that fall within the "Good" to "Very Good" range (i.e. between 3 and 4 on a 5 point scale). Of the benefits analyzed, the most highly rated was total cost of the activity, an important result given the critical importance of that factor in the outsourcing decision. The next two benefits—improved focus on core business and improved flexibility—also link well with the core competency and capacity requirements. The only major disconnect found between the benefits ratings and the key considerations related to customer service quality. It was the second most often mentioned factor but the lowest rated outcome.

TABLE 3
EXPECTED FREQUENCY OF ACTIVITY OUTSOURCING IN THREE YEARS

Activities	% of Respondents	% Increase in # of Respondents	Relative change in ranking
Scrap, recycling, waste disposal	42.4	14	+2
Producing finished products	41.7	15	+2
Outbound transport	41.7	9	-2
Inbound transport	39.1	4	-2
Producing materials (direct materials)	36.4	4	0
Information systems	36.4	38	0
Engineering	27.8	14	0
Inbound storage(warehousing)	27.2	24	0
Outbound storage(warehousing)	23.2	21	0
Producing MRO (indirect materials)	19.9	15	0
Packaging	17.2	13	0
Buying finished products	17.2	18	0
Buying MRO (indirect materials)	17.2	44	0
Purchasing research	15.9	33	0
Human resource management	15.9	140	+10
Buying services	14.6	47	+1
Manage material inventories	13.9	40	+1
Buying materials (direct)	13.2	25	-3
Product repair, returns	13.2	33	0
New product development	12.6	36	0
Buying capital assets	11.9	20	-5
Supplier quality assurance	11.9	50	-1
Pre-production kitting	11.3	55	+1
Customer service	10.6	33	-2
Outsourcing/sourcing/value analysis	9.9	36	-2
Manage finished inventories	6.6	25	+1
Manage work-in-process inventories	6.6	11	-1
Production scheduling	3.3	150	0

**FIGURE 3
FUTURE OUTSOURCING—SPENDING PREDICTIONS**



**TABLE 4
BENEFITS GAINED VIA OUTSOURCING**

Outsourcing Benefits	Mean Impact Rating*
Decreased total cost of performing activity	3.64
Improved focus on core business	3.57
Improved organization flexibility	3.54
Improved activity effectiveness	3.43
Improved expertise/technology capability	3.43
Decreased human resources	3.35
Decreased capital assets	3.33
Increased customer service/value	3.20

*Impact Rating Scale: 5 = Excellent to 1 = Poor

Offshoring Spend

A key issue regarding the 28 outsourced activities focused on the international spending component of outsourcing. On average, less than one fifth of outsourcing budgets are spent outside the U.S.. Figure 4 reveals that fewer than 15 percent of the respondents rely upon offshoring for the majority of their outsourcing spend. In contrast, nearly 40 percent rely exclusively on domestic outsourcing, while another 22 percent spend less than five percent of their dollars offshore.

A related spending question provides insight into the future intentions of the respondents. Of those organizations outsourcing activities today, approximately 41 percent indicate that they will increase their offshoring activity and over one-quarter of these firms will increase offshoring spend by more than 50 percent. In contrast, less than three percent plan to reduce their reliance on offshoring, while 56 percent will remain at current spending levels.

Offshoring Locations

Currently, the offshoring activities of the respondents cover a wide geographic range. When asked to identify their top three non-U.S. countries in terms of outsourcing spend, the respondents revealed that they source products and services from 32 non-North American countries across seven geographic regions. Table 5 indicates that the most popular regions for offshoring include the Pacific Rim countries in East and Southeast Asia, Southern Asia, and Western Europe. Overall, China, India, Taiwan, and Japan are the most frequently cited locations for offshore outsourcing activity.

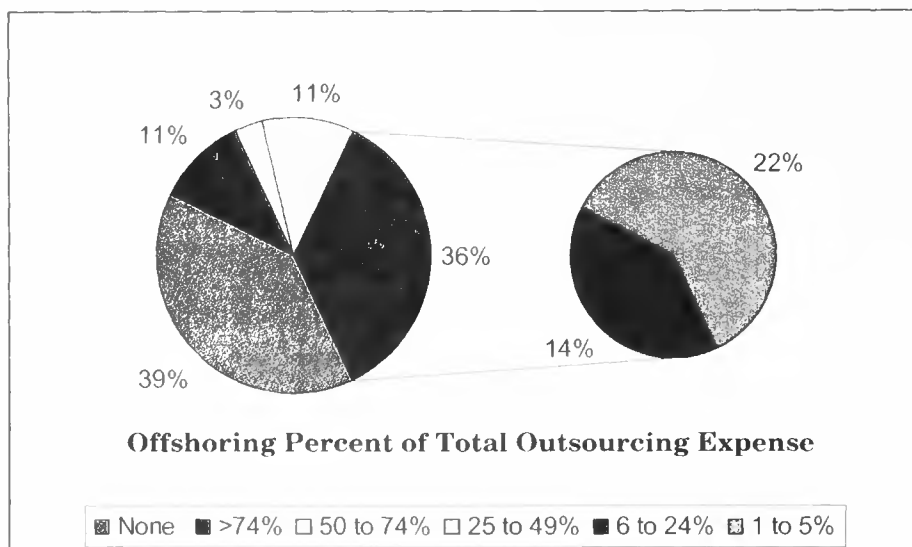
The responses to a related request – identify the top three non-U.S. countries under consideration for outsourcing – suggest geographic shifts may occur. Of note is the respondents' focus on South and Central American countries, which may be driven by recent free trade agreement legislation. Also, growing interest in China and India versus Taiwan, Japan, and Singapore, may portend offshoring activity swings within the Asian regions. Similar activity may take place in Europe, given the respondents' growing consideration of Eastern European countries versus their Western European counterparts.

Offshoring Inhibitors

The general reasons for offshoring (supply access, cost savings, and improved flows) are widely discussed in the literature. However, limited attention has been paid to issues that may inhibit the use of offshoring. These events can dampen interest by creating supply chain disruptions, increasing costs, and/or encouraging domestic activity. To gain insight, the respondents were asked to evaluate the impact of recent events on their offshoring intentions.

Of the five potential inhibitors identified in the survey, those that related to security issues had the greatest negative impact on future offshoring plans. Table 6 underscores concerns about terrorist attacks and related border security regulations among a noteworthy contingent of respondents. Otherwise, capacity limitations and government regulations that encourage domestic activity had a negative impact on only a moderate number of respondents. Most U.S. firms plan to continue offshoring at current or increasing levels despite these regulatory and business challenges.

**FIGURE 4
OFFSHORING SPEND**



**TABLE 5
OFFSHORING ACTIVITY AND PLANS**

Region	CURRENT USE		FUTURE PLANS	
	% of Responses	Most Frequently Identified Countries	% of Responses	Most Frequently Identified Countries
East / Southeast Asia	45.0	China/Hong Kong	42.5	China/Hong Kong
North America*	20.6	Mexico	15.1	Mexico
Southern Asia	13.6	India	17.1	India
Western Europe	13.6	Germany	3.4	No primary choice
East / Central Europe	3.0	Hungary	8.2	Russia
Middle East	2.4	No primary choice	2.1	No primary choice
South / Central America	1.2	No primary choice	10.3	Brazil
Africa	0.6	No primary choice	1.4	No primary choice

* This international outsourcing activity, while technically not “offshoring” activity, is provided for comparison purposes

TABLE 6
ANTICIPATED IMPACT OF OFFSHORING INHIBITORS

Event	Impact — will cause organization to outsource ...		
	Less	Same	More
Potential terrorist attacks that may close U.S. borders	43.2%	39.8%	16.9%
New TSA border security regulations for imported cargo	41.7%	42.5%	15.8%
Omnibus Appropriations Law forbidding government contract work to be outsourced to foreign entities	31.1%	53.8%	15.1%
Legislation providing tax reductions on domestic manufacturing income	30.3%	48.7%	21.0%
Shortage of carrier and airport/port cargo capacity	30.2%	50.0%	19.8%

MANAGERIAL IMPLICATIONS

The research results indicate that the respondents are benefiting from outsourcing and intend to expand outsourcing and offshoring efforts during the next three years. The potential impact of these results on management practices and planning are presented in the next section.

U.S. Manufacturing/Merchandising Firm Supply Chain Managers

Outsourcing implications. Supply chain managers should consider both outsourcing and offshoring as critical aspects of supply chain management strategic planning efforts. When considering which supply chain activities to outsource, managers should determine which activities are core/distinctive competencies or strategic and which are not. Activities that are not strategic can be considered for outsourcing (Maltz and Ellram, 1999). To determine viable candidates for outsourcing, managers should evaluate the impact of outsourcing an activity on corporate efficiency (total costs, human resources and assets), effectiveness (customer value created) and competitive position (flexibility, technical capability).

In firms where currently few or no supply chain activities are outsourced, supply chain managers should focus initial outsourcing efforts on non-core transportation, warehousing and production activities (See Figure 3). These activities are frequently outsourced and have a significant history of being outsourced. Additionally, these 3 functions typically represent a significant portion of operations cost and involve significant fixed assets (eg. plants, warehouses, vehicles, equipment).

In firms where many supply chain activities are outsourced, supply chain managers should consider outsourcing non-core information systems, human resource management and procurement activities (See Figure 5). These activities are receiving more attention as possible outsourcing candidates. Specifically, buying services and materials, supplier quality assurance and managing material inventories could be considered.

A likely consequence of outsourcing more activities will be more business partners which may result in increased supply chain complexity. As supply chain managers strive to improve integration across supply chain partners, they

will need to focus more attention on the following: (1) global supply chain measures and assessment tools; (2) information technology integration and inventory visibility capabilities; and (3) more standardized policies/procedures/contracts for managing supply chain activity outsourcing.

Offshoring implications. Offshoring is a growing practice of U.S. firms. The research results indicate that sixty-one percent of respondents practice offshoring and that forty-one percent of these firms plan to increase offshoring spend, some by more than fifty percent.

Supply chain managers in firms currently not offshoring should consider if material and/or labor cost savings from offshoring supply chain management activities will be greater than the increased logistics costs. Managers who are or will use offshoring for activities involving materials will face increased operational risk from longer and more variable leadtimes, extended material pipelines and more complicated material flow (e.g., border crossings, shipping capacity issues) (Stalk, 2006). Managers should be prepared to mitigate the effects of potential supply chain disruptions through a number of strategies including: global information systems that provide inventory visibility and timely information, safety stocks and alternate local sources of emergency supply, among others.

Supply chain managers following an offshoring strategy involving materials will most likely face a more complex transportation challenge involving governmental officials from multiple countries, multiple modes of transportation, required international paperwork, banks and more. Managers should identify global third party logistics (3PL) providers that fit their needs and develop 3PL provider partnerships to facilitate global transportation efforts.

Supply chain managers that undertake offshoring must understand that global supply chains are especially vulnerable to disruptions

caused by a myriad of man made and natural disasters. Such supply chain disruptions can devastate corporate performance and profitability (Hendricks and Singhal, 2005). As a result, managers must assess the vulnerability of their global supply chains and help the firm develop disaster plans to mitigate and detect disasters and then respond and recover (Crone, 2006). As part of this effort, managers should maintain a heightened awareness of U.S. security policies that may affect international shipments.

3PL Managers and U.S. Transportation Planners

Outsourcing implications. As U.S. firms increase the scope of supply chain activities outsourced, 3PL managers should consider adding new supply chain activities to their firms' service offerings to broaden their service capabilities (See Table 3). As Harry Sink (2006) reported in a recent *Journal of Transportation Management* issue, 61 percent of the buyers of 3PL services considered "multiple, integrated services provided by a single 3PL" to be the critical differentiating factor in selecting a 3PL service provider.

Respondents indicated that outsourcing growth over the next three years will come primarily from firms that currently outsource. As a result, 3PL managers should use a Market Penetration Strategy—focus on expanding the relationship and service offering with existing customers. 3PL managers should work with existing customers to (1) manage a larger percentage of an activity that is currently outsourced or (2) manage a new activity that is not currently outsourced.

Offshoring implications. As offshoring grows, it will become increasingly important for 3PL firms to have an international capability as part of their service offering. International capability is becoming a critical 3PL competitive factor (Sink, 2006).

As U.S. firms continue to expand offshoring efforts, 3PL managers should continue to

improve Chinese, Indian, Japanese and Western European supply chains to meet existing customer requirements. 3PL managers should be developing new global supply chain capabilities/partnerships to serve low labor cost Asian countries, Mexico, Eastern Europe and South America to meet changing customer needs.

As offshoring to Asia continues to grow (annual container throughput could double in seven years (Crone, 2006)), U.S. transportation planners should focus efforts on increasing U.S. west coast port capacity, expanding containerized cargo handling capabilities and adding rail and road infrastructure to and from ports.

In response to heightened global supply chain security concerns and new U.S. regulations, 3PL managers and U.S. transportation planners should continue to focus efforts on improving and implementing technologies that meet security requirements and increase shipment visibility and flow at border crossings.

CONCLUSION

Caution should be used in applying these results to a larger population because this research was exploratory in nature and the sample size was very small. While the results do not represent all

U.S. firms, they do reflect the outsourcing/offshoring practices and plans of CPO's from 151 U.S. firms.

Over 90 percent of respondents outsource at least one supply chain activity with 4 activities being the median number outsourced. Current outsourcing focuses on logistics and production activities while future outsourcing plans target information systems, human resource management and purchasing activities. Firms are benefitting from outsourcing supply chain activities and over one-third of the firms plan to increase outsourcing spend. Regarding offshoring, 60 percent of firms surveyed are currently outsourcing offshore, and of these firms, 41 percent will increase their offshore spend and over one-quarter of these increases will be greater than 50 percent. Current popular offshoring locations are Southeast Asia, Southern Asia and Western Europe. Future plans target less expensive Southeast Asian countries, Eastern Europe and South America.

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TRANSPORTATION MANAGEMENT SYSTEMS: AN EXPLORATION OF PROGRESS AND FUTURE PROSPECTS

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ABSTRACT

This research reports the experiences of both adopters and non-adopters of transportation management system (TMS) technology. TMS adopters represent a diverse array of companies, with a surprisingly high percentage of adopters using outsourced services for decision support activities. Motives for adoption tend to align with the firm's strategic needs though functionality focuses on the shipper's day-to-day operational needs. While expectations of system performance and return on investment vary greatly, TMS users illustrate a generally high level of satisfaction. Non-adopters view decision support for transportation activities as a low priority. The article explores future prospects for TMS development and adoption.

INTRODUCTION

Achieving supply chain excellence is far from given. A study conducted by Deloitte & Touche in 2003 found that only seven percent of global manufacturers surveyed believed that they were effectively managing their supply chains (Deloitte & Touche, 2003). The vast majority (84 percent) viewed their supply chain performance as "average" to "poor." These lower performing firms suffered the financial symptoms of an ailing supply chain, including failure to achieve goals for return on capital and return on assets, operating margins of less than 5 percent, and falling short of revenue goals and profitability targets. The study results pointed to the critical

need to manage ever-increasing complexity through a holistic approach to the supply chain. Key factors that separated global manufacturers with successful supply chains from others included the way these companies: 1) collaborated with customers, 2) effectively managed the product life cycle for their goods, and 3) implemented technology throughout their supply chain operations. Interestingly, the study indicated that while long-term planning tools like enterprise resource planning (ERP) can prove valuable in managing supply chain complexity, so too do the tactical technologies like the advanced planning and scheduling (APS) system, warehouse management system (WMS), and transportation management system (TMS).

Another industry report published by the ARC Advisory Group in 2005 echoes the importance of technology in managing today's extended and complex supply chains. ARC surveyed logistics executives of Global 1000 companies to identify the top ten research interests and priorities of these executives (Gonzalez, 2005a). While supply chain metrics and benchmark standards topped the list of interests, three of the top six topics involved technology applications in the supply chain, including: the impact of supply chain software on creating strategic value (third), the impact of supply chain optimization on the business (fifth), and the merits of tracking and exception management technology (sixth).

As indication of this increasing interest in supply chain technology, AMR Research estimates that the market for supply chain management applications grew by three percent in 2005, with forecasts suggesting growth of seven percent and five percent in 2006 and 2007, respectively (Bowling, 2006). ARC estimates the worldwide market for supply chain execution technologies¹ at US\$5.51 billion in 2005 with an anticipated compounded annual growth rate (CAGR) of 8.6 percent over the next five years, taking the market to over \$8.30 billion in 2010 (ARC Advisory Group, 2006). Accelerating growth in this technology segment is the transportation management system. Investments in TMS have more than doubled from 1998 to 2005 (from US\$468 million to \$956 million), a time in which investment in many technologies cooled (Gonzalez, 2005b). ARC estimates the worldwide market for TMS will grow by 6.4 percent annually through 2009, reaching \$1.24 billion in 2009 (ARC Advisory Group, 2005).

Transportation management systems are information technologies used to plan, optimize, and execute transportation operations. A TMS can facilitate transportation management activities that take place before, during, and after the transportation movement by optimizing freight flows among multiple facilities, tracking freight in transit, and managing the freight payment process (Coyle, Bardi and Langley, 2003). While TMS technology has existed for

quite some time, the imperative for their adoption has never been greater given logistics managers' concerns of dramatically rising freight costs, capacity shortages, and increasing complexities in transportation management today. Though the trade press is laden with case studies of successful TMS implementations and solution vendors readily publicize the merits of their software, little independent research has examined the motives for adoption, benefits achieved, comparative costs, and challenges of implementation. The purpose of this article is to examine the state of TMS development and adoption, giving particular attention to the motives, means, costs, and benefits of adoption by reporting the experiences of 45 North American firms. The article includes a review of the relevant literature of information technology in logistics and transportation management.

INFORMATION TECHNOLOGY IN LOGISTICS AND TRANSPORTATION

Logistics information systems (LIS) have represented a rich area of research since the ready application of computers to logistics management over the past 25 years. Logistics offers a natural area of application for advanced information technology given the complexity of facilitating physical flow management. As noted by Closs, Goldsby and Clinton (1997), information technology has the potential to improve logistics capabilities while simultaneously reducing costs. Information systems convert data into information to improve managerial decision-making, yielding greater effectiveness, efficiency, and flexibility in logistics activity (Introna, 1991; Rabinovich and Evers, 2002; Rutner, Gibson and Williams 2003). Some even refer to the "information imperative" that exists in logistics management where the company must either invest in advanced technologies or suffer competitive disadvantage in today's "connected economy" (Gustin, Stank and Daugherty, 1994; Ernst & Young, 1999; Closs, Swink and Nair, 2005). This contention is supported by the "World Class Logistics" research conducted by The Global Logistics Research Team at Michigan State University

(1995) which found that information technology capabilities served as a key differentiator between "world class" logistics organizations and all others. Subsequent research suggests that enhanced decision-making through information technology remains a key basis of differentiation (Closs and Xu, 2000; Motwani et al., 2000; Shore and Venkatachalam, 2003).

Most research in this area has focused on broad-based application of information technology to logistics (see Dudley and Lasserre, 1989; LaLonde and Cooper, 1989; Loar, 1992; Bardi, Raghunathan, and Bagchi, 1994; Bowersox and Daugherty, 1995; Closs, Goldsby and Clinton, 1997). Relatively little has examined the application of IT to specific activity areas of logistics. An emerging literature is developing on the topic of warehouse management systems. Nynke Faber, de Koster and van de Velde (2002), for instance, explore the appropriate development strategy for WMS technology. Other works in the WMS arena include those of Mason et al. (2003) and Autry et al. (2005). Mason et al. is notable in its recommendation of integration in warehouse management systems and transportation management systems to improve global inventory visibility and, in turn, reduce costs and improve service in the supply chain.

