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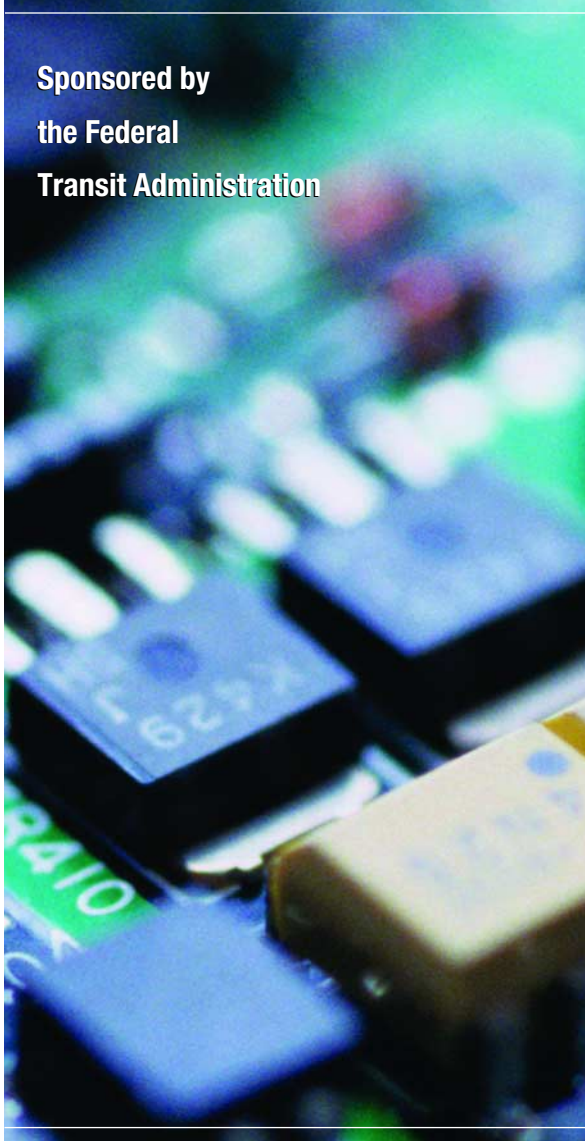

e-Transit: Electronic Business Strategies for Public Transportation
Volume 1

Supply Chain: Parts and Inventory Management

TRANSPORTATION RESEARCH BOARD
OF THE NATIONAL ACADEMIES

TRANSIT COOPERATIVE RESEARCH PROGRAM

TCRP REPORT 84

e-Transit: Electronic Business Strategies for Public Transportation

Volume 1

Supply Chain: Parts and Inventory Management

MITRETEK SYSTEMS
Washington, DC

and

TRANSTECH MANAGEMENT, INC.
Greensboro, NC

SUBJECT AREAS
Public Transit

Research Sponsored by the Federal Transit Administration in Cooperation with the Transit Development Corporation

TRANSPORTATION RESEARCH BOARD

WASHINGTON, D.C.
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TRANSIT COOPERATIVE RESEARCH PROGRAM

The nation's growth and the need to meet mobility, environmental, and energy objectives place demands on public transit systems. Current systems, some of which are old and in need of upgrading, must expand service area, increase service frequency, and improve efficiency to serve these demands. Research is necessary to solve operating problems, to adapt appropriate new technologies from other industries, and to introduce innovations into the transit industry. The Transit Cooperative Research Program (TCRP) serves as one of the principal means by which the transit industry can develop innovative near-term solutions to meet demands placed on it.

The need for TCRP was originally identified in *TRB Special Report 213—Research for Public Transit: New Directions*, published in 1987 and based on a study sponsored by the Urban Mass Transportation Administration—now the Federal Transit Administration (FTA). A report by the American Public Transportation Association (APTA), *Transportation 2000*, also recognized the need for local, problem-solving research. TCRP, modeled after the longstanding and successful National Cooperative Highway Research Program, undertakes research and other technical activities in response to the needs of transit service providers. The scope of TCRP includes a variety of transit research fields including planning, service configuration, equipment, facilities, operations, human resources, maintenance, policy, and administrative practices.