Upon closer examination, transportation management offers a particularly rich area for technology application. Masters and LaLonde (1994) note that traffic management has long represented an information-intensive undertaking. This observation is particularly true today in light of increasing complexity in the transportation environment, given interest in managing inbound and outbound flows, globalization and extended supply chains, heightened documentation and tracking requirements for international shipping, just-in-time operations with narrow delivery windows, revised hours of service regulations for U.S. motor carriers, and Sarbannes-Oxley (S-OX) compliance, to name a few added complexities. Most research of technology use in transportation management is directed toward

communicative technologies. Important work was conducted by Crum et al. (1990, 1996, 1997, 1998) and Williams et al. (1994, 1995, 1996, 1998), among others, on the implementation of electronic data interchange (EDI) throughout the 1990's. More recently, research has examined the roles, benefits and challenges of new communicative technologies, like the Internet (Murphy and Daley, 2000; Dresner, Yao and Palmer, 2001; Boyson, Corsi and Verbraeck 2003; Patterson, Grimm and Corsi, 2003; Nair, 2005), mobile communications (Manrodt, Kent and Parker, 2003; Giaglis et al., 2004), and satellite-based systems (Rishel, Scott and Stenger, 2003).

Despite the impressive TMS adoption data presented in the introduction, exploration of recently developed decision support tools for transportation management has been limited. Goldsby and Eckert (2003) examine electronic transportation marketplaces and propose the linkage between transportation exchanges and TMS technology. Vannieuwenhuysse, Gelders and Pintelon (2003) illustrate a web-based decision support tool for transportation mode selection. Similarly, Caplice and Sheffi (2003) present an optimization-based transportation procurement approach facilitated by on-line auctions. There has yet to be research that examines TMS technology, in particular, and the current state of TMS adoption.

RESEARCH METHODS

An electronic survey methodology was used to collect the data for this research. A preliminary survey instrument was developed and distributed to three consultants and four logistics researchers familiar with the subject topic area to ensure the survey was thorough and contained content and language consistent with that currently in use. Following modification from this first review, the survey was distributed to a group of practitioners with TMS adoption experience to further assess content and survey length. Once comments from this review were incorporated, the web-based survey was developed and tested.

Potential respondents were notified by electronic mail that a survey regarding transportation management systems was being conducted and the website hosting the survey was provided. Past research has shown that the quality of the data obtained from surveys of this nature can be considered equivalent to mail surveys while the speed of response is generally quicker (Griffis, Goldsby and Cooper 2003). Notification of the survey was sent to 1,651 subscribers of *Supply and Demand Chain Executive* magazine in the U.S. This sample frame was chosen because of the anticipated familiarity that potential respondents would have with logistics activity and transportation management systems. Care was taken to contact only one respondent per company, and to seek individuals employed in positions where transportation-related IT would be a salient issue.

Of the 1,651 contact e-mails that were sent, a significant percentage (32.1 percent) was undeliverable. Of the remaining potential respondents (N = 1,121), 45 individuals completed surveys for an effective response rate of 4.01 percent. Though much lower than desired, the response is sufficient for an exploratory work of this kind involving descriptive rather than inferential statistics. Should the research be focused on testing relationships, the sample would likely prove inadequate for sufficient statistical power and construct validity assessment. However, the sample provides an ample snapshot for preliminary investigation, capturing experiences and opinions of TMS among managers and executives at 45 separate firms. Given that the survey was quite long, contained numerous open-ended questions requiring more than simple yes/no responses, and was targeted toward individuals with both logistics experience and familiarity with TMS, generating a high response rate proved very challenging. Despite these limiting factors, the depth and nature of the survey provided high quality responses. Because of the open-ended nature of many questions, the responses more closely approximate interview data than typical survey data.

RESEARCH FINDINGS

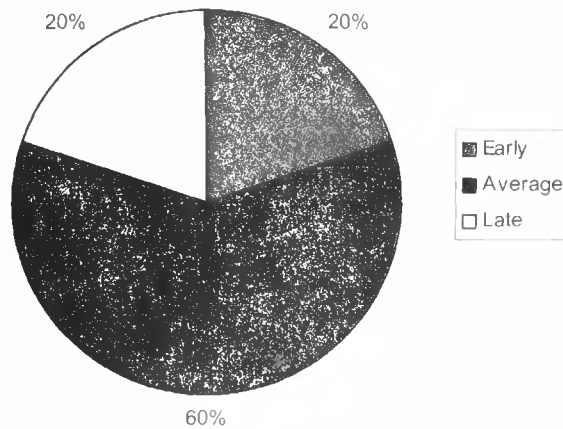
The survey examined six broad areas, including: characteristics of TMS system usage, system development strategies, TMS functions desired and obtained, system performance assessment, implementation issues and their resolutions, and the experiences of TMS non-adopters. These six themes outline the results that follow.

Characteristics of TMS System Users

Survey respondents indicated that their firms were in various stages of consideration when it came to TMS adoption. Twenty-seven percent of respondents had committed in some fashion to a TMS implementation. Another 24 percent of the respondents were actively considering a TMS implementation. Forty-nine percent of the respondents had either entertained the idea previously, but ultimately decided against TMS adoption, or had not considered a TMS.

As for the adopting firms, describing the "average" adopter is a challenging task. The annual revenues of adopting firms in the survey ranged from a low of US\$38 million per year, up to \$80 billion per year. The transportation budgets of adopters were understandably broad as well, ranging from \$1 million to \$4 billion per year, with an average annual budget of almost \$503 million. The technology mindset of TMS adopters was less aggressive than expected. The results are shown in Figure 1. As can be seen, 20 percent of respondents classified their firms as early adopters of technology, 60 percent classified themselves as average technology adopters, and 20 percent as late adopters. The less aggressive technology mindset appeared to be reinforced in the relative newness of TMS to respondents, with adopters averaging 1.8 years of TMS usage since installation. Meanwhile, respondents' IT spending in general was slightly higher than average (4.4 on a 7-point scale), further implying a seemingly cautious nature among adopting firms.

FIGURE 1
TECHNOLOGY ADOPTION MINDSET OF ADOPTING FIRMS



Interestingly, the degree to which transportation was viewed as a strategic function of the firm did not differ between TMS adopters and non-adopters. When rated on a 7-point Likert-type scale with 1 identified as “Not at all Strategic,” 4 as “Neutral,” and 7 as “Very Strategic,” adopting firms rated their transportation function as slightly more strategic than neutral (4.2). Non-adopting firms rated the transportation function slightly below neutral (3.7). Despite the absolute difference in means, these scores were not significantly different from each other at reasonable alpha levels, and a true difference cannot be statistically supported. However, when comparing those who had fully implemented a TMS to those currently adopting the technology, a significant difference was found (at the 0.10 level of significance) between the groups’ assessments of the strategic nature of transportation to the firm. Firms currently implementing a TMS saw transportation as very strategic (6.0) compared to the firms already using a TMS (4.2). This difference was unexpected in light of the lack of a significant difference between adopters and non-adopters,

but could result from a “halo effect” brought on by a recent investment of capital in the transportation function.

Firms that had completed or were currently installing a TMS were asked to provide insight into why the technology was pursued. Respondents were asked to rank their top five priorities among a set of sixteen possible alternatives, including opportunities for open-ended response. The primary motives for adoption are reported in Table 1. These findings indicate that cost drivers, including fewer shipments as a result of shipment consolidation, lower freight bills, and lower administration costs, are the chief reasons firms pursue a TMS, although customer service issues and lane network analysis also hold sway.

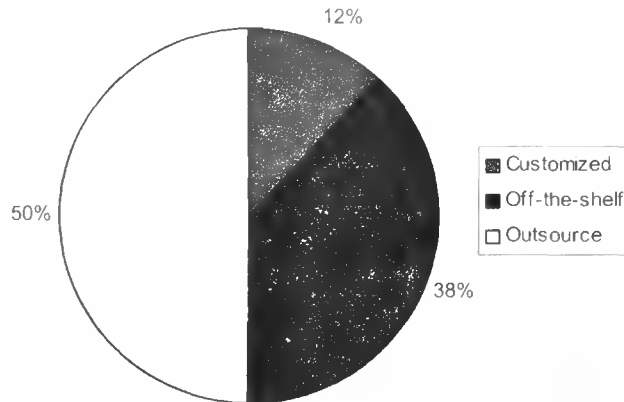
System Development

Firms adopting TMS technology chose to do so in one of three ways. Figure 2 depicts the system development approaches. Approximately 12 percent of respondents chose to install customized systems modified specifically to fit

TABLE 1
PRIMARY MOTIVE RANKING

Motive	Average Rank
Improved shipment consolidation	1.9
Lower freight bill	2.2
Lower administrative costs	2.3
Improved lane analysis	2.4
Lower total logistics cost	2.5
Improved carrier selection	2.7
Improved network analysis	2.8

FIGURE 2
SYSTEM DEVELOPMENT APPROACH



the needs of their firms. A greater number of firms (38 percent) chose to purchase-off-the-shelf systems to support their transportation needs, while fully 50 percent of the firms using a TMS chose to outsource the effort completely and allow a vendor or third-party provider to host the needed services. The 50 percent figure for the externally-hosted systems is consistent with the observations of ARC's Gonzalez (Levans, 2006) and the findings of a study conducted by the Aberdeen Group focusing on-demand SCM solutions, in general (Enslow, 2006). The study noted that on-demand TMS is becoming increasingly popular in light of cost concerns and the substantial development time required of hosted systems (McCrea, 2006). On-demand solutions also prove more affordable for small- and medium-sized companies, though companies of various sizes in the sample reported the use of externally-hosted systems.

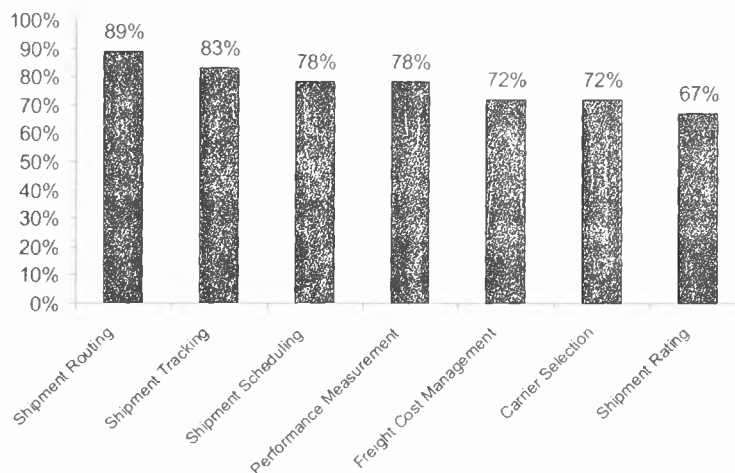
While the level of investment varied substantially, the cost of TMS technology appears relatively low, when compared to many other logistics information systems. The cost to purchase a hosted TMS ranged from a low of \$100,000 to a high of \$1,000,000. Similarly, installation costs of these systems exhibited wide

disparity, ranging from \$20,000 to \$450,000. The annual maintenance of these types of systems should be a concern and the study results indicated substantial range in annual maintenance costs, ranging from \$4,000 per year to \$400,000 per year.

TMS Functionality

TMS users reported a variety of functions that were important in the systems they installed. Figure 3 illustrates the most popular functions employed by adopting firms. These functions tend to be related to the operational tasks associated with day-to-day management of transportation activity. Shipment routing, determining how and where to route individual shipments during the planning stages, was the most frequently cited function employed by respondents. Shipment tracking, providing the shipper with visibility of in-transit inventory, was a close second among installed functions. Given the impact that enhanced visibility has on service commitment and cost containment, this function's appearance near the top of the list was not unexpected. Shipment scheduling, transportation performance measurement, overall freight cost management, and carrier selection

FIGURE 3
MOST COMMON TMS FUNCTIONS



round out the top six functions. It is interesting to note that the functionality most commonly realized does not directly overlap with the motives for TMS adoption. While motives tend to speak of high-level strategic concerns, the functions most commonly employed involve support for operations-based decisions, those involving individual shipments and transactions.

TMS Performance

In general, TMS users feel that the systems are having a positive effect upon the performance delivered by the firm. When asked to answer the question "As a result of our TMS, our total logistics costs are lower," users responded with an average score of 5.2 (standard deviation of 1.3) on a scale where 1 = Strongly disagree, 4 = Neutral, and 7 = Strongly agree. When non-users were asked if a TMS would result in lower total logistics costs, these respondents suggested a general indifference to expectations in this regard with an average score of 4.1 (standard deviation of 1.8).

One key area where a TMS would be expected to show benefit is in the delivery of customer service. TMS users were asked whether the service offered to their customers was better as a result of their TMS. They responded with an average score of 5.4 on the 7-point scale, while non-users reported an average score of 3.7, a difference that was statistically significant at an alpha level of 0.05. This indicates that, in general, adopters believe their service provision is better as a result of TMS and that non-adopters believe that a TMS would not necessarily improve the service they offer to customers.

Better transportation decisions are a presumed benefit of a TMS. TMS users and non-users responded with averages of 5.2 and 4.4 respectively to the question "We now make better transportation decisions." Again, this difference appears managerially relevant, but failed to achieve statistical significance.

When considering financial measures of performance, TMS users were often satisfied with the performance of their systems. Users reported a range of expected returns on investment (ROI) from as low as three percent to as high as 300 percent. As noted in the discussion of system costs, the range of investment varied greatly. Therefore, it is not unexpected that the reported benefits and subsequent ROI might vary widely as well. Upon achieving system implementation, the level of satisfaction associated with TMS appears to have met most expectations with an average score of 5.6 on the 7-point scale. The data appear to support the claims of TMS users and vendors alike in that these systems' return on investment often makes their consideration very worthwhile.

Implementation Issues and Resolutions

No IT system installation progresses without issues arising that must be addressed. TMS implementations appear normal in this regard. The incompatibility of systems, a perennial IT issue, appeared in 57 percent of the implementations reported by TMS users. Delays in the implementation phase of the project were also an issue for one-half of the respondents. Reluctance among the top levels of the firm to adopt a system presented problems for 43 percent of the firms installing a TMS as senior management and executives questioned the need for or value of these systems. Once management was convinced of the needs and benefits of the system, the issue was not necessarily over as 43 percent of the staff responsible for using the system was also resistant to using a TMS. A lack of quality training was reported also, as 21 percent of the adopting firms reported that insufficient training was a problem with TMS in their implementation.

Despite these challenges, TMS implementation teams found a variety of ways to address these issues. Issues of incompatibility typically generated system modifications to allow the affected systems to communicate more

effectively. Implementation delays, seemingly ever-present in IT installations, were addressed by working more closely with vendors and taking a more hands-on approach in managing the implementation phase. People-related issues, resistance, and the lack of training appeared to be best handled by educating users of the system's capabilities and potential, and training end-users on the actual software to better prepare them for the modified manner in which their individual tasks would be accomplished on the new systems. Unfortunately, in some instances, companies reacted to challenges and implementation issues in a defeated manner—simply accepting the deficiency and expecting no resolution.

THE EXPERIENCES OF NON-TMS USERS

The information reported by those who either had not considered purchasing a TMS or who had considered TMS but chose against installing one was very illuminating. Non-adopters represented almost one-half of the research sample. These firms gave varied reasons for why they had not adopted the technology. These responses ranged from "Not a priority" (54 percent of respondents) to "We do fine without it" and "We do not manage transportation" at 31 percent each. These responses indicate that some firms either view transportation as an area not in need of decision support, or lacking sufficient strategic importance to mandate investment. Of those who do not manage transportation, one reason given for outsourcing was the expectation of their third-party logistics provider having TMS support for operational decision-making. As for those companies that still manage transportation in the absence of a TMS, 30 percent continue to rely upon a legacy IT system of some kind to accomplish the tasks a TMS might otherwise perform. Another 50 percent of non-users reported performing their transportation management activities manually rather than with a TMS. Given this overview of the current state of TMS adoption, attention

turns to the future prospects for TMS and transportation-related information technologies.

FUTURE PROSPECTS FOR TMS

This research suggests two broad categories of TMS customers; those that develop and maintain internal systems and those that buy specific services from externally-hosted (outsourced or on-demand) systems. Among internal systems users, TMS will increasingly find interconnectivity with other LIS tools to provide comprehensive visibility and improved management of physical flows. Mason et al. (2003) illustrate the benefits of an integrated system of TMS and WMS technologies that provides global inventory visibility. When coupled with an order management system and supply chain event management system, TMS and WMS provide for a more complete order fulfillment suite of systems (Goldsby and Eckert, 2003). Software vendors are recognizing the potential of integrated system architecture and actively expanding the scope of their offerings. ERP and WMS vendors have proven the most aggressive to date by acquiring complementary TMS solutions or building their own capabilities in an effort to provide comprehensive supply chain IT solutions (McCrea, 2006).

At the same time, TMS vendors are responding to customers' needs for greater transportation functionality in their product offerings. To date, most TMS offerings focus on the individual shipment as the primary unit of analysis, as indicated by the functions most commonly employed by systems in the current study. In fact, many systems do not have the ability to optimize multi-load shipments, making load consolidation a manual activity. Leading vendors have recognized that shippers want to be able to not only plan and track individual loads but to identify and facilitate opportunities for inbound/ outbound consolidation as well as temporal and vehicle consolidations. Additionally, shippers seek better support for international transportation and multi-modal movements (Levans, 2006).

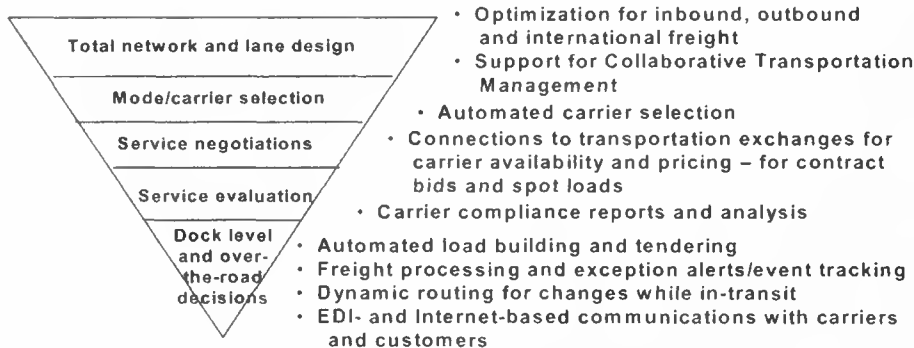
Figure 4 illustrates how TMS functionality is expanding to serve the broader scope of shipper requirements. The figure depicts the various levels of transportation decision-making from most strategic (total network and lane design) to most operational (dock level and over-the-road decisions). While the primary focus among TMS users and vendors is directed toward decision support of operational activity, great potential rests with incorporating strategic analytical support. By accumulating transactional data, these systems can serve as data warehouses as well. When coupled with optimization and simulation capabilities, the TMS can provide critical support for optimal network design and lane analysis.

TMS can also provide the interconnectedness required of Collaborative Transportation Management (CTM), an initiative developed by the Voluntary Interindustry Commerce Solutions Association (VICS). Sutherland, Goldsby and Stank (2004) define Collaborative Transportation Management as “a holistic process that brings together supply chain trading partners and service providers to drive inefficiencies out of the transport planning and execution process” (p. 193). Though the authors contend that CTM is not a “technology solution,” IT is viewed as a

critical enabler of the initiative; particularly as higher orders of collaboration involving multiple shipper networks are pursued. Esper and Williams (2003) emphasize the critical roles fulfilled by IT in supporting and enabling CTM. Leading vendors of TMS technology therefore should seek to provide decision support for the whole of the framework presented in Figure 4, adding functionality to support strategic analysis and decision making as interest in these higher-order initiatives calls for capabilities that embrace the inherent challenges of scope and complexity.

Externally-hosted application service providers (ASP's) are expected to enjoy continued adoption by small and mid-sized companies who are unable or unwilling to commit to a fully-functional internal system. These users generally expect to enjoy many of the benefits of internal applications, but at reduced, intermittent costs. Still others are expected to use ASP versions of TMS on a trial basis, testing the functionality and gauging the benefits before committing to a full-time solution. The current research appears to indicate that the market for ASP's is quite robust given that half of the TMS adopters in the sample are using a third-party system. While bias could be present in the

**FIGURE 4
TMS DECISION SUPPORT**



(Figure adapted from Stank and Goldsby, 2000)

relatively small sample found in this research, there is support of a growing interest in externally-hosted systems. Many large third-party logistics companies are expanding their service portfolios by offering pay-as-you-go systems as a supplement to their traditional operations activity. Future research should reflect this two-segment market composition and further examine distinctions in TMS motives, functionality, and satisfaction among users of internally- and externally-hosted systems. Generating a sample of TMS users large enough for more thorough empirical analysis will prove challenging until adoption becomes more pervasive, yielding improved sampling potential. Once adoption reaches this level, it will be more feasible for research to move beyond descriptive data to the testing of critical relationships, such as those between TMS adoption, logistics outcomes, and the overall performance of the firm.

CONCLUSIONS

Given the complexity that today's logistics and supply chain managers face, it is becoming more apparent that logistics information systems can prove effective in making the complexities more manageable. The introduction to this article suggested that transportation management systems are separating themselves from other LIS technologies given steady adoption in recent years, with adoption growth expected to continue in the future. This research sought to provide some explanation for why firms are choosing to adopt TMS in light of the varied portfolio of IT investment opportunities. In pursuing this objective, our preliminary analysis serves as a first step toward broader examination of transportation management systems. Though research to date has provided considerable insight on the application of LIS technology, relatively little focus is directed to transportation-specific decision support tools.

The general findings of the research indicate that many companies find the risks of non-

adoption to be greater than those of adoption. While the levels of investment varied greatly and virtually all implementations faced difficulties of one kind or another, adopting firms were usually satisfied with the performance of their systems given the total price paid for hardware, software and installation. In this regard, TMS seems to be fulfilling the promise of value, yielding efficiency gains that offset the required investment in a timely manner. Though tenable in their determination, expected ROI and payback proved critical in the adoption of TMS. The payback on TMS appears to be relatively quick and more certain than other technologies vying for shares of a company's technology budget, as inferred by TMS' increased rate of adoption.

An interesting finding compares the motives for adoption and the functionality realized ultimately by TMS adopters. The most pressing motives tended to involve high-level, strategic decision-making. Meanwhile, the most common functions utilized by the adopters involved the day-to-day execution of transportation activities. Certainly, the strategic objectives cannot find achievement without sufficient control at the operation level. However, review of open-ended responses suggested that the systems' promised capabilities of strategic decision support went largely unfulfilled as priorities changed or software proved ineffective in high-level analyses.

Providing better coverage of strategic analysis needs represents an opportunity for differentiation among TMS vendors in the current and near-term marketplace. In addition, those vendors that can deliver on the promise of interoperable systems across the domain of supply chain execution and analysis tools should enjoy an advantage in the immediate future and survival in the longer term as industry consolidation activity reduces the number of viable competitors. Future adopters are expected to benefit from heightened competition as technology capabilities improve and pricing remains in check.

ENDNOTE

1. The ARC Advisory Group defines "supply chain execution solutions" as including

Collaborative Production Management, Warehouse Management, and Transportation Management systems.

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ENTRY-LEVEL HEAVY TRUCK DRIVERS AND HIGHWAY SAFETY: IS IT FINALLY TIME FOR FEDERALLY MANDATED TRAINING?

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ABSTRACT

This article examines the need for mandated instruction and a uniform curriculum for entry-level commercial drivers. The study also addresses the discontinuity resulting from the establishment of a uniform licensing standard without requiring preparatory training. The research involves a review of Federal regulations pertaining to obligatory operator instruction in the air, water and rail mode. The investigation concludes that weak support and lobbying efforts by certain trucking interests have thwarted the adoption of mandatory instruction and/or a uniform curriculum. The study also highlights a pressing need for policy revision given the imminent retirement of many "baby boom" generation drivers.

INTRODUCTION

Trucks designated by the Federal Department of Transportation as large or heavy are involved in a disparate number of fatal highway accidents each year. These vehicles are manufactured with a gross weight rating of 10,000 pounds or more. During 2004 trucks of this type were involved in 416,000 accidents, 4,862 resulted in at least one fatality and a total of 5,190 people died. These accidents represented 12.0% of all traffic fatalities; however, large trucks accounted for only 3.4% of vehicles registered and 8.0% of total vehicle miles traveled during this year. In addition 116,000 people were injured and 324,000 of the crashes involved solely property damage (NHTSA, 2004). Drivers or occupants of the large trucks involved in these crashes sustained 15.0% of the deaths and 23.0% of the injuries. From 1994 to 2004, the number of

fatalities involving large trucks increased by 5.0 percent (FMCSA, 2006).

The National Transportation Safety Board (NTSB) is responsible for investigating accidents to determine probable cause. While much of its effort is devoted to air crashes, the agency has conducted a number of inquiries involving heavy truck accidents over many years. Mr. Jim Hall, a former Chairman of the NTSB, summarized results of the agency's large truck investigations in his remarks at a conference on highway accident litigation a few years ago. Mr. Hall advised attendees that ". . . we know that the vast majority of truck accidents, like other highway accidents, involve some form of human error. We also know that although truck equipment and maintenance shortcomings were discovered in many of our investigations, those problems were not usually the primary accident

cause. In all highway crashes, we have found that driver-related factors such as speeding, fatigue, the use of alcohol and other drugs, inattention, aggressive driving, and inadequate training were often contributory causes" (NTSB, 1998).

Commercial motor vehicles (CMV) constitute a subset of the large truck category established by the Federal Department of Transportation. These vehicles are defined as truck-trailer combinations or straight trucks with a gross vehicle weight rating of 26,001 pounds or more, or any size truck transporting a placardable quantity of hazardous materials. The Federal Motor Carrier Safety Administration (FMCSA) classifies drivers of these vehicles as commercial motor vehicle operators (CFR Title 49 Part 383.5). They are required by Federal and state law to be qualified whenever they operate a CMV on a public highway. An examination of minimum CMV operator qualification requirements appears below.

MINIMUM QUALIFICATION REQUIREMENTS FOR COMMERCIAL DRIVERS

The Federal government has established regulations regarding the qualification of a commercial motor vehicle/heavy truck driver. These regulations have been codified into law and appear as Part 391 of Title 49 of the Code of Federal Regulations. Most states have essentially adopted Title 49 verbatim as state law. A few states have slightly modified or supplemented Title 49 in the derivation of their own statutes regarding commercial motor vehicle drivers.

The rules found in Part 391 establish minimum qualification requirements that must be maintained by commercial motor vehicle operators and their employers. If a driver is self-employed as an owner-operator, he/she must comply with Part 391 requirements for drivers and employers. The regulations state that a driver must be qualified to operate a commercial

motor vehicle in interstate commerce and the specific requirements appear in Table 1.

Part 391 regulations also provide that a motor carrier cannot permit a driver to operate a CMV unless the driver can 1) determine whether the freight to be transported is properly loaded and distributed and 2) is familiar with the methods and procedures for securing cargo in a CMV. Further, the rules state that a driver cannot operate a CMV until he/she has completed an employment application as proscribed in Title 49 and advised the employing motor carrier of any moving violation convictions incurred during the previous twelve months. Finally, the employing motor carrier must investigate the driving history of each applicant for the previous three years by requesting a copy of the motor vehicle driving record from each state in which the driver held a license and by contacting previous trucking company employers. In essence, these additional requirements are also germane to the proper qualification of a commercial driver (CFR Title 49 Part 391 Subpart B).

**TABLE 1
MINIMUM QUALIFICATION
REQUIREMENTS FOR CMV DRIVERS**

- Operator must be at least 21 years old
 - The ability to read, write & speak English well enough to work as a commercial driver
 - Be able to safely operate a commercial vehicle as a result of experience and/or training
 - Be physically qualified as documented with a valid DOT Medical Examiner's Certificate
 - Possess only one valid Commercial Driver's License
 - Furnish to the employing motor carrier a list of motor vehicle violations which the driver has been convicted in the last 12 months
 - Not be disqualified by license suspension/revocation or because of criminal/other offenses
 - Successfully complete a road test or provide a document acceptable in lieu of a road test
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ESTABLISHING MINIMUM TRAINING FOR COMMERCIAL DRIVERS

In 1986 Congress passed the Commercial Motor Vehicle Safety Act (CMVSA) requiring the DOT Secretary to formulate regulations leading to the establishment of uniform standards for commercial driver's licenses (CDL). Once created, a CDI would be necessary for the operation of a commercial motor vehicle. The individual states were tasked with the testing and issuance of such licenses. However, the Federal standards subsequently developed did not specify or mandate any training regimen or curriculum. They merely suggested that candidates for a CDL should study such areas as vehicle inspection procedures, off-road vehicle operation and driving a large truck in traffic (U.S. Court of Appeals, 2005).

As a result of concern about the number and severity of heavy truck accidents, Congress, in 1991, instructed the Secretary of Transportation to determine whether a need existed for the establishment of entry-level training for commercial truck and bus drivers. The Federal Motor Carrier Safety Administration considers commercial drivers possessing less than two years experience to be entry-level operators. The DOT was ordered to submit a report to Congress by 1993 or explain why such training was not necessary. The Federal Highway Administration's Office of Motor Carriers, predecessor to today's Federal Motor Carrier Safety Administration, previously developed minimum standards for the training of tractor-trailer drivers. These standards were used as the basis for a uniform or "model curriculum" published in 1985. This "model curriculum" guide required at least 320 hours of instruction including 116 hours of "on-street time" as well as 92 + hours of "driving-range" time. A 1995 Highway Administration study stated the "model curriculum" was the starting point for commercial driver training and determined that only 8.1% of motor carriers and 18.5 percent of bus companies provided their entry-level drivers with adequate training (Public Citizen, 2005).

The FMCSA held a public hearing in 1996 investigating the need for mandatory training for entry-level truck and bus drivers but did not follow up on this meeting. For all intents and purposes, the agency allowed the issue to remain dormant until a consortium of private entities instituted litigation seeking an order forcing the FMCSA to issue a rule and fulfill Congress' mandate on this issue. As part of a settlement agreement, the agency agreed to issue a final rule on the matter by May 31, 2004 (Public Citizen, 2005).

In August 2003, the FMCSA published an advanced notice of proposed rulemaking dealing with mandatory commercial driver training. The proposed rule applied solely to entry-level drivers. The required training involved the following four areas 1) driver qualification requirements, 2) hours-of-service limitations, 3) driver wellness and 4) whistle blower protection. The agency anticipated the training would require 10.5 hours study time, none of which involved skill development behind the wheel. After obtaining comments and holding a public hearing, a final rule was announced in May 2004, to become effective on July 20, 2004. The agency proclaimed the issuance of this rule was in response to the 1991 government mandated study determining private-sector training of commercial drivers to be inadequate (U.S. Court of Appeals, 2005).

In 2004, a group of safety advocates and several industry associations filed petitions for review of the FMCSA's final rule on entry-level commercial driver training. Petitioners in this matter argued that the agency's training requirements were arbitrary and capricious and did not adequately address the problem nor materially enhance safety. The U.S. Court of Appeals hearing the case agreed with the petitioners and remanded the issue back to the FMCSA for further consideration. Specifically, the court said,

In short, the record in this case shows that the agency entirely failed to consider the important aspects of commercial motor vehicle training before it; it largely ignored the evidence...and abandoned the recommendations of the Model Curriculum without reasonable explanation; and it adopted a final rule whose terms have almost nothing to do with an "adequate" commercial motor vehicle training program. FMCSA simply disregarded the volume of evidence that extensive on-street training enhances commercial motor vehicle safety (U.S. Court of Appeals, 2005).

The only other current commercial driver-training requirement concerns the operation of longer combination vehicles (LCV). A LCV is defined by the DOT as a truck-tractor pulling two or more semi-trailers with a gross weight rating greater than 80,000 pounds over the interstate highway system. Drivers of these vehicles must complete a proscribed curriculum, at an institution approved by the Department of Education, that includes a mandated amount of classroom and behind-the-wheel training time. Minimum requirements are also specified for instructors at these facilities and students must pass a written knowledge test and over-the-road skills test before being allowed to solo operate a LCV (CFR Title 49 Part 380).

It is clear that courts in the United States do not believe the Federal agency responsible for motor carrier safety has acted in a proactive manner regarding adequate commercial driver training for entry-level drivers. The reason for such "neglect" may be related to the significant Congressional influence wielded by the trucking industry via such industry organizations as the American Trucking Association, the Truckload Carrier's Association and the National Private Truck Council. Such industry organizations routinely lobby members of Congress to impede regulations thought to be detrimental to their cause as well as promote legislation favorable to the trucking industry.

Currently the FMCSA is investigating a rulemaking initiative that would implement a mandatory commercial driver-training curriculum applicable to all entry-level drivers and the creation of a graduated commercial driver licensing system (Federal Register, 2004). The trucking industry will likely oppose these changes as they will increase training costs and result in reduced entry-level driver flexibility. An example of this opposition was recently published in a well-known industry trade journal. The authors, in a guest editorial, cautioned commercial trucking owners and managers by proclaiming that motor carriers must monitor the Federal Register and strongly oppose new minimum training-hour requirements and the concept of graduated licenses. The readers were also advised to monitor legislation at the state level (Barr and Gibbs, 2006).

Most transportation related accidents and fatalities occur in the motor carrier industry (U.S. Census Bureau, 2006). Thus, it is logical to conclude this mode would require the most rigorous training requirements. An examination of government mandated training, qualification and certification in other transportation modes provides insight into whether this reasoning is valid. A comparison of this nature is especially relevant given the paucity of mandatory training currently required of entry-level commercial motor carrier operators.

MANDATORY TRAINING REQUIREMENTS IN OTHER MODES

Certified Locomotive Engineer

The requirements for the qualification and certification of locomotive engineers are housed in Title 49 Part 240 of the Code of Federal Regulations (CFR). This part specifies the components of the locomotive engineer certification process, implementation of the certification process, administration of certification programs and dispute resolution procedures as well as numerous appendices. This section of the

regulations also provides the minimum Federal safety standards for the training, testing and certifying of individuals operating locomotives in the rail industry. Training and safety regulations in the rail mode are promulgated and administered by the Federal Railroad Administration (FRA), a sister agency of the FMCSA. Both agencies are part of the Federal Department of Transportation.

Railroads are required to maintain a FRA approved initial/continuing training program for all Certified Locomotive Engineers. Initial training may be provided by the railroad itself or an approved external entity. However, the employing railroad is responsible for insuring all externally provided training meets the terms and conditions of the training and testing regimen accepted by the FRA. The curriculum for the initial training of student engineers includes the following: classroom exercises, skill performance, and familiarization with the physical characteristics of a locomotive and a train of cars. Training must be provided by a qualified instructor engineer, i.e., a Certified Locomotive Engineer with a comprehensive knowledge of the employing carrier's territory of operation, and include study areas pertaining to personal safety, railroad operating rules, mechanical condition of equipment, train handling procedures (including use of locomotive and train brake systems), and compliance with Federal regulations (CFR Title 49 Part 240.123).

The regulations require that locomotive skill training be conducted with a qualified instructor engineer located in the same compartment as the student whenever possible. The Federal training rules also require student engineers to operate the controls of a locomotive for a significant portion of time with a variety of trains. This is done to replicate the conditions normally incurred by the railroad likely to employ the student engineer (CFR Title 49 Part 240.123 Subpart 5).

Federal regulations also specify criteria for testing knowledge and examining skill performance of student engineers. Each

railroad's FRA approved training program must include procedures to examine a student's knowledge and skills to insure compliance with the railroad's operating rules and safe operation of trains. The program must be (a) objective in format, (b) administered in written form, (c) test personal safety practices, operating principles, equipment inspection, train handling skill within the physical characteristics of the territory, and compliance with Federal safety regulations. The skill examination process must occur in the most demanding class of service the person will be subjected to by the employing railroad (CFR Title 49 Part 240.127). No individual will receive classification as a Certified Locomotive Engineer until they complete the FRA approved training program and successfully pass the examination.

Railroads are also required by FRA regulations to monitor the ongoing conduct of their Certified Locomotive Engineers by operational observations and via unannounced operating rules compliance tests. Certified engineers are required to undergo at least one unannounced compliance test each calendar year (CFR Title 49 Part 240.303). The Federal rail safety rules also address prohibited conduct by Certified Locomotive Engineers. Prohibitions include operating a locomotive/train past a signal indication, exceeding the maximum authorized speed limit by at least ten miles-per-hour, and failure to utilize safe braking practices. Other prohibitions involve occupying a main track segment without proper authority, tampering with safety devices installed in the locomotive, or failure to take appropriate safety precautions when serving as a designated Supervisor of Locomotive Engineers, a Certified Locomotive Engineer or an Instructor Engineer (CFR Title 49 Part 240.305).

Civil penalties are specified in Appendix A of the Federal safety regulations applying to the rail mode. An abundance of fines relating to every conceivable regulatory part and subpart addressing required training, testing and documentation is included. For example, a fine of \$2,500 for each violation, and a penalty of \$5,000 for each willful violation, is applied to the

following offenses: failure to adequately train new engineers, failure to have an adequate "required knowledge" testing procedure, failure to have adequate procedures for evaluating and documenting skill performance and failure to have adequate procedures for continuing education and the monitoring of ongoing performance (CFR Title 49 Part 240 Appendix A).

Appendix E to the Federal regulations delineates the procedure to be used in the conduct of a locomotive/train skills test. Among other requirements, each railroad must maintain adequate operating, safety and train handling rules. These rules must include preferred operating ranges for the throttle, brakes and overall speed. These ranges constitute benchmarks to be used by examiners and reviewing bodies. A test of a locomotive engineer's skill is required to evaluate compliance with Federal regulations, pre-departure inspections, proper use of the horn, whistle and headlight, safe coupling techniques, proper control to minimize train slack and buff forces, safe use of braking systems, compliance with signal and speed restrictions and use of the locomotive hand brake (CFR Title 49 Part 240 Appendix E). Succinctly stated, the FRA regulations delineate the training, testing and compliance required to obtain and maintain qualification as a locomotive engineer. The rules also include voluminous penalties for non-compliance.

Master Maritime Rating

The required training, testing and licensing of maritime personnel, e.g., deck officers, engineers, pilot officers, radio operators, etc., is found in the Title 49, Part 10 of the Code of Federal Regulations. These rules are in accordance with the provisions of the 1978 International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW), as amended in 1995. The International Maritime Organization, an agency of the United Nations, developed the STCW. The United States is signatory to the STCW and

agrees with STCW's goals of reducing human error and accidents by developing practical training standards for mariners. The U.S. Coast Guard is responsible for implementing the regulations found in CFR Title 49 Part 10.

Candidates for licensing in the maritime industry must possess minimum qualifications relating to age, experience, character references/recommendations, physical health, tests for dangerous drugs, citizenship, approved training, successful completion of professional examinations and, where designated, a practical demonstration of skills (CFR Title 49 Part 10.201). The U.S. Coast Guard Officer in Charge, Marine Inspection, administers licensing at seventeen port cities across the United States.

One classification in the U.S. maritime industry is that of Master. The individual holding this license is qualified to serve as the officer in command of a vessel. The Master of a water vessel is analogous to a Certified Locomotive Engineer or a large truck operator possessing a CDL. The licensing of all U.S. maritime personnel is predicated on a minimum amount of documented sea service, professional examinations and/or completion of Coast Guard approved coursework (CFR Title 49 Parts 10.211, 10.217, and 10.311).

An example of the service requirements for a Master rating, in ocean or near coastal trades for a vessel of any tonnage, is one year service as chief mate on an ocean steam or motor vessel subject to a minimum of six months of service as chief mate, and, service as an officer in charge of a navigational watch. To attain the rating of chief mate one must serve as an officer in charge of a navigational watch for a period of twelve months while licensed as a second mate. To obtain a rating of second mate one must hold a rating of third mate and serve for twelve months as an officer in charge of a navigational watch while holding a rating of third mate. Another option allows a third mate to complete twelve months of service, with a least six months as officer in charge of a deck watch, in combination with six months service as a boatswain, able

seaman, or quartermaster while holding a certificate as an able seaman (CFR 49 Parts 10.404, 10.405 and 10.406).