TCRP was established under FTA sponsorship in July 1992. Proposed by the U.S. Department of Transportation, TCRP was authorized as part of the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA). On May 13, 1992, a memorandum agreement outlining TCRP operating procedures was executed by the three cooperating organizations: FTA; the National Academies, acting through the Transportation Research Board (TRB); and the Transit Development Corporation, Inc. (TDC), a nonprofit educational and research organization established by APTA. TDC is responsible for forming the independent governing board, designated as the TCRP Oversight and Project Selection (TOPS) Committee.

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Once selected, each project is assigned to an expert panel, appointed by the Transportation Research Board. The panels prepare project statements (requests for proposals), select contractors, and provide technical guidance and counsel throughout the life of the project. The process for developing research problem statements and selecting research agencies has been used by TRB in managing cooperative research programs since 1962. As in other TRB activities, TCRP project panels serve voluntarily without compensation.

Because research cannot have the desired impact if products fail to reach the intended audience, special emphasis is placed on disseminating TCRP results to the intended end users of the research: transit agencies, service providers, and suppliers. TRB provides a series of research reports, syntheses of transit practice, and other supporting material developed by TCRP research. APTA will arrange for workshops, training aids, field visits, and other activities to ensure that results are implemented by urban and rural transit industry practitioners.

The TCRP provides a forum where transit agencies can cooperatively address common operational problems. The TCRP results support and complement other ongoing transit research and training programs.

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The members of the technical advisory panel selected to monitor this project and to review this report were chosen for recognized scholarly competence and with due consideration for the balance of disciplines appropriate to the project. The opinions and conclusions expressed or implied are those of the research agency that performed the research, and while they have been accepted as appropriate by the technical panel, they are not necessarily those of the Transportation Research Board, the National Research Council, the Transit Development Corporation, or the Federal Transit Administration of the U.S. Department of Transportation.

Each report is reviewed and accepted for publication by the technical panel according to procedures established and monitored by the Transportation Research Board Executive Committee and the Governing Board of the National Research Council.

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FOREWORD

By Gwen Chisholm
Staff Officer
Transportation Research Board

TCRP Report 84: e-Transit: Electronic Business Strategies for Public Transportation documents principles, techniques, and strategies that are used in electronic business strategies for public transportation. *TCRP Report 84* will be published as multiple volumes; *Volume 1*: *Supply Chain: Parts and Inventory Management* examines the supply-chain concept and identifies supply-chain strategies used by non-transit fleets to reduce investments in parts and inventory while increasing fleet availability. This report includes a clarification of supply-chain terms, discussion of the impact of asset-management decisions on parts and inventory management needs, and strategies for streamlining the supply chain. Non-transit fleets with practices identified for emulation include utility fleets, a state DOT fleet, private-sector motor carriers, and the U.S. military. This report may be used by senior managers, operations managers, materials managers, asset managers, inventory professionals, and procurement officers.

The Internet and other new information and communication technologies are revolutionizing the way services are delivered and organizations are structured. Electronic business processes change the ways organizations operate and conduct business. Opportunities to lower transaction costs and improve efficiency have changed relationships between transit agencies and their suppliers and customers, and electronic business processes are likely to change industry structures in the longer term. Portals for transactions in government-to-government and business-to-government marketplaces are offered through diverse organizations. Numerous transit agencies are preparing to offer customized itinerary planning and fare media purchasing over the Internet.

The declining costs of communications, data storage, and data retrieval are accelerating the opportunities spawned by the Internet and other information and communications technologies. Choosing and sequencing investments in technologies, processes, and people to reduce costs and increase productivity present challenges to the transit manager, who must weigh the costs, benefits, and risks of changing the ways services are delivered. To assist in meeting such challenges, TCRP Project J-09 will produce a multiple-volume series under *TCRP Report 84*. The research program will identify, develop, and provide flexible, ongoing, quick-response research designed to bring electronic business strategies to public transportation and mobility management.

Volume 1: *Supply Chain: Parts and Inventory Management* is the first volume in the *TCRP Report 84* series. Mitretek Systems and TransTech Management, Inc., prepared this report. To achieve the task objective of gathering information about how non-transit organizations used information technology to support fleet operations, an Internet-based survey form was used as the focal instrument. Secondary information sources complemented the survey results and provided additional insight into the findings. The findings of the study reveal that non-transit, fleet-focused organizations have achieved a

significant degree of supply-chain integration for parts and materials support with Internet parts sourcing at most companies limited