To attain a rating of third mate one must possess three years of service in the deck department of an ocean going vessel with at least six months of this service as an able seaman, boatswain or quartermaster, while holding an able seaman certificate. A third mate rating may also be obtained by graduating from the U.S. Merchant Marine Academy, the U.S. Coast Guard Academy, the U.S. Naval Academy, the deck class of a maritime academy approved by the U.S. Coast Guard Maritime Administrator, three years as an apprentice mate in a training program approved by the U.S. Coast Guard Commandant or graduation from the deck class of the Great Lakes Maritime Academy (CFR Title 49 Part 10.407).

The examination topics for those applying for a license as a Master vary in accordance with the route selected. However, typical areas include navigation and position determination, celestial observations, times of celestial phenomena, watch keeping (including navigation safety regulations), radar equipment, compass, tides and tidal currents. Other subjects include ship maneuvering and handling, ship stability, cargo handling and stowage, international maritime law, shipboard management, ship's business, communications, and search/rescue. Examination areas for lesser grades such chief mate, second mate, etc., involve prerequisite topics such as fire prevention and firefighting appliances, emergency procedures, medical care, and lifesaving. Since maritime licensing is progressive, examinations for higher-grade classifications require successful completion of lesser grade examinations and minimum periods of service as referenced above. Mariners desiring service in international trades are required to obtain a STCW certificate in addition to U.S. Coast Guard licensing (CFR Title 49 Part 10.910).

Every individual desiring employment on a U.S. flag vessel of at least 100 gross regulatory tons

(GRT) must initially obtain a Merchant Marine Document ("Z Card"). A "Z" card permits a seaman to work only on U.S. inland waters. To serve on vessels of at least 200 GRT aboard a U.S. flag vessel serving international trades, an untrained person must obtain a STCW-95 Certificate in addition to a "Z Card." To obtain a STCW-95 Certificate a new mariner must meet the following conditions: complete a U.S. Coast Guard (USCG) approved training program, possess seagoing experience of at least one year (said experience must include onboard training documented in a USCG approved training record book), or otherwise possess approved seagoing experience of at least three years. An additional condition requires bridge-watching service under the direct supervision of the Master, Chief Mate, or a Navigator for a period of at least six months while attaining experience at sea (STCW 1995). The Merchant Marine Licensing and Documentation Program administers Coast Guard licensing. All STCW-95 training programs are required by the International Maritime Organization to be monitored by a quality standards system that parallels ISO 9000 guidelines.

The USCG approved training program that a new mariner must successfully complete, for service aboard vessels of at least 200 GRT, entails the following study areas: Automatic Radar Plotting Aid (if the ship the mate will serve on is fitted with an Automatic Radar Plotting Aid), the Global Maritime Distress and Safety System (GMDS), basic training including personal survival techniques, personal safety and social responsibility, elementary first aid, fire prevention and firefighting. Additional training may be required depending on employer need such as proficiency in survival craft and rescue boats, medical first aid, and medical care (USCG, 2006).

Mandatory on-board training for new mariners varies depending on vessel type and service area. For example, to serve as an Able Seaman-Unlimited one must possess a minimum of three years service on deck on vessels operating on the oceans or the Great Lakes. Service as an Able

Seaman-Limited, requires that one possess eighteen months experience on deck in vessels of at least 100 GRT in waters not exclusively confined to rivers and small inland lakes of the U.S. To qualify as an Able Seaman-Special, a mariner must possess at least twelve months on deck service on vessels operating on the oceans or navigable waters of the U.S., including the Great Lakes (USCG, 2006).

To obtain a STCW-95 certificate a new mariner must complete additional U.S. Coast Guard approved training. This training includes Bridge Resource Management (for those desiring to work on deck), Radar and GMDSS Certificates (for deck officers serving on vessels equipped with ARPA/GMDSS), FCC License for GMDSS (for deck officers) and proof of proficiency in the use of survival craft. STCW-95 Certificate testing requires an applicant to demonstrate expertise in the required training areas, not merely pass written examinations. The STCW-95 certificate is the only document recognized by foreign governments (USCG, 2006).

Commercial Aviation Pilot

Pilot training requirements, examination and certification are the responsibility of the Federal Aviation Administration (FAA). The pertinent regulations are found at CFR Title 14 Parts 61 and 141. While there are numerous classifications of certified pilots in the U. S., only two types permit a pilot to transport people on a for-hire basis, i.e., Commercial Pilot and Airline Transport. The regulations specify certification by aircraft type and class. Large aircraft (those exceeding 12,500 pounds gross weight) or those equipped with one or more jet engines, e.g., a Boeing 747, require a pilot to hold a "type" rating. FAA issued Commercial Pilot and Airline Transport certifications do not expire but require

pilots to remain "current" with a minimum amount of relevant flight experience and undergo a flight review with an instructor every two years. Commercial and Airline Transport pilots are also required to pass a medical examination at varying intervals depending on age and appropriate flight privileges.

The provisions under CFR Title 14 Part 61 permit any flight school to train student pilots as long as the CFR requirements are met, whereas, Part 141 schools must meet certain FAA requirements to operate. For example, Part 141 flight schools must maintain minimum levels of personnel, aircraft and facilities, utilize a detailed course syllabus, and maintain a high student pass ratio. In essence, Part 141 schools are more structured and less flexible than programs offered under Part 61 regulations. Students may complete certificates and obtain ratings in less time and with fewer hours under Part 141. As a case in point, Commercial Pilot certification requires 190 hours of flight time under Part 141 whereas 250 hours are mandated in Part 61.

Appendix D of CFR Title 14 Part 141 sets forth the minimum training requirements relating to Commercial Pilot certification. To be eligible for enrollment in a Part 141 Commercial Pilot Certification course a person must at least hold a Private Pilot Certificate and appropriate instrument rating or be concurrently enrolled in an instrument rating course and pass an instrument rating practical test before completing the Commercial Pilot certification course. The Commercial Pilot certification course must include a minimum of 35 hours of ground training appropriate to the airplane category and class rating desired by the student. This training must encompass the aeronautical knowledge areas appearing in Table 2.

TABLE 2
MANDATORY GROUND TRAINING: COMMERCIAL PILOTS

FAA Regulations	Safe/Efficient Aircraft Operations	Chart and Compass Usage	Emergency Maneuvers/Procedure
NTSB Accident Reporting	Weight & Balance	Air Navigation Facility Usage	Night & High Altitude
Basic Aerodynamics	Aircraft Performance Chart Utilization	Aeronautical Decision Making	National Airspace System Procedures
Meteorology & use of Weather Reports	Exceeding Aircraft Performance Limitations	Principles & Functions of Aircraft Systems	

Mandatory in-flight training is also required under Part 141 regulations pertaining to a Commercial Pilot certification course. This training must be in areas appropriate to the aircraft category and class rating to which the course is designed. For example, an airplane requires a minimum of 190 hours. The in-flight training for an airplane multiengine course requires at least 55 hours of instruction, on the topics appearing in Table 3, and be received from a Certified Flight Instructor (CFR Title 14 Part 141 Appendix D).

Under CFR 14 Part 61.129 aeronautical experience for an airplane multiengine rating requires that a person seeking certification must log at least 250 hours of flight time including:

- 100 hours in a powered aircraft
- 100 hours of pilot-in-command time
- 50 hours in cross-country flight
- 20 hours flight proficiency training that involves the following:
 - 10 hours of instrument training (5 hours must be in a multiengine airplane)
 - 10 hours in a multiengine plane with a retractable landing gear, flaps, turbine power
 - A cross-country flight of at least 2 hours in a multiengine plane under daylight VFR conditions of more than 100 nautical miles in length

- A cross-country flight of at least 2 hours in a multiengine plane under night VFR conditions of more than 100 nautical miles in length
- 3 hours in a multiengine airplane within 60 days of taking the practical test
- 10 hours of solo flight time in a multiengine plane or 10 hours of flight time performing the duties of pilot in command with an authorized instructor that includes at least one of the following:
 - 1 cross-country flight of at least 300 nautical miles with landings at a minimum of 3 points, one of which is a straight-line distance of 250 nautical miles
 - 5 hours under night VFR conditions with 10 takeoffs and 10 landings with each of the landings involving a flight pattern at an airport with an operating control tower

In-flight training under Part 141 must be appropriate to the aircraft category and class rating and include approved subject material. The FAA multiengine airplane curriculum specifies the following mandatory knowledge areas: 1) pre-flight preparation, 2) preflight procedures, 3) airport base operations, 4) takeoffs, landings and go-arounds, 5) performance maneuvers, 6), navigation, 7) slow flight and stalls, 8) emergency operations, 9) multiengine

TABLE 3
MANDATORY MULTI-ENGINE IN-FLIGHT TRAINING: COMMERCIAL PILOTS

5 Hours of Multiengine Aircraft Instrument Training	One Cross-Country Flight of at Least 2 Hours Duration, Occurring in Night VFR Conditions
10 Hours with a Retractable Landing Gear, Flaps & Controllable Pitch Prop or Turbine Power	3 Hours in a Multiengine Aircraft at Least 60 Days Preceding the Practical Test
One Cross-Country Flight of at Least 2 Hours Duration, Occurring in Daylight VFR Conditions	

operations, 10) high-altitude operations and 11) post-flight procedures (CFR Title 14 Part 141 Appendix D).

The FAA regulations for a Commercial Pilot certification course under Part 141 also require solo flight training. For a multiengine airplane 10 hours are required, with the pilot seeking certification performing the duties of the pilot-in-command while under the supervision of a Certified Flight Instructor. The 10 hours must include at least one cross-country flight with landings at a minimum of 3 points and one segment of the flight involving a minimum straight-line distance of 150 nautical miles. The solo training must also include 5 hours in night VFR conditions with 10 landings. These landings must involve a flight with a traffic pattern at an airport with an operating control tower (CFR Title 14 Part 141 Appendix D).

TRAINING, OPERATOR COMPETENCE AND SAFETY

As chronicled above, the Federal agencies responsible for safety in the rail, maritime and air modes require extensive mandatory training for those seeking to operate vehicles in commerce. This training must comply with uniform standards and include an approved curriculum. The coursework must involve classroom study and a proscribed amount of time at the vehicle's controls, exposed to varying operating conditions, under the tutelage of a qualified instructor.

Proper training appears to impact safety in the trucking industry. A 2000 study noted that drivers obtaining instruction at formal training schools with established curriculums were less likely to receive citations for moving violations than drivers trained exclusively on-the-job (Monaco and Williams, 2000). In a 2003 report investigating driver management practices among some of the nation's safest motor carriers, the findings revealed an emphasis on pre-service and in-service training for company drivers and owner operators (Mejza et al., 2003).

The 2003 research involved a survey of motor carriers with exemplary safety records, as measured by compliance with Federal, state and local safety regulations, crash (accident) statistics and the recommendations of FMCSA Safety Directors. A high percentage of motor carriers included in the study required their newly hired drivers to undergo pre-service and in-service training before solo vehicle operation. This mandatory training most often included the following subject matter: defensive driving techniques, Federal safety regulations, pre-trip and post-trip vehicle inspections, and accident notification. These safety conscious carriers were also noted to use vehicle-based (on-road and off-road) and classroom based (oral and written) examinations to evaluate the effectiveness of their mandated training. The motor carriers requiring formal training clearly perceived benefits exceeding the cost of such training. The safety performance of these carriers also revealed fewer accidents and injuries/deaths.

Given the benefits resulting from structured training in the motor carrier industry, it may be time to revisit the mandatory adoption of a "model curriculum," especially for entry-level heavy truck drivers.

A MODEL CURRICULUM AND THE PROFESSIONAL TRUCK DRIVER INSTITUTE

A model curriculum developed by the FMCSA in the early 1980's was adopted in its entirety by a motor carrier industry group, The Professional Truck Driver Institute (PTDI), for use in certifying the programs of truck driver training schools. The model curriculum specifies core training requirements and study materials. It also addresses the appropriate type of vehicles, facilities, instructor hiring practices, graduation requirements and student placement practices to be utilized. The model curriculum was needed since the Commercial Motor Vehicle Safety Act did not contain any prerequisite training to obtain a CDL. However, provisions of the curriculum were never made mandatory by law and, thus, are still voluntary today. This condition continues despite an admission by the FMCSA that

...the "model curriculum" represents the basis for training adequacy and...(the) knowledge (required) to pass the CDL test is not sufficient to determine training adequacy (Federal Register, 2003).

Further insight into the FMCSA's position concerning mandatory training can be obtained from a recent report detailing public comments on the agency's newly proposed Minimum-Training Requirements for Entry-Level Commercial Motor Vehicle Operators. One question published in the FMCSA advanced notice of proposed rulemaking addressed the following question: "Should the training requirements for entry-level commercial motor vehicle drivers be mandated by the Federal government?" After synthesizing input from 151 responders, the agency concluded that training should be mandatory for all entry-level (CMV) drivers,

irrespective of the kind of vehicle they drive or the size of the employing carrier (Federal Register, 2003).

As noted above, the PTDI has incorporated this model curriculum into its "Curriculum Standard Guidelines for Entry-Level Tractor-Trailer Courses." These guidelines are used by the PTDI to certify truck driver training programs offered by private and publicly funded schools in the United States. This document states that "... it is the product of the collective wisdom of 250 motor carriers' safety personnel, drivers and educators teaching in the field of tractor-trailer operating, curriculum and safety...and represents the touchstones that a tractor-trailer driver training course should contain, and against which any such course may be judged" (PTDI, 1999).

The PTDI curriculum specifies the minimum amount of training and time necessary to become a "second seat" driver. Such a driver is considered to possess the skills to operate a commercial vehicle safely, but without supervision, lacks the experience to perform as a solo driver. Further, the PTDI curriculum publication declares that fully trained "solo-ready" drivers must undergo additional training provided by a considerably expanded curriculum. Such enhanced training must include additional road experience and supplemental vocational instruction under the guidance and supervision of an experienced, professional driver (PTDI, 1999).

A minimum of 148 training hours is specified by the PTDI curriculum including at least 44 hours behind-the-wheel time by the student. However, the guidelines allow up to 14 of the 44 hours behind-the-wheel time to be provided via an externship option. In essence, a qualified driver-trainer of the trucking firm intending to employ the student may provide this training. The guidelines also specify that 12 of the 44 mandatory driving hours must be spent on the street/road and 12 hours on a driving range (an off-road private training area). The remaining 20 driving hours may be split between the driving

range and road training. A minimum of 2 hours of driving range time and 1 hour of road time is recommended at night in areas without illumination (PTDI, 1999).

Five units of classroom/lab instruction are also required by the PTDI curriculum. These five units incorporate the remaining 104 hours of mandatory training as summarized in Table 4.

SUMMARY AND CONCLUSIONS

It is apparent the Federal government long ago recognized the need for mandatory operator training, in accordance with a uniform curriculum based on proven safety principles for the rail, maritime and air modes. The agencies charged with safety oversight in these modes established mandatory areas of study and training requirements for the licensing (certification) of water vessel, aircraft and locomotive operators. Statutory law formalized these training requirements.

The Federal agency responsible for safety in the trucking industry (FMCSA) has also repeatedly acknowledged the need for a unified training curriculum and standards for entry-level heavy truck drivers. In fact, the FMCSA, along with industry advisors, devised a model curriculum for the training of entry-level truck drivers over 25 years ago. The agency has also repeatedly acknowledged that training provided by many private and publicly funded schools and motor carriers is deficient. However, no uniform training curriculum or minimum training standards have been codified into law and made mandatory for entry-level heavy truck drivers.

Many previously believed the establishment of Commercial Driver License (CDL) requirements would be sufficient to improve highway safety. But, in reality, CDL requirements represent a licensing standard, not a training standard. Even today one may obtain a CDL by passing a series of "written" exams and a "skills" test without the completion of any required training.

TABLE 4
MINIMUM PTDI CLASSROOM/LABORATORY TRAINING REQUIREMENTS

UNIT NO.	STUDY AREA	TASKS	HOURS
1	Basic Operation	Vehicle Inspection & Control Shifting, Backing & Docking Coupling & Uncoupling	18
2	Safe Operating Practices	Visual Search Speed Management Space Management	8
3	Advanced Operating Practices	Night Operation Extreme Driving Conditions Hazard Perception Emergency Maneuvers Passive RR Crossings	14
4	Vehicle Systems	Maintenance Diagnosing Malfunctions	6
5	Non-Vehicle Activities	Hours-of-Service Accident Procedures Handling Cargo	43
	Discretionary Hours		15
Total			104

Even the International Brotherhood of Teamsters, a group acutely interested in the licensing of additional heavy truck drivers, has acknowledged that mere possession of a CDL does not guarantee that a driver has the necessary experience and skill to safely operate a commercial motor vehicle (Federal Register, 2003).

The CDL "skill" test (commonly known as the road test) may even be administered by third party entities on behalf of many state governments today. These third parties are often the very schools providing entry-level training to students seeking employment as heavy truck drivers. This practice may be convenient and cost effective for state governments but it raises an ethical question in the minds of many regarding a conflict of interest on the part of truck driver training school administrators.

Most transportation related injuries and deaths occur in the motor carrier industry and a significant amount of property damage results from crashes in this sector. There is also an ongoing shortage of heavy truck drivers in certain segments of the motor carrier industry. Mr. Bill Graves, President of the American Trucking Association at an industry conference, recently quantified the significance of this shortage (Reddy, 2006). He placed the current shortage at 20,000 drivers, growing to 111,000 drivers by 2014. Much of this anticipated shortage is related to the imminent retirement of many existing "baby-boom" generation commercial drivers.

Another measure of highway activity and heavy truck exposure is provided by the amount of freight moved by trucks over time. For example, from 1993 to 2002 total ton-miles transported by truck increased from 931 to 1,449 billion ton-miles (BTS 2002). This trend is not likely to be reversed given projected GNP growth and U.S. dependence on imported goods requiring a constant need to move goods from port areas to inland markets. Succinctly stated, many new heavy truck drivers will soon be required. Also, the DOT is currently taking steps to soon allow 100 Mexican trucking companies to begin operation throughout the U.S. (Corsi, 2007). There is likely to be much concern with the type and degree of training possessed by these foreign heavy truck drivers, among other issues.

Some would argue that a clear need exists for the establishment of a uniform curriculum and mandatory training for entry-level heavy truck drivers. An adequate amount of proper training has been shown to increase the likelihood of competence in many human endeavors. The model curriculum as adopted and modified by the Professional Truck Driver Institute provides a roadmap to consistency in the training and development of individuals desiring to operate the largest, and potentially most dangerous vehicles, on our nation's highways. Many laws and regulations pertaining to transportation vehicles and safety are "written in blood," hasn't enough already been shed? If this is not the time to adopt a uniform curriculum and mandate entry-level heavy truck driver training, when will the time come?

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EVALUATION OF AN EXPANDED SATELLITE BASED MOBILE COMMUNICATIONS TRACKING SYSTEM

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ABSTRACT

Since the terrorist events in the United States on September 11, 2001, the Federal Motor Carrier Safety Administration has been testing and evaluating cargo tracking technologies to improve the safety, security, and efficiency of commercial motor vehicle operations. While satellite-based systems used for tracking vehicles and cargo provide sufficient geographic coverage in the majority of the United States, there remain several vital regions that are uncovered and difficult to monitor. One such region is Alaska, where officials are particularly concerned with the hazardous materials shipments that are transported parallel to the Trans-Alaska Pipeline. This article analyzes the risks and benefits associated with adopting an Expanded Satellite-Based Mobile Communications Tracking System to monitor hazardous materials and high-value cargo in Alaska. Technical and acceptance risks are evaluated against the communication, safety, security and real time information benefits that the system provides. The findings indicate that the system provides a significant communications upgrade relative to previously available technology.

Since the terrorist events in the United States on September 11, 2001, the Federal Motor Carrier Safety Administration (FMCSA) has been testing and evaluating technologies to improve the safety, security, and efficiency of commercial motor vehicle operations. Several key studies have evaluated vehicle and cargo tracking systems. These systems provide automated updates of location information to a dispatcher on a regular basis. They also include the ability to share critical information with carrier-authorized third parties, such as public sector agencies. While satellite-based systems used for tracking vehicles and cargo provide sufficient

geographic coverage in the majority of the United States, there remain several vital regions that are uncovered and difficult to monitor.

One such region is Alaska, where officials are particularly concerned with the hazardous materials (HazMat) shipments that are transported along the Dalton Highway from Prudhoe Bay in the north to Fairbanks and other cities in the south. The Dalton Highway runs parallel to the Trans-Alaska Pipeline. If a terrorist attack were to occur in Alaska, authorities believe that the pipeline would be one of the likely first targets and a hijacked

HazMat shipment would be a convenient weapon. Additionally, the vast geographic expanse and harsh climate of the Alaskan region, as well as limitations in currently available communications systems, make vehicle breakdowns and other emergencies potentially life threatening situations for vehicle operators.

This article analyzes the risks and benefits associated with adopting an Expanded Satellite-Based Mobile Communications Tracking System (ESCT) to monitor hazardous materials and high-value cargo in Alaska. One major goal of this system is to improve communications in the event of an emergency, while enhancing trucking operations en route and for each phase of movement—pick up, delivery, receipt, and storage.

After evaluating the risks and benefits associated with the ESCT, it was found that benefit estimates outweigh the potential risks. The system provides a significant communications upgrade relative to previously available technology. The safety and security improvements have already had an effect on the operations of those carriers participating in a pilot study, and the system has found wide acceptance among employees, while the potential of the real time information provided by the ESCT is yet to be fully realized. The system will still require further improvements, since the satellite coverage of the region left several areas uncovered. However, with the limited risk involved and the potential for benefit, implementation of the ESCT on a wider scale would result in a significant improvement in the tracking of cargo in Alaska.

This article is organized as follows: the following section describes the new satellite system and presents the guidelines under which the satellite system was tested; the risks associated with adopting the new system are then described, analyzing both technical and acceptance risks; the various benefits of the system, including improvements in communication, safety and security, and the use of real time information are then presented; and the final section presents the conclusions.

SATELLITE SYSTEM REQUIREMENTS AND TEST GUIDELINES

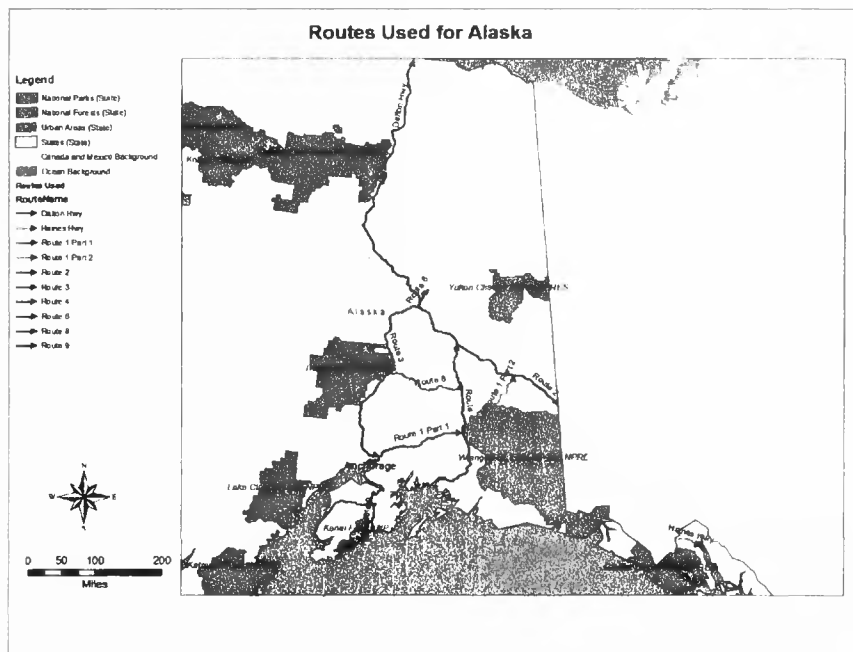
Travel on Alaskan highways is often a very dangerous undertaking. Trucks must traverse some of the most remote, harsh territory in the U. S., with 250 mile long stretches of highway that have no rest stops and no gas stations, while temperatures may reach -80° F. Truckers regularly deal with vehicle breakdowns caused by extreme temperatures, or the poor quality of the potholed roads. Under these conditions, it is of critical importance to be able to maintain some type of contact with drivers in the event of an emergency. However, this has not been possible in the past. The satellites used for tracking vehicles in the 48 continuous states do not provide coverage in Alaska. Cell phone coverage is isolated to urban areas, while CB radio availability is often intermittent due to the mountainous terrain. Therefore, a new system was required in order to extend vehicle tracking to most of the region.

Qualcomm, Inc. was selected to develop an expanded satellite system for the region. The new system required the use of a satellite positioned such that contact with the entire region could be maintained at all times at a reasonable cost. The orbits used by tracking systems for the 48 continuous states do not reach far enough to cover the majority of Alaska. Modifying those orbits would be cost prohibitive for the volume of traffic to be monitored. A geostationary satellite that has an orbit allowing for coverage in Alaska was selected for the system. Because the geostationary satellite is lower on the horizon, the antenna on each vehicle was adjusted such that the elevation angle was lowered. Further, a high powered transceiver component was used to ensure that the satellite could reliably communicate with the mobile unit even in northern Alaska, where the sensitivity of the satellite was the weakest. With satellite coverage extended by this new system, testing could begin to analyze the risks and benefits associated with the new service.

The three month test period began in mid-October 2005. The trucking routes of interest are detailed in Figure 1, covering over 2100 miles of roadway. Four carriers participated in testing the satellite system, with a total of 100 tractors outfitted with mobile transceiver units. The components required for each tractor were a dome antenna mounted on the roof of the tractor, a mobile communication unit (keyboard) installed in the cab, a panic button mounted inside the cab, and a wireless panic button that the driver could carry on a keychain. Messages from the tractor are relayed through a commercial Network Management Center (NMC) to the carrier's host system. Several technologies were evaluated during the test, including a messaging system that allowed for text or macros to be sent between the dispatcher and driver, location and mapping of tractors, and a system to send out panic messages in the event of an emergency.

During the three month test period, certain technologies were evaluated regularly on a day to day basis. Each mobile unit would take a reading to determine if satellite tracking was available at the unit location, and if so, to generate a position report. The units each took a reading every 15 minutes while the vehicle was in operation, resulting in over 263,000 position reports during the test. Over 2000 regular messages and 50 panic messages were sent during daily operations over the three months. In addition to the day to day testing, an evaluation team conducted tests during two site visits with each carrier. These site visits allowed for controlled testing of all technologies, in particular those that were infrequently used, such as the panic buttons.

**FIGURE 1
ROUTES OF INTEREST IN ALASKA**



Source: Battelle, 2006; Roadway Data: Esri Street Map

RISKS

For the purposes of this study, two risks were analyzed when evaluating the ESCT, technical risks and acceptance risks. The technical risks are those associated with how reliably the system may perform under day to day operating conditions. System performance is defined in two ways: message transmission latency and data quality. Based on testing during site visits, both latency and data quality do not appear to be significant technical risks. The acceptance risks are those associated with the willingness of employees or customers to adopt the system and use it on a regular basis. Both employees and customers appear to be very likely to utilize the ESCT given their experience with the test configuration.

Technical Risks

Latency was measured as the elapsed time from when a message was sent from the mobile unit in the vehicle until it was received at the carrier's host system. The current version of this system cannot provide a time stamp when the message was actually sent from the mobile unit. Rather, the system creates a time stamp when a message is received at the NMC and again when that message is forwarded to the carrier's host system for viewing by the dispatcher. Therefore, in order to accurately determine the amount of time that elapses between the driver sending the message and the dispatcher receiving it, the send time must be manually recorded. This only occurred during the two site visits and not during regular daily testing. It is important to note that these tests were run when the vehicle was positioned with a clear line of sight to the satellite. Attempting to transmit messages without a clear line of sight, such as in a remote area, should result in a greater latency period.

During the staged test, the evaluation team recorded the time (as displayed on the in-cab mobile unit) that the message was sent by the driver. This was compared with the automated system logs for time of receipt at the host system. The send and receive times for return

messages (from the host to the mobile unit in the truck) were also recorded to calculate system latency for these messages. Tests were performed for regular text messages, macros, and panic messages. The tests for each message type were performed no more than four times per carrier over the course of two staged tests. This results in a small sample size. However, it is still possible to draw some conclusions from the results in regards to technical risks.

In evaluating the results of the testing, a set of criteria must first be established to provide a benchmark for performance. The messaging service provided by the ESCT system closely parallels the Short Messaging System (SMS), or text messaging, used by cellular providers in many ways. Given that this system is to fill a role that cellular providers may take under less extreme conditions, we may apply the standards of the mobile telecommunications industry to the ESCT system. However, this industry is somewhat reticent to reveal how well their systems perform. Therefore, research in this area has been inadequate and the analysis was based upon the limited information available.

Some software developer tool kits can specify a time delay for sending a message, but it is dependent on operator network traffic, congestion, optimization, etc. Most findings report on the degradation of service under extreme circumstances with very high messaging volumes, but even this can be revealing as standards have changed with the significant increase in text messaging. The delay for a high volume event from a few years ago, New Year's Eve of 2003, was several hours (Sturgeon, 2004), while some companies today are promising the delivery of messages in less than 15 seconds (Wieland, 2006). The latter criterion is rather stringent and would be difficult to guarantee under any circumstances. Based on the requirements of the carriers participating in this study, the criteria in Table 1 were established. Given these standards, the metric for "excellent" service should be regularly satisfied, with a maximum transmission delay of two minutes for

regular messages and one minute for panic messages.

Table 2 presents the latency times for regular text messages sent from the driver to dispatcher and dispatcher to driver. The average latency time for messages sent from the driver to dispatcher is 50.7 seconds, while dispatcher to driver is 69 seconds. Both of these values are well below the two minute criteria for "excellent" service. Only one message required more than two minutes for transmission, while four were over one and a half minutes.

Table 3 presents the latency times for macros sent from the driver to dispatcher and dispatcher to driver. The average latency time for messages sent from the driver to dispatcher is 70.6 seconds, while dispatcher to driver is 77 seconds. Both of these values are well below the two minute criteria for "excellent" service, but greater than the average values for regular text messages. However, there are two macro messages that required significantly more time, with one transmitting in over two and a half minutes and the other in almost four and a half minutes. Also, the median value for messages from the dispatcher to the driver is 46 seconds for the macros while it is 62.5 for the regular text messages. Furthermore, the average latency value for the macros is 53.5 seconds when the message requiring 265 seconds is removed. These inconsistencies are difficult to justify given the limited data available. It would appear that sending a macro generally results in an "excellent" latency time, with the two delayed messages resulting in a rating of "appropriate" based on the carrier required expectations.

Table 4 presents the latency times for panic messages sent from the driver to dispatcher through the use of the wired and wireless panic buttons. The wired panic button is installed in the cab, while the wireless button is held by the driver. A metric for these messages for "excellent" service is transmission in less than one minute. Based on the intended usage of this tool, this is an appropriate standard. The average for wired messages was 52 seconds, while wireless messages required 54.1 seconds. Two messages sent during testing did not satisfy the criteria for "excellent" service, with one of the messages requiring almost two minutes for transmission. One message represents 6 percent of all those transmitted, which is a reasonable rate of occurrence for messages with an "appropriate" service level.

The majority of messages sent, whether text, macro or panic message, were transmitted with a latency time that could be qualified as "excellent." One out of 28 text messages, two out of 20 macros and two out of 24 panic messages could be classified as "appropriate." While the test sample sizes were not large, the results indicate that message latency is not a technical risk. Sending messages while the vehicle does not have a direct line of sight to the satellite should result in a greater latency. This potential problem was not addressed with these tests. However, concerns over coverage areas will be discussed in a later section.

Data accuracy was determined by comparing the content of the sent message with that of the received message. Similar to the latency tests, data accuracy was evaluated with both messages

TABLE 1
COMMUNICATION LATENCY EVALUATION METRICS

Rating	Panic Alert Requirements	Other Messages
Excellent	Less than one minute	Less than two minutes
Appropriate	Between one and three minutes	Between two and five minutes
Degraded	Between three and five minutes	Between five and ten minutes

**TABLE 2
LATENCY MEASUREMENTS FOR TEXT MESSAGES (IN SECONDS)**

Direction	Staged Test	Carrier 1	Carrier 2	Carrier 3	Carrier 4
Driver to Dispatcher	1	39	34	77	21
		31		31	
	2	63	40	109	77
		78	24	30	56
Dispatcher to Driver	1	66	70	63	134
		62	112		106
	2	43	21	51	59
				41	

**TABLE 3
LATENCY MEASUREMENTS FOR MACROS (IN SECONDS)**

Direction	Staged Test	Carrier 1	Carrier 2	Carrier 3	Carrier 4
Driver to Dispatcher	1		67	80	11
	2	65	67	67	154
				54	70
Dispatcher to Driver	1		89	21	265
				39	
	2	46	25	79	43
			86		

**TABLE 4
LATENCY MEASUREMENTS FOR WIRED AND WIRELESS PANIC MESSAGES
(IN SECONDS)**

Direction	Staged Test	Carrier 1	Carrier 2	Carrier 3	Carrier 4
Wired	1	52	48	57	55
					58
	2	43	35	33	30
				109	
Wireless	1	58	66	47	46
	2	52	51		57
			56		

sent from the mobile unit and from the host system. The content of the message was manually checked by the test personnel at either location prior to transmittal and then compared with the message that was received. While this testing was somewhat limited, it was found that data quality was maintained throughout the process. All sent messages were identical in content to the corresponding received message. As with delays in transmission, there is little information available regarding data accuracy for the mobile telecommunications industry.

Acceptance Risks

These risks are associated with the willingness of employees or customers to adopt the system and use it on a regular basis. If those who are expected to use a new technology are not comfortable with it, or do not find it helpful, there is a good likelihood that the technology will not succeed. Several technology acceptance models have been developed in literature, correlating the characteristics of a technology with the potential for acceptance. One of the more commonly reported factors is a technology's ease of use, with models by Davis (1989), Ajzen (1991), Thompson et al. (1991), Venkatesh et al. (2003), and Moore and Benbasat (1991) considering this correlation. Additional theories on the factors that may correlate to acceptance pertain to the perceived usefulness of the technology (Davis, 1989), enhancement of on the job performance (Thompson et al., 1991), compatibility with the needs of potential users (Moore and Benbasat, 1991), and the anxiety generated by operating the new technology (Compeau and Higgins, 1995). If, for example, a technology is very easy to use and understand, the acceptance of that technology is not necessarily guaranteed, but there should be a greater likelihood of acceptance. Based on interviews with the participating carriers, information was obtained on how the satellite system was perceived by those who use the system. These perceptions relate to the factors described above such that an evaluation can be made as to the potential for acceptance.

The ease with which new users can learn the system is one of the more important technical factors related to acceptance. If drivers and dispatchers struggle with the system, then they are unlikely to adopt it for regular use. Based on independent interviews conducted with the carriers, this is not a problem. The carriers indicated that training required from a half hour to a few hours for each driver. None of the drivers or dispatchers expressed any concerns with significant technical problems that limited their capacity to learn how the system operates.

In addition to finding the system easy to use, most employees felt that the system was helpful in performing their job. Dispatchers found that it makes the load planning process simpler, as there is more visibility in terms of vehicle location and status. With the system, the dispatcher knows if a vehicle will arrive at a destination on time, such that the vehicle can then be used to pick up another load. In the past, alternate arrangements had to be made in order to guarantee that a load was picked up. This topic will be further explored in the section on real time information.

Drivers found the system helpful in that they feel safer and more secure, as they know that contacting a dispatcher in an emergency is much easier. The carriers believe that this is helping with driver recruiting and retention. However, some drivers have expressed the fear that the new tracking technology may allow their employer to monitor their performance more closely. While the carriers are not yet using the system to track driver performance, they have indicated a desire to do so. When this occurs, drivers will be less likely to cooperate in the implementation of the new system. Drivers can be slow to embrace new technologies, particularly when that may entail a loss of some privacy. The carriers will have to emphasize the positive aspects regarding safety and security in order to overcome any fears drivers may have. Also, if the majority of carriers adopt this technology, the drivers will have little alternative except to adopt and use it.

It is also important that the customer is willing to accept the system. This requires that each customer has a high level of comfort interacting with the system, whether information on load status is provided through a website or from a dispatcher. Customers have been very pleased with the system and everything that it has to offer. They find that the improved vehicle tracking is most beneficial. The system allows for the vehicle tracking information to be fed directly through the Internet so that customers have 24 hour access without continuously calling the dispatching center. Not only are customers pleased with this service, many are beginning to mandate it (including the Department of Defense).

Based on independent interviews, the acceptance risk is limited. The ease of use is not a concern as training requires a minimal amount of time. Employees find the system to be useful and to have the potential to enhance job performance, while customers also find the system to be very helpful. The only problem may arise as the system is used to monitor employee performance more rigorously. Drivers are often suspicious of any technology that allows an employer to look over their shoulder while they work, and this may lead to resistance on the part of the employees.

BENEFITS

This study focuses on three potential benefits that may be gained through the use of the ESCT system: improvements in coverage, safety and security, and the use of real time information. While coverage is spotty in limited areas, the overwhelming majority of routes see a significant improvement in the level of communication available. The carriers have already realized many safety and security benefits brought about by the satellite system, responding to emergency incidents more rapidly, while retaining more drivers by creating a safer environment. An additional benefit that is analyzed is the availability of real time information provided by the ESCT. With real time information, the carriers may utilize their fleets with an efficiency

that was previously impossible. A simulation is used to determine that there may be a reduction in operating cost through a simple change in vehicle routing policy.

Improvements in Coverage

The most vital information provided during the test period indicates where and how often a vehicle is out of coverage (OOC). The OOC areas were established primarily through regular position reports that the vehicle transmitted every hour. A satellite availability check was performed every fifteen minutes by the mobile unit, with these results included in each hourly report. Determining the percentage of OOC reports relative to the total number of position reports for each location provides an accurate picture of where the most troublesome areas may be. Table 5 provides a summary of all OOC incident spikes for the routes (outlined in Figure 1) carrying the most traffic for the four carriers tested. This table indicates the location on the route at which the spike occurred, the probable reason for this occurrence, and the percentage of OOC incidents relative to total position reports. A primary objective for this system is to provide consistent communication with vehicles in remote locations, while two vital secondary objectives are to provide a secure form of communication that is not easily compromised and a method for transmitting more than just an audio signal, but data packets as well. In the majority of areas, this was accomplished. However, there are still some shortcomings.

In Table 5, those OOC incident locations where alternate forms of communication would most likely not be available have been highlighted. The incidents that are not highlighted occur in locations where the driver should be able to communicate with the dispatcher when the satellite system is unavailable, whether through the use of cellular phone, radio or land line. For example, in the case of Dalton Highway there were three locations with a significant number of OOC incidents where some other form of communication was accessible. Prudhoe Bay is a relatively urban area with cellular coverage, as

TABLE 5
LOCATION, JUSTIFICATION, AND OCCURRENCE PERCENTAGE OF OOC
INCIDENT SPIKES ON ROUTES OF INTEREST

(OOO incident locations where alternate forms of communication would most likely not be available have been highlighted)

Route	Location	Probable OOC Justification	% OOC
Dalton Highway	Prudhoe Bay	Buildings/Overhead facilities	25-75
	Atigun Pass	Terrain – North/South valleys	>75
	Cold Foot Midway Point	Truck Stop/Facility	>75
	Baker's Knob	Truck Stop/Facility	<25
	Entire Highway	Terrain – North/South valleys; Oversized equipment	25-75
State Route 1	Anchorage	Terminals/Urban environment	<25
	Mileposts 220 – 240	Terrain – North/South valleys	<25
	Mileposts 65 and 85	Dining establishments	<25
	Mileposts 80 – 150	Terrain – West/East valleys	<25
State Route 2	Fox	Weigh Station	25-75
	Fairbanks	Terminals/Urban environment	25-75
	Mileposts 21 – 46	Terrain – North/South valleys	25-75
	Mileposts 61 – 80	Terrain – North/South valleys	25-75
State Route 3	Fairbanks	Terminals/Urban environment	<25
	Trapper Creek	Truck Stop/Facility	<25
	State Route 1 Junction	Truckers Domiciled	25-75
State Route 4	Delta Junction	Terrain/Facility	<25
State Route 6	Fox	Weigh Station	<25

well as radio accessibility. Cold Foot Midway Point and Baker's Knob are truck stops which should have personnel on hand to help in the event of an emergency, in addition to lines of communication that can access a dispatcher.

Consistent communication is available in locations such as truck stops and urban areas, even if the vehicle is out of satellite coverage. However, the security of this communication is not at the level provided by the ESCT system. As several carriers indicated, assigning a new load or rerouting a vehicle via CB radio is not an appealing option as this information is accessible to anyone using the same bandwidth. This information may be more securely transferred via the ESCT system. Many of these new vehicle assignments occur while the driver is within an urban area, where many of the OOC incidents occur. While the driver may easily contact help in the event of an emergency, a secondary objective of the satellite system is not realized, as the level of secure communication is limited. Another similar benefit that may be interrupted is the added reliability and accuracy that is gained through use of the system. With a larger fleet, there is a significant amount of radio traffic that can lead to missed or misheard messages and driver error. The satellite system allows for text messages with explicit instructions to be sent to a specific vehicle, eliminating most of the room for error.

Those OOC areas where an alternate form of communication is not available are rather limited throughout the network of tested routes. OOC incidents occurred along the entire length of the Dalton Highway, primarily due to terrain. Many problems occurred as trucks moving north/south on the highway dipped into valleys, losing the line of sight with the satellite in the southern sky. However, the percentage of OOC incidents was below 25 percent for much of the highway, with some spikes scattered along the route. The most significant spike occurred at the Atigun Pass, with more than 75 percent of location reports indicating no satellite coverage. As a truck moves up and down this pass, it is

almost constantly surrounded by terrain that blocks the line of sight to the satellite.

The only other OOC areas where an alternate form of communication is not available with a percentage greater than 25 percent occurred in two locations along Route 2. While the coverage in these areas was not as spotty as at the Atigun Pass, there were a significant number of OOC incidents. The cause of these was similar to that for the Pass, as the trucks dipped into valleys on a route with a north/south direction. The other OOC spikes were below 25 percent, which may still indicate poor coverage, but not to the extent found on Dalton Highway or Route 2.

The six routes considered above cover over 2100 miles of highway. Excluding the scattered OOC incidents along the length of the Dalton Highway, OOC incidents occurred for over 25 percent of position reports on less than 100 miles of highway. This is less than 5 percent of the tested routes. The satellite system does have holes in coverage, particularly along the Dalton Highway. However, the coverage is rather expansive, particularly when compared to alternative systems of communications. Cellular coverage is limited to the southwest corner of the state and only to the urban areas, with no coverage for significant portions of the routes used by the participating carriers. The satellite system requires several improvements in order to provide a consistent level of coverage across all routes used by carriers, but it does allow for communication with a significantly larger region than previously available.

Safety and Security

The safety and security improvements that are provided through the use of the satellite system come primarily in two forms. One is the ability to maintain contact with vehicles in remote areas in emergency situations. The other allows for more secure transmission of information. In the past, all contact between a dispatcher and vehicle was via radio, allowing for easy access to outsiders. The text messages transmitted via the

satellite prevent the open transmission of sensitive information. In this section, details are provided on how these improvements have already affected carrier operations and what additional benefits may be derived from the satellite system.

The extreme environment in which the Alaskan carriers operate is the cause of a significant number of vehicle breakdowns. Because of the regularity of these breakdowns and the harsh climate in which drivers must wait for assistance, it is important that the time required to react to a vehicle breakdown is minimized. While a quick response to these incidents improves fleet utilization, it also results in a greater level of safety for the driver. During the test, the carriers had the opportunity to use the system to respond to vehicle breakdowns several times. Each carrier found that it handled incident response very well, with drivers on certain routes requiring emergency assistance on a weekly basis. In the past, when a breakdown occurred in a remote location that was not within the reach of radio or cellular communication, the driver would have to wait for a ride from a passing vehicle and then contact the dispatcher when communication was reestablished. This would often require several hours. Now, the drivers simply use the panic button and wait for a response. The system has helped in retaining and recruiting drivers, as they feel safer because of the rapid response to emergency incidents. Also, the dispatchers feel that they can sleep soundly at night, knowing that their drivers are always within immediate reach of assistance in the event of a breakdown.

There were no events during testing that involved a breach of security. Clearly, such events are a very rare occurrence. However, based on the rapid response in the event of a breakdown, it can be assumed that response to a security event would be just as immediate, if not more so. In addition to improving response time, the satellite system may be viewed as a deterrent for hijacking or other breaches of security. The potential rapidity of response in an emergency situation should serve as a security

feature in and of itself. The carriers also indicated that the system will allow for a more secure method of transmitting sensitive information. In the past, they have contacted drivers regarding loads they are carrying or picking up through the use of CB radio. This information is then accessible to competitors or other unwelcome listeners. By using the messaging system available with satellite communication, the transmissions become much more difficult to intercept.

Very little research has been done to relate vehicle tracking to improvements in safety and security. Therefore, it is difficult to quantify the benefit that can be gained in this area. Judgments must be made primarily from the qualitative results of the test. Based on carrier interviews, the satellite system has already made an impact on incident response over the brief three month test period and should soon be an aid in transmitting sensitive information. The realization of these benefits will continue as the system is further adopted. One important note is that the emergency response system can operate only when there is contact between the dispatcher and driver. As was shown in the previous section, there are sporadic pockets of the test region that resulted in a high frequency of out of coverage incidents. While the system has dramatically improved the safety and security of the trucks traveling in the test region, it could not be described as 100 percent reliable.

Real Time Information Applications

Given that the satellite system provides two-way communication between dispatchers and drivers, it is possible that operating efficiencies may be generated by deployment. In addition, since communications along certain routes in Alaska are so limited, these efficiencies may be quite substantial in this environment. As dispatchers have more access to real time information about vehicle location and status, vehicles may be rerouted to service new loads or to aid vehicles that have broken down. The satellite system provides a method for maintaining almost constant contact between the dispatcher and

driver. In this study, a routing simulation was used to analyze the benefit of increased communication with vehicles on the road. A simulation was developed to determine how often a vehicle should be rerouted and to quantify the benefits associated with the information made available by the satellite system.

A great deal of literature covers the use of information systems to aid with vehicle tracking and routing. Much has been written on the benefits of tracking systems and how they are used for transportation management. Grainger (2005) examines the Iowa Rural Transit Integration Consortium and its use of an expansive ITS initiative implementing GPS and vehicle tracking to improve customer service, safety and security. Similarly, El-Gelil et al. (2004) describe how the Toronto Transit Commission created a more efficient bus schedule with accurate predictions on bus arrival times with a transit monitoring system. The movement of freight has also benefited, as many trucking firms are finding success through the use of trailer tracking systems, reducing trailer fleet size, improving customer service, and reducing the number of yard checks required (Mele, 2003). Freight transported by rail is better managed through the use of tracking systems, even in Alaska (Schiestl, 2004). The Alaska Railroad Corporation implemented a collision avoidance system, improving safety, protecting track maintenance personnel, and enforcing speed limits. They have also focused on improving customer service through reduced transit times and reliable delivery under frequently adverse conditions. This is just a sample of the many instances where using tracking technology to provide real-time information has improved a transportation network. Clearly, this technology has resulted in many operational improvements in other applications, with the search continuing for further advances.

The availability of tracking technology has led to a significant amount of research into how resources such as the ESCT system may best be further utilized. Some of that research is

discussed here as it underlines the benefits that can be gained through the use of the satellite system and it provides motivation for the simulation that was performed for this study. Ichoua et al. (2005) exploit information about future events to improve decision making. They develop a strategy based on probabilistic knowledge about future request arrivals to better manage a fleet of vehicles, with promising results. Decision-making procedures for determining the optimal driver attendance time, optimal departure times, and optimal routing policies under time-varying traffic flows are developed by Kim et al. (2005). With a numerical study carried out on an urban road network in Southeast Michigan, they demonstrated significant advantages when using the real-time information in terms of total cost savings and vehicle usage reduction while satisfying or improving service levels for just-in-time delivery. Powell (1996) presents a hybrid model that handles the detailed assignment of drivers to loads, as well as handling forecasts of future loads. Numerical experiments demonstrate that his stochastic, dynamic model outperforms standard myopic models that are widely used in practice. Dynamic routing decisions for the application of ITS technologies are introduced by Wang et al. (2004) to improve freight mobility, reducing operational costs and enhancing service levels. Real-time traffic information was considered in their model, displaying the benefits of routing advisory systems that many logistics companies use in their day-to-day operations.

The pertinent literature on the use of tracking systems indicates that benefit can be gained through various methods. An effective use of tracking technology can result in improvements in vehicle routing, load planning and customer service. However, these improvements can only be generally described through the literature. In order to provide an analysis specific to the scenario under which freight is moved in Alaska, a simulation was developed with that scenario in mind. The simulation focuses on using the satellite system for more effective load planning, as this is where the most consistent improvements can be found.

With communication previously limited to certain populated regions, contact with a driver was difficult after the vehicle had left a pick up location. If a dispatcher had received information regarding a new load to be picked up or a vehicle was to be rerouted due to road conditions, there was only a small time window during which the dispatcher could provide a driver with alternative instructions. When deciding which vehicle should be used to deliver a new load, the dispatcher was only able to communicate with several vehicles in the fleet. Therefore, the vehicle that would be optimally suited to service the load may have been out of the range of those communication capabilities. Extending the range of communication should have an impact on assignment of loads to vehicles, vehicle routing, and operations in general.

The Simulation Model and Results

A model was developed to simulate a simple daily decision process describing how loads are assigned to vehicles, in particular delivery requests that occur over the course of a day that were not initially planned for. The model was used to evaluate how this process is affected by improved satellite communication and information availability. The simulation allows for a comparison of two scenarios:

1. Communication between the dispatcher and driver is limited such that loads may only be assigned to vehicles within the vicinity of the origin location.
2. Communication between the dispatcher and driver is via the satellite system such that loads may be assigned to vehicles that are no longer within the vicinity of the origin location.

Under the first scenario, when a new request to deliver a load arises, either a new vehicle or a vehicle that is still close to the terminal is assigned to service the load. The satellite system allows for communication with vehicles that are much farther from the terminal, so that the pool of vehicles available to deliver the load is larger under the second scenario.

For the purposes of the simulation, all vehicles will travel from Fairbanks to Prudhoe Bay along the Dalton Highway (the results for vehicles that travel from Prudhoe Bay to Fairbanks should be similar as the conditions for the problem remain the same). This highway was selected as a significant amount of freight is moved along the route and it connects two large terminals from which many loads originate. The distance between the two endpoints was set at 500 miles for the simulation.

At the beginning of the simulation, a fleet of vehicles is stationed in Fairbanks, with sufficient vehicles available to service all loads. The vehicles have a known capacity that is homogeneous across the entire fleet. Each vehicle incurs a fixed cost when it is used to service a load. Based on a survey of carriers, this fixed cost was set at \$150. A variable cost is also incurred for every mile the vehicle travels, with a value of \$2 per mile. It is assumed that the vehicle can travel 50 miles per hour on average. An initial set of loads to be serviced is known beforehand. Additional loads requiring service arise over time at random intervals. Loads may be combined on a vehicle as long as capacity constraints are not violated.

A new request may be serviced immediately by any vehicle in the fleet that has sufficient available capacity. A vehicle that is waiting at an endpoint may be used or a vehicle that is already traveling with a load may return to the endpoint to pick up the additional load. A time limit, T_{max} , indicates how long a truck may wait in the Fairbanks area to pick up another load. A partially loaded truck may wait at the terminal location for another load as long as this time constraint is not violated. This allows for multiple loads to be delivered by one vehicle. Another limit, T_{truck} , designates the maximum amount of time that a load may be on a vehicle after leaving Fairbanks. This limit serves two purposes: decreasing the value shortens the distance within which the terminal may communicate with vehicles on the Dalton Highway; and it prevents the same vehicle from continuously being called back to Fairbanks to

service multiple loads. By adjusting this value, a scenario with limited communication could be compared to one in which the satellite system is operational.

This simulation was run over the course of a day until all loads were serviced. There were 17 loads to be serviced in a day for each simulation. The time intervals between service requests were randomly generated, ranging from 10 to 60 minutes. The load sizes were also randomly generated within a specified range. Three sets of intervals and four sets of loads, or twelve different problem instances, were used for each T_{max} and T_{truck} combination. The cost to service a set of loads was determined by adding the fixed cost of each vehicle used and the variable cost of the total distance traveled by all vehicles. The cost under limited communication was compared to that using the satellite system. Table 6 presents the results for several different combinations of T_{max} and T_{truck} . The percentage of cost savings indicates the amount that cost was reduced when the satellite system was used, while the vehicle reduction percentage indicates if fewer vehicles were used under the satellite system. The size of each load for this simulation ranged from 1 percent to 50 percent of vehicle capacity.

The values of T_{max} and T_{truck} were chosen based on carrier interviews. It was assumed that without the satellite system, reliable contact

with the vehicles was available for half an hour after they had left the terminal. While this is low under many operating conditions, for the purposes of this simulation the value of T_{truck} under limited communication relative to that with satellite communication is most important. The values of T_{truck} listed are those used for simulations of communication with the satellite system. Therefore, the length of time that a vehicle is within reach of the dispatcher is two, three and four times greater than that with limited communication for the T_{truck} values of 60, 90 and 120, respectively.

There is some benefit to the satellite system with almost every combination of T_{max} and T_{truck} . As the value of T_{truck} increases, the benefit increases. This is because there is more time to contact a vehicle that has already departed the Fairbanks area to have it return to service another load. By increasing this radius of communication, the pool of available vehicles to utilize increases as well. A dispatcher will have many more options from a load planning perspective and costs should undoubtedly decrease.

In order to analyze the effect that load size may have on the benefit of using real time information, several simulations were run with varying size ranges. As indicated earlier, four different sets of loads were generated for each range and combined with three time interval sets. Table 7 presents the results from those

TABLE 6
PERCENTAGE COST SAVINGS AND REDUCTION IN NUMBER
OF VEHICLES USED FOR DIFFERENT PARAMETER SETTINGS

T_{max}	120			90			60		
	120	90	60	120	90	60	120	90	60
cost savings percent	4.27	3.78	1.46	4.57	1.42	0	3.59	2.59	0.99
vehicle reduction %	8.33	4.72	1.67	6.94	2.78	0	4.32	3.27	1.19

TABLE 7
PERCENTAGE COST SAVINGS AND REDUCTION IN NUMBER
OF VEHICLES USED FOR SEVERAL RANGES OF LOAD SIZE

Load size range	1-100	1-50	1-10	11-20	21-30	31-40
cost savings %	4.78	4.57	4.50	4.50	4.40	0
vehicle reduction %	6.02	6.94	5.56	5.56	5.56	0

simulations. The load size ranges are listed as a percentage of vehicle capacity. The T_{max} and T_{truck} values used for these simulations were 90 and 120, respectively. The benefit decreased marginally as the load sizes increased until there was no benefit with loads in the range 31-40 percent (there was also no benefit with loads in the range 41-50%). With larger loads, there are fewer combinations of loads that can be placed together onto one truck. For the results in the range 1-100 percent and 1-50 percent more vehicles were used and the overall cost was greater, such that there was more potential for improvement.

Every scenario simulated resulted in a cost savings of less than 5 percent. While this may not appear to be significant, in an industry where many carriers operate with margins below 5 percent, any cost savings is important. Also, the model used for this simulation was, while meaningful, a simplified version of actual operating procedure. When a vehicle returned to pick up a load, it had to return to the same location (the terminal) each time. This will probably not be the case in most situations, such that the distance the vehicle must travel to return to pick up a load will not be as great.

The reduction in the number of vehicles used may also have an important impact. While the model accounted for a financial fixed cost for each vehicle, there are additional less tangible costs that are related to the number of trucks on the road. By decreasing the number of vehicles utilized, other benefits may be realized. These may include an increased level of safety and security, as fewer vehicles are exposed to the

remote conditions, and less wear and tear on vehicle fleets. Also, the carriers mentioned two additional benefits that this simulation does not take into account, savings that are a result of rerouting vehicles to aid other vehicles and to avoid traffic and weather problems. The carriers described a situation in which a vehicle had mechanical difficulties in a remote area, with another vehicle in the vicinity. In the past, communication with the other vehicle was not possible and a third vehicle was dispatched from the terminal area to aid the disabled truck. The satellite system could be used to instruct the driver of the second vehicle to aid the disabled truck, saving time and the cost associated with using a third vehicle. Because these events do not occur as frequently, it is difficult to simulate these scenarios to quantify the potential benefit of improved communication. However, as indicated by the carriers, such events do occur and the satellite system would be a very useful tool in responding more rapidly and efficiently.

CONCLUSIONS

After evaluating the risks and benefits associated with the ESCT, it was determined that the benefits outweigh the potential risks. For the purposes of this study, two risks were analyzed when evaluating the ESCT, technical risks and acceptance risks. Based on testing during site visits, both latency and data quality do not appear to be significant technical risks. The number of tests was limited, particularly when evaluating the tethered trailer tracking system, so it is difficult to make a conclusive statement on latency. However, the tests that were performed do indicate that messages are

passed through the system with an acceptable amount of latency. The acceptance risks were primarily associated with the concern that employees have in regards to the system's potential use for monitoring performance. Both employees and customers found the ESCT easy to use, as training requires a minimal amount of time. Employees found the system to be useful and to have the potential to enhance job performance, while customers also found the system to be very helpful. The only problem may arise as the system is used to monitor employee performance more rigorously. Drivers are often suspicious of any technology that allows an employer to look over their shoulder while they work, and this may lead to resistance on the part of the employees.

This study focused on three potential benefits that may be gained through the use of the ESCT system, improvements in coverage, safety and security, and the use of real time information. It was found that while coverage is spotty in limited areas, the overwhelming majority of routes see a significant improvement in the level of communication available. The coverage must be further extended in order to provide a service that is reliable without fail. However, the ESCT is a major upgrade to previously available communication alternatives. The carriers have already realized many safety and security benefits brought about by the satellite system. They have been able to respond to emergency incidents more rapidly, while retaining more drivers by creating a safer environment. In addition to improving response time, the satellite system may be viewed as a deterrent for hijacking or other breaches of security. The potential rapidity of response in an emergency situation should serve as a security feature in and of itself. The carriers also indicated that the system will allow for a more secure method of transmitting sensitive information. However,

this safety and security can only be extended so far as communication is available. With spotty coverage in some areas, the system can not be considered 100 percent reliable. An additional benefit that was analyzed was the availability of real time information provided by the ESCT. With real time information, the carriers may utilize their fleets with an efficiency that was previously impossible. A simulation was used to determine that there may be a reduction in operating cost through a simple change in vehicle routing policy. Real time information may also be used to reroute vehicles to aid other vehicles and to avoid traffic and weather problems.

The benefits associated with the ESCT system are widespread, with several yet to be realized. The most significant negative is the lack of coverage in some of the most remote areas in Alaska. Some of these problems may be remedied by adjusting the placement of the antenna on a vehicle, such as when an oversized load that is being hauled blocks the view to the satellite. Many of the out of coverage areas are so remote that any system will have difficulty maintaining a line of communication, short of locating a satellite even farther north or dotting the landscape with cellular towers. These are problems that must be addressed in order to achieve a goal of completely reliable communication along every route. However, the system does significantly expand communication for a majority of the region, while providing additional improvements to carrier operations.

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A DECISION SUPPORT APPROACH TO DESIGNING THE INLAND LOGISTICS NETWORK IN CHINA

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ABSTRACT

With the unprecedented growth of international trade, a growing number of multinational firms have coped with logistical challenges of shipping products to and from unfamiliar territories in many countries. These logistical challenges include the cross-border transportation of products originated from inland port to another inland port isolated from major waterways. In particular, the lack of access to major waterways would not only constrain the intermodal transportation option, but also make door-to-door, containerized delivery services nearly impossible. Such a limited option would eventually lead to increased transportation costs and transit time, and thereby offset low-cost global sourcing advantages. To aid multinational firms in addressing the problem of determining the optimal supply chain link between inland origin and destinations ports, this article proposes a shortest-path model based decision support system. The usefulness of the proposed model-based decision support system was validated by its application to a real problem encountered by a multinational firm that would like to strengthen its foothold in the Chinese market.

INTRODUCTION

As trade barriers have begun to crumble, a growing number of firms are expanding their supply and customer bases into vast regions of the world. However, an opportunity to capitalize on cheaper sources of supply and greater market share in foreign markets can evaporate unless firms can control hidden costs associated with

global supply chain operations. These hidden costs may stem from high tariffs, excessive documentation, compliance with foreign rules and regulations, security concerns, mounting insurance costs, in-transit inventory carrying costs, incompatible communication, fuel surcharges, and logistical inefficiency. In particular, the "last mile" transportation from the port of entry to the final destination can dictate the

success of global supply chain operations. Despite the increasing use of containerized traffic that is secure and inexpensive, global supply chain planning based on port-to-port transit has become increasingly difficult due to worsening longshore labor troubles, port congestion, and demurrage fees. To cope with this logistical challenge, many multinational firms (MNF's) explore ways to enhance efficiency and visibility from port of entry to inland destinations (or from inland origins to port of exit). For example, the MNF may consider using rail shuttles as a means to transship imported container loads of goods to inland shippers in lieu of harbor trucks.

In recent years, the inland logistics network design garnered significant attention from government policy makers, because it will impact the viability of local firms clustered around inland cities and the subsequent regional economy. The inland logistics network design is primarily concerned with the development of minimum-cost and/or time intermodal, door-to-door logistics links between origin and destination ports that are isolated from major waterways and river/ocean ports. Key logistics issues to be addressed by the inland logistics design include:

1. Which port of entry (or exit) should be selected as an inland transfer point (transshipment location)?
2. Which intermodal combination (e.g., piggyback, all truck, all rail, and barge-truck, barge-rail) should be used for last-mile transportation from the port of entry (or exit) to the final inland destination (or origin)?
3. Which routes should be selected to minimize total logistics cost and/or time?

The inland logistics network design problem can typically arise in a practical situation where either importers or exporters are located in landlocked countries such as Mongolia and Uzbekistan. Another common inland logistics

scenario is the transshipment of imported or exported goods via inland transfer points to reach sources of supply or customer bases located in inland cities that are isolated or inaccessible from major waterways. In this study, for illustrative purposes, the authors look into an inland logistics scenario that arises in seven provincial regions along the Yangtze River Delta in China (see Figure 1). As shown in Table 1, China has emerged as the major trading partner with the United States. Indeed, almost half of goods manufactured in China were imported to the U.S. (USA Trade Online, 2003). After China's recent entry into the World Trade Organization (WTO), China's role as the major source of inexpensive products is expected to increase for years to come. For instance, China is known to be the biggest producer of many industrial commodities such as steel, coal, and grain (Feng et al., 2007). However, transportation of these commodities within inland locations in China can pose a number of logistical challenges for the importers, because these commodities are bulky and access to inexpensive means of transportation, such as barge and rail, is limited.

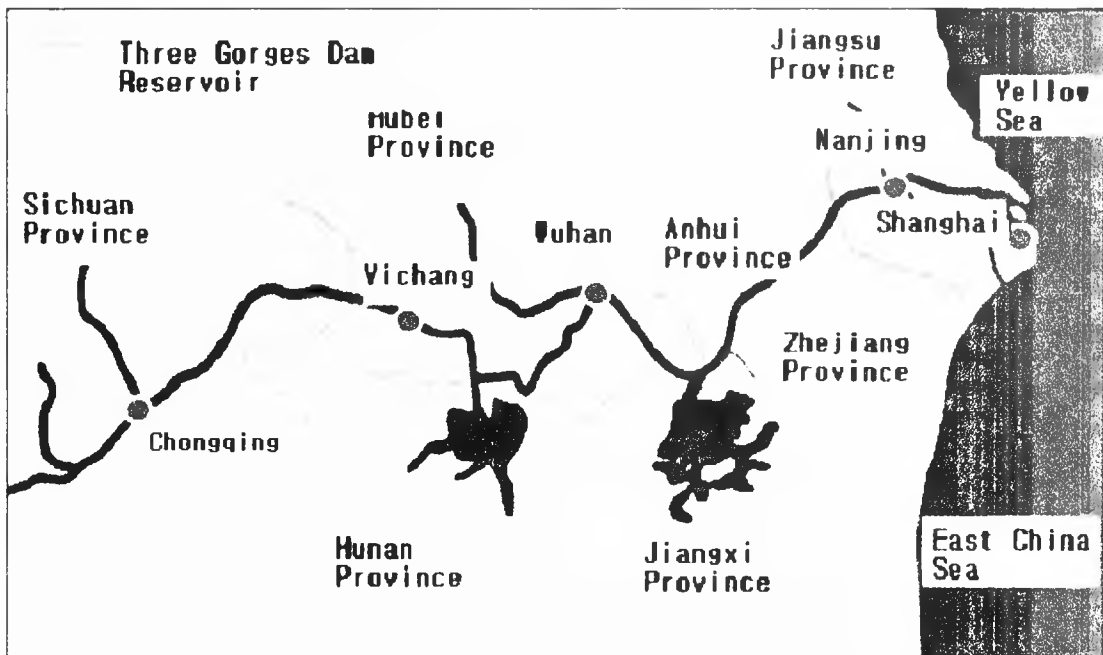
For example, railroads in China meet less than 45 percent of demand due to shortages in box-cars, locomotives, and dual tracks, while barge shipments are subject to extra surcharges for traveling through the Yangtze River (Min and Chen, 2003). Although trucks have been heavily used for short distances (e.g., less than 300 kilometers and/or 8 hours of driving distance), transportation cost via truck is ten times higher than rail freight cost (Min and Chen, 2003). As a matter of fact, logistics activities consume nearly 90 percent of the total order cycle time and 40 percent of the total sourcing cost in China (Hong Kong Trade Development Council, 2002). According to Gould (2001), logistics costs account for a staggering 24 to 34 percent of the total landed costs of appliances, tools, toys, and other basic goods sourced from China as opposed to 10 percent of the landed costs for the same type of products sourced from the U.S. and Europe. As of 2002, the total logistics expenditure in China accounted for 21.5 percent of the Chinese Gross

TABLE 1
CHINA'S MAJOR TRADING PARTNERS (IN US\$ MILLION)

Exports			Imports		
Rank	Total	\$583,100.0	Rank	Total	\$552,400.0
1	US	\$132,946.8	1	Japan	\$88,936.4
2	Hong Kong	\$94,462.2	2	Taiwan	\$60,211.6
3	Japan	\$72,304.4	3	South Korea	\$57,449.6
4	South Korea	\$25,656.4	4	US	\$42,534.8
5	Germany	\$23,324.0	5	Hong Kong	\$40,877.6

Source: *World Fact Book*, 2004

FIGURE 1
PROVINCES ALONG THE YANGTZE RIVER



Domestic Product (GDP), whereas the total logistics expenditure in the U.S. comprised a mere 9.3 percent of the U.S. GDP (Rodrigues et al., 2005; Wang, 2006).

Considering the increasing logistical challenges faced by MNF's sourcing and/or selling in China, this article proposes a decision-aid tool within a model-based decision support system framework that can optimally create the inland logistics network linking the port of entry (or exit), an inland transfer point, and an inland destination (or origin).

PROBLEM SCENARIO

For purposes of this study, inland logistics refers to a series of transportation and distribution activities assuring door-or-door services involving inland destinations or origins remotely located from major waterways. These activities may encompass intermodal combinations, the port of entry/exit selection, inland transfer point selection, consolidation, product mixing, transshipment at an inland transfer point (or a transportation hub), and last-mile delivery/pickup arrangements. The inherent complexity of inland logistics calls for a systematic decision-aid tool that can help MNF's leverage low-cost sourcing options or broader customer bases, without incurring unnecessary costs. Nevertheless, no prior literature to date has developed a systematic decision-aid tool such as a mathematical model, a simulation model, and an expert system that can deal with inland logistics issues. To fill the void left by prior studies, the authors conducted an inland logistics case study inspired by the United Nations Economic Social Commission for Asia and the Pacific (UN ESCAP) and developed a model-based decision support system (DSS) that can solve the inland logistics network design problem.

To elaborate, the case study focuses on actual logistical problems encountered by seven inland cities along the Yangtze River Delta in China. These cities are: (1) Chengdu, Sichuan; (2) Chongqing, Chongqing; (3) Changsha, Hunan; (4) Xiangfan, Hubei; (5) Nanchang, Jiangxi; (6)

Hefei, Anhui; (7) Quzhou, Zhejiang. Since these cities represent regional provinces of high economic importance to China, future prosperity for China may depend heavily on the economic viability of these cities. As a matter of fact, the regions where the seven cities are located accounted for 39 percent of the total Chinese GDP, 32.8 percent of the total Chinese international trade volume, and 42.1 percent of foreign direct investment (FDI) in 2003 (The National Bureau of Statistics of China, 2004). As such, the Yangtze River Delta area was designated by the Chinese government as the region for high technology and heavy manufacturing and has emerged as the gateway to Central and Northern China's inland areas (Yam and Tang, 1996). However, over the last few years, there have been increasing concerns over logistics inefficiency caused by the lack of transportation infrastructure, chronic traffic congestion, mounting freight cost, bureaucratic government rules and regulations, and limited carrier and forwarder options within these regions. For example, when an international carrier goes beyond the navigating range, the ship-navigating fee is surcharged 30 percent for 10 miles or less, and 50 percent for over 10 miles. In addition, the international carrier is subject to trans-anchoring, mooring/unmooring, harbor and groundage fees, and terminal handling charges (Min and Chen, 2003).

Given the limited number and capacity of domestic barge carriers operated within the Yangtze River Delta, it would be very difficult for international shippers to take advantage of the cheaper mode of barge transportation. There are only three domestic barge carriers that can haul freight exceeding 100,000 TEU's (Twenty-foot equivalents). To make matters more complicated, ships or barges weighing more than 10,000 tons may not be able to navigate through the Yangtze River for most of the seasons due to the lower water level. Although the completion of the ongoing Three Gorge project would allow large freight liners to sail as far as Chongqing, the fluctuating water level of the Yangtze River poses another logistical challenge for bulk shipment. Alternative means of inexpensive

transportation such as rail often requires long waits for space booking and long delivery times (Min and Chen, 2003).

Considering the complexity in selecting the right mode of transportation for inland logistics, this study explores three modal selection options: (1) all rail; (2) all road (truck); (3) intermodal mix of barge and rail or barge and truck. In this study, the authors did not consider the option of using air due to the limited airport infrastructure for inland cities and prohibitively high freight cost. However, the possibility of utilizing direct shipment from port of entry to inland destinations, while considering the inland transfer point such as an inland river-port or an inland rail/truck terminal was explored. To solve this inland logistics problem, a multiple objective shortest path model was developed and then incorporated into a decision support system (DSS) framework. The details of the proposed model and DSS are provided in the following section.

ARCHITECTURE OF THE MODEL-BASED DECISION SUPPORT SYSTEM

Figure 2 depicts the schematic architecture for the model-based decision support system (DSS) developed to enable viable inland logistics strategies. Within the DSS framework suggested by Sprague and Carlson (1982), the DSS is comprised of three components: (1) **database**, consisting of accurate, timely data necessary for model development; (2) **model base**, a computerized optimization model to determine the shortest route from the port of entry to inland destinations with or without inland transshipment; (3) **dialogue base**, a series of "if-then" or "what-if" rules for changes in mode of transportation, shipping routes, and transportation policy. The DSS can be used by international shippers/carriers associated with MNF's for inland logistics operations at minimum cost while minimizing the delivery time. The DSS will help MNF's make strategic decisions as to which inland transfer point to use as a transshipment facility, which shipping routes to take, and which combinations of transportation mode to assemble. The DSS is tested and validated

with real data furnished by both UN ESCAP and the Korea Maritime Institute (KMI). Unlike a stand-alone mathematical model whose efficiency relies on the accuracy of available data, this DSS allows for interfaces between databases and models and subsequently handles what-if scenarios in the case that model parameter values change over time.

Database Management Subsystem

A model is only as good as the quality of the data that support it (Napolitano, 1998). To enhance data quality and avoid data redundancy, a database that contains two data sources, governmental and non-governmental, was developed. The database management subsystem (DBMS) is designed to supplement standard operating systems by allowing greater integration of data, complex file structure, quick retrieval and changes, and better data security (Turban and Aronson, 2001). Governmental sources include regulatory guidelines and reports issued by federal (e.g., Harbor Superintendent Department of China; China's Customs General Administration, the Chinese Ministry of Foreign Trade and Economic Cooperation; the Chinese Ministry of Communication; the Chinese State Development Planning Commission; the National Bureau of Statistics of China) and public transportation authorities. Non-governmental sources include public data files (e.g., published literature, websites and CD-ROMs) available from the World Bank, the World Trade Organization (WTO), the Chinese Transport Intelligence Limited, the Chinese Shipping Exchange, the Chinese Warehousing Association, and the Hong Kong Trade Development Council. In addition to raw data that were obtained by the above sources, more specific data categories that are relevant to inland logistics planning were created.

Cost data. Cost is one of the primary concerns of inland logistics planning. These costs include: navigating fees, trans-anchoring fee, mooring/unmooring fee, harbor fee, groundage fee, demurrage fee, terminal handling charge, freight rate, freight surcharge, port charge, loading/

FIGURE 2
AN ARCHITECTURE FOR THE MODEL-BASED DECISION SUPPORT SYSTEM

Data Base

1. Cost data

- a. Navigation fee
- b. Trans-anchoring fee
- c. Mooring/unmooring fee
- d. Demurrage fee
- e. Unit freight rate
- f. Freight surcharge
- g. Loading/unloading cost
- h. Port charge
- i. Insurance cost
- j. Taxes

2. Traffic data

- a. Proximity to inland river-ports
- b. Port infrastructure and amenities
- c. Access to major highways/railways
- d. Transit time between nodes
- e. Government traffic rules and regulations

Forecasting

- Anticipated shipment size
- Cost change
- Infrastructure development



Data request

Bi-objective Shortest Path Model

- LINDO/LINGO
- Dijkstra's labeling procedures

User interface

"What-if" Analysis

- Changes in priority of multiple criteria (cost versus time)
- Alternative means of transportation
- Formulation of inland logistics strategies

unloading, transshipment cost, insurance cost, in-transit inventory carrying cost, taxes, and customs duties.

Traffic data. Important concerns of inland logistics operations include proximity to inland river-ports, break-bulk terminals, paved roads

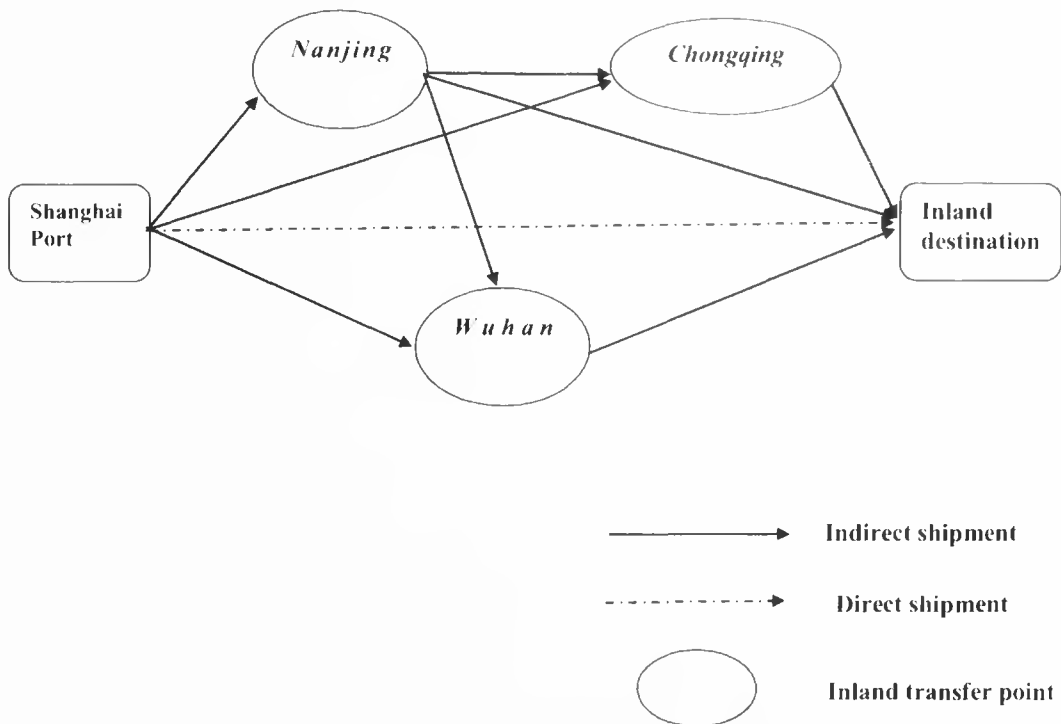
and major road arteries, access to forwarders and common carriers, seasonal water level at the Yangtze River, barge/rail/truck schedules, barge/rail/truck transit time, loading/unloading time, shipment transfer time, choke points, and compliance with the Chinese government traffic regulations and rules.

Model Management Subsystem

As a core of the model base within the DSS framework, a shortest-path model was developed that considers multiple objective aspects of inland logistics planning. The shortest-path model is supported by a forecasting model that predicts any changes in the size of shipment between the port of entry and inland destinations. The shortest-path model will determine which route should be selected to minimize the total transportation cost, while speeding up the delivery process (see, e.g., Phillips and Garcia-Diaz 1981; Bertsekas, 1991 for detailed

features of the classical shortest path model). This decision includes the consideration of either direct or indirect shipment via an inland transfer point and optimal combination of the intermodal mix (see Figure 3). Since the use of a cheaper mode of transportation requires longer transit time, the goal of minimizing transportation cost is inherently conflicting with the goal of minimizing transit time. The presence of these conflicting goals requires the bi-objective model that makes an optimal trade-off between cost and time. The detailed mathematical formulation is presented on the following page.

FIGURE 3
VARIOUS ROUTING OPTIONS FOR INLAND DESTINATIONS WITHIN THE YANGTZE RIVER DELTA



Indices

I = set of origin node (e.g., port of entry);
{1, ..., NI }

J = set of destination nodes (e.g., inland cities); {1, ..., NJ }

Model Parameters

C_{ij} = cost per unit flow of shipment from origin node i to destination node j ; $i \in I, j \in J$

T_{ij} = transit time between origin node i to destination node j ; $i \in I, j \in J$

α = weight coefficient assigned to each objective ($0 \leq \alpha \leq 1$)

Decision Variable

X_{ij} = unit of traffic flow from node i to node j ;
($i \in I, j \in J$)

Mathematical Formulation

$$\text{Minimize } \sum_{i \in I} \sum_{j \in J} [\alpha C_{ij} + (1 - \alpha) T_{ij}] X_{ij} \quad (1)$$

Subject to:

$$\sum_{j \in J} X_{oj} = 1, o = \text{starting node}, \forall j \in J \quad (2)$$

$$\sum_{i \in I} X_{ij} - \sum_{j \in J} X_{ji} = 0, i \neq o, j \neq d \quad (3)$$

$$-\sum_{j \in J} X_{jd} = -1, d = \text{destination node}, \forall j \in J \quad (4)$$

$$X_{ij} \geq 0 \quad \forall i \in I, \forall j \in J \quad (5)$$

The objective function (1) minimizes total logistics costs, composed of shipping, loading/unloading, and transshipment costs, while minimizing transit time. Constraint (2)

guarantees that unit of traffic flow leaves the origin node (source). Constraint (3) represents a flow conservation constraint that ensures the conservation of unit of traffic flow as it moves through the inland logistics network. Constraint (4) specifies that unit of traffic flow arrives at the destination node. The shortest path can be identified as the connected sequence of arc (i, j) such that $X_{ij} = 1$. Constraint (5) assures the non-negativity of decision variable X_{ij} .

Dialogue Management Subsystem Direct Shipment

At best, the model is an abstraction of real-world situations. Consequently, it cannot capture reality without running it more than once (Dyer and Mulvey, 1983; Min, 1989). Thus, the model should enable MNF's or public transportation planners to evaluate "what-if" scenarios associated with changes in the logistics strategy (e.g., a shift from cost savings to prompt delivery services or vice versa), accessibility to logistics infrastructure (e.g., inland transportation hubs, terminals, rail sidings) and government regulations and rules. In other words, the model's successful implementation depends on its flexibility for contingency planning. To enhance the model flexibility, the results of the model runs should be reported in user-friendly formats. These formats include standardized reports such as spreadsheets and tables summarizing cost saving opportunities and figures depicting routing options.

MODEL-BASED DSS APPLICATION AND RESULTS

The developed DSS was applied to an actual inland logistics problem encountered by a MNF headquartered in Korea. To protect the confidentiality of the MNF, it is referred to as "Blue Star." The company sells its finished products to Chinese retailers and distributors located in inland cities throughout the Yangtze River Delta area. These products are often shipped to the major port of entry, Shanghai, which is equipped with gantry cranes that can handle containerized

shipments originating from foreign ports. To reach inland destinations, Blue Star explored several different transportation options that are available to the shipper. The selection of the particular mode of transportation also affects the shipping routes. For example, barge transportation cannot provide door-to-door service and thus necessitates transshipment through inland river-ports such as Nanjing, Wuhan, and Chongqing (see Figure 4). Since these inland ports are not on the direct path to final destinations, the use of barge creates a lengthy detour and takes more time to deliver the products. However, barge is still one of the cheapest modes of transportation and provides significant cost saving opportunities.

To solve both modal selection and shipping route problems described above, the authors developed the shortest path model under three different scenarios: (1) cost minimization; (2) transit time minimization; (3) best compromise between cost and transit time minimization. The results of the model experiment under these three scenarios are summarized in Table 2. As Table 2 indicates, the intermodal option (i.e., barge-rail) turned out to be the least expensive mode of transportation for each path, but the slowest mode of transportation. On the other hand, the all truck option turned out to be the most expensive mode of transportation, but with the fastest transit time (Figures 5 and 6). In fact, all truck is three

FIGURE 4
THE GRAPHICAL DISPLAY OF INLAND TRANSFER POINTS

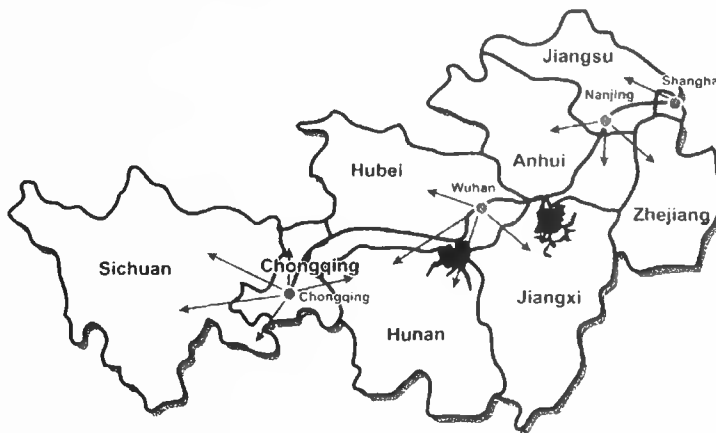


TABLE 2
THE COMPARISONS OF THE THREE ALTERNATIVE MEANS OF TRANSPORTATION

From Shanghai to	Province	Intermodal (Barge-Rail)		All Rail		All Road	
		Cost (\$)	Time (hr)	Cost (\$)	Time (hr)	Cost (\$)	Time (hr)
Chengdu	Sichuan	555	275	700	220	4,440	144
Chongqing	Chongqing	453	310	690	200	4,320	144
Changsha	Hunan	530	282	850	240	4,070	120
Xiangfan	Hubei	580	292	610	185	2,350	120
Nanchang	Jiangxi	550	216	580	170	1,010	72
Hefei	Anhui	265	131	300	85	640	24
Quzhou	Zhejiang	110	30	110	30	470	24

FIGURE 5
THE COST COMPARISONS OF THE THREE ALTERNATIVES

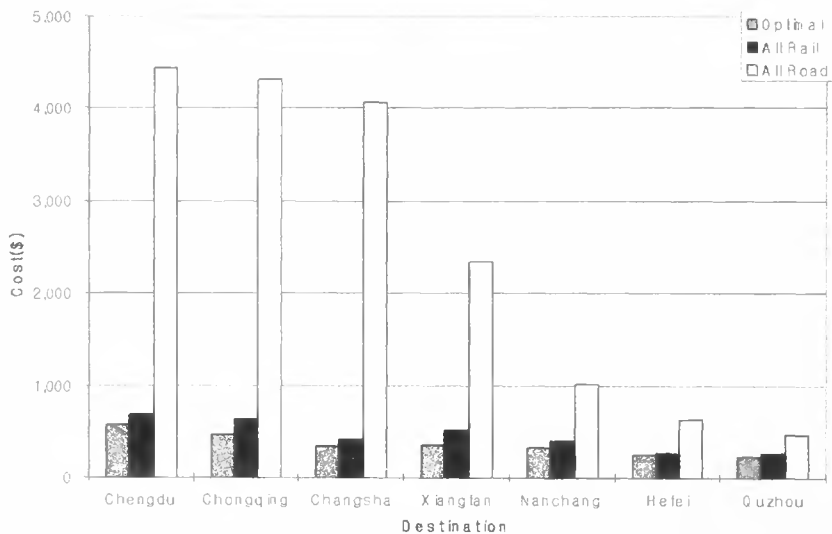
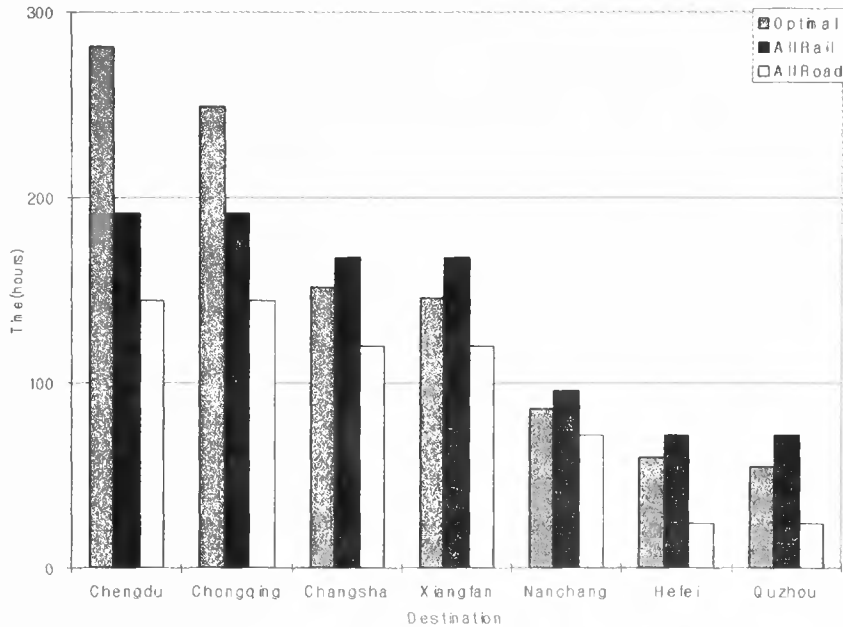


FIGURE 6
THE TIME COMPARISONS OF THE THREE ALTERNATIVES



times as expensive as all rail on average, but nearly twice as fast as all rail. To summarize, by using the weight of 0.8 and higher to the cost criteria, the combination of barge-rail intermodal mix created the optimal routes for all inland destinations with an exception of Quzhou (see Table 3).

Also, it is worth noting that the transfer of shipments from barge to rail can take place at several inland river-ports such as Nanjing, Wuhan, and Chongqing. To elaborate, Nanjing is situated at the lower reaches of the Yangtze River and is currently open to navigation for 35,000 ton vessels all year long. It is capable of making river/sea transshipment and water/land transshipment with an annual cargo throughput of over 60 million tons. As the largest river-port along the Yangtze River

with an annual throughput capacity exceeding 400,000 TEU's, it has easy rail access with an 18 km port railway. Wuhan Port is located in the middle reaches of the Yangtze River and is designated as a Class 1 inland river-port. This port can handle vessels up to 3,000~5,000 tons. Frequent feeder service is available between Wuhan and other ports along the Yangtze River. The port can handle up to 900,000 tons in general cargo and 25,000 TEU's of container traffic a year. Chongqing Port is in the upper stream of the Yangtze River. This port is linked through the various railways of Chengdu-Yu, Xiang-Yu, Yu-Qian, and Yu-Huai, and the freeways of Cheung-Yu, Yu-Qian, Chongqing to Wuhan, and Chongqing to Changsha. Thus, Chongqing is suited for inland transfer. Its cargo throughput capacity reaches 9 million tons a year.

TABLE 3
THE SUMMARY OF THE OPTIMAL SHIPPING ROUTES

Destination	Criteria	Optimal Routes
Chengdu (Sichuan)	Cost	Shanghai-(water)-Chongqing port-(rail)-Cheongdu
	Time	Shanghai-(road)-Cheongdu
	Multiple	Shanghai-(water)-Chongqing port-(rail)-Cheongdu
Chongqing (Chongqing)	Cost	Shanghai-(water)-Chongqing port-(rail)-Chongqing
	Time	Shanghai-(road)-Chongqing
	Multiple	Shanghai-(water)-Chongqing port-(rail)-Chongqing
Changsha (Hunan)	Cost	Shanghai-(water)-Wuhan port-(rail)-Changsha
	Time	Shanghai-(road)-Changsha
	Multiple	Shanghai-(water)-Wuhan port-(rail)-Changsha
Xiangfan (Hubei)	Cost	Shanghai-(water)-Wuhan port-(rail)-Xiangfan
	Time	Shanghai-(road)-Xiangfan
	Multiple	Shanghai-(water)-Wuhan port-(rail)-Xiangfan
Nanchang (Jiangxi)	Cost	Shanghai-(water)-Nanjing-(rail)-Nanchang
	Time	Shanghai-(road)-Nanchang
	Multiple	Shanghai-(water)-Nanjing-(rail)-Nanchang
Hefei (Anhui)	Cost	Shanghai-(water)-Nanjing-(rail)-Hefei
	Time	Shanghai-(road)-Hefei
	Multiple	Shanghai-(water)-Nanjing-(rail)-Hefei
Quzhou (Zhejiang)	Cost	Shanghai-(rail)-Quzhou
	Time	Shanghai-(road)-Quzhou
	Multiple	Shanghai-(rail)-Quzhou

Note: Multiple refers to the use of multiple criteria with assigned weight of 0.8 or higher for cost and assigned weight of 0.2 or lower for transit time.

CONCLUDING REMARKS AND FUTURE RESEARCH DIRECTIONS

In the era of globalization, some supply chains include customers or suppliers that are located in inland regions isolated from major transportation arteries such as waterways. Despite increasing needs to reach inland customers or suppliers, a vast majority of the existing literature has overlooked the unique logistical challenges associated with last-mile transportation to and from inland regions. Since the failure to cope with these logistical challenges can lead to declining international trade and lagging economic development involving the inland

areas, this article reported on a mode-based DSS that can aid MNF's in making the decision as to which mode of transportation should be used and which routes should be taken to reach inland destinations at minimum cost and time. The DSS experimentation revealed that it presented promise in solving practical inland logistics problems that arose in the Yangtze River Delta area in China. The model can also provide valuable insights into various what-if scenarios, including the options of both direct shipment from the port of entry to inland destinations and indirect shipment via inland transfer points. Despite these merits, the proposed DSS points to a number of directions for future work:

- (1) The DSS can be expanded to include the element of risk and uncertainty involved in the inland logistics network design problem.
- (2) The theme of future research should include dynamic design of the inland logistics network which reflects the time-sensitivity of cost parameters over a multiple planning horizon.
- (3) In addition to the consideration of cost and time, future research can add another criterion such as delivery reliability to the multiple criteria decision.
- (4) A series of model experimentations with varying weights of the multiple criteria may yield insight into the sensitivity of model results to changes in the relative importance of multiple criteria.
- (5) Future research can explore how the backhaul option can influence the route structures and intermodal transportation choices.

ACKNOWLEDGMENT

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BOOK REVIEW:

TRUCKING IN THE AGE OF INFORMATION

Dale Belman and Chelsea White, III, Editors
Ashgate Publishing Company, Burlington, VT, 2005

Reviewed by
Terence A. Brown
Pennsylvania State University at Harrisburg

This excellent book is intended to provide an introduction to the modern U.S. trucking industry as well as a source of in-depth information on some specific topics for more knowledgeable people (see p. xv). The work includes eleven chapters, each written by one or more different authors that are current faculty members in U.S. universities. It is particularly interesting because it covers a wide array of topics involving trucking, written by a variety of researchers.

The book is divided into two sections: Chapters one through five provide an overview of the industry and chapters six through eleven focus on specific topics. Chapter one provides a history of the motor carrier industry broken into three eras: the infant industry prior to 1935, the regulated era of 1935 to 1980, and the deregulated era from 1980 to the present. After reviewing these eras, the author concludes that deregulation has benefited shippers and their customers but trucking labor and many trucking companies have suffered. Of particular interest is data which shows the enormous growth of trucking in terms of total transport revenues—from 23% in 1948 to 81% in 1998.

Chapter 2 provides a profile of truckload carriers, the largest sector of trucking. These firms had significant productivity gains since 1980, but their financial rewards have not kept pace. The carriers now face a number of challenges including a shift to package transport

direct to consumers and leaner inventories—both of which reduce the use of truckload shipments.

Chapter 3 describes less-than-truckload (LTL) carriers and notes that today there are fewer but larger firms in this sector in comparison to 1980. In addition, total sector revenues have not grown greatly from 1980 through 2000. The chapter also includes a description of LTL operations, networks and technology.

Chapter 4 is devoted to package express, a rapidly growing part of trucking. The development of United Parcel Service, Federal Express and DHL is described and the authors note how well these firms have integrated trucking and air transport. Package express has grown along with trends toward global operations, lean inventories, rapid customer response and e-commerce.

Chapter 5 is an overview of logistics service providers also called the third party logistics (3PL) industry. Survey results from 3PL customers identify success factors, concerns, services offered and common types of services outsourced. Chapter 6 describes state trucking deregulation and shows that it was followed by a small decline in real truck rates.

Technology in trucking is the focus of Chapter 7, which describes six technologies: mobile communications, decision support systems, automatic vehicle identification, electronic data

interchange (EDI), bar coding, and imaging systems. Survey results indicate mobile communications is most commonly used (probably due to low cost), followed by EDI, which is often installed in response to customer demands.

A particularly important topic—truck drivers—is addressed in Chapter 8. Results of two surveys are reviewed and four conclusions are suggested:

1. Deregulation hurt driver earnings.
2. There is no evidence of driver shortage, but high turnover makes it seem so.
3. Drivers are not underpaid—they earn somewhat more than others with comparable skills.
4. Owner-operators are an important group of drivers and tend to be older, more experienced, and have more financial assets than the typical driver.

Chapter 9 analyzes five case studies and concludes that the Toyota-Transfreight example is the only true lean learning system studied. Toyota views the people in its production system as the backbone of the organization while other firms focus on technology and see humans as necessary evils.

Chapter 10 concerns truck safety and describes new information technologies that may offer help

in improving truck safety in the future. The authors note that "...there are abundant sources of trucking related information but they are not linked to form a composite overview of trucking health and safety" (p. 263). In addition, the authors conclude that there is little known about the effects of training on safety and driver performance.

Chapter 11 reviews a variety of industry developments, including earnings declines, greater regulation and scrutiny of drivers, that have led to poorer working conditions in the industry. The author (an employee of the International Brotherhood of Teamsters) concludes that the only way to improve the lot of drivers is for them to join a union.

This book makes an excellent contribution to the literature on the U.S. trucking industry. It should serve as a useful reference for students, practitioners and researchers. In addition, it could also be used as a supplemental source for courses on transportation. In fact, it might be the primary text for a seminar on the industry. Of course, all books can be improved. A useful addition would be a chapter on the role of truck brokers in the industry. In any case, this book is an excellent source of timely information and should be read by everyone with an interest in trucking.

Journal of Transportation Management

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Pohlen, Terrance L. (2003), "A Framework for Evaluating Supply Chain Performance," *Journal of Transportation Management*, 14(2): 1-21.

Book Chapter:

Manrodt, Karl (2003), "Drivers of Logistics Excellence: Implications for Carriers," In J. W. Wilson (Ed.), *Logistics and Transportation Research Yearbook 2003* (pp. 126-154) Englewood Cliffs, NJ: Prentice-Hall, Inc.

Book:

Coyle, John J., Bardi, Edward J., and Novack, Robert A. (2004), *Transportation*, 6th ed., Cincinnati, OH: South-Western College Publishing.

Website:

Wilson, J. W. (2003), "Adapting to the Threat of Global Terrorism: Reinventing Your Supply Chain," [On-line]. Available: <http://georgiasouthern.edu/coba/centers/lit/threat.doc>. Accessed: 11/12/03.

MANUSCRIPT SAMPLE

A FRAMEWORK FOR EVALUATING SUPPLY CHAIN PERFORMANCE

Terrance L. Pohlen, University of North Texas

ABSTRACT

Managers require measures spanning multiple enterprises to increase supply chain competitiveness and to increase the value delivered to the end-customer. Despite the need for supply chain metrics, there is little evidence that any firms are successfully measuring and evaluating interfirm performance. Existing measures continue to capture intrafirm performance and focus on traditional measures. The lack of a framework to simultaneously measure and translate interfirm performance into value creation has largely contributed to this situation. This article presents a framework that overcomes these shortcomings by measuring performance across multiple firms and translating supply chain performance into shareholder value.

INTRODUCTION

The ability to measure supply chain performance remains an elusive goal for managers in most companies. Few have implemented supply chain management or have visibility of performance across multiple companies (Supply Chain Solutions, 1998; Keeler et al., 1999; Simatupang and Sridharan, 2002). Supply chain management itself lacks a widely accepted definition (Akkermans, 1999), and many managers substitute the term for logistics or supplier management (Lambert and Pohlen, 2001). As a result, performance measurement tends to be functionally or internally focused and does not capture supply chain performance (Gilmour, 1999; *Supply Chain Management*, 2001). At best, existing measures only capture how immediate upstream suppliers and downstream customers drive performance within a single firm.

Table 1 about here

Developing and Costing Performance Measures

ABC is a technique for assigning the direct and indirect resources of a firm to the activities consuming the resources and subsequently tracing the cost of performing these activities to the products, customers, or supply chains consuming the activities (La Londe and Pohlen, 1996). An activity-based approach increases costing accuracy by using multiple drivers to assign costs whereas traditional cost accounting frequently relies on a very limited number of allocation bases.

$$y = a^2 - 2ax + x^2 \quad (1)$$

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- Coyle, John J., Bardi, Edward J., and Novack, Robert A. (2004), *Transportation*, 6th ed., Cincinnati, OH: South-Western College Publishing.
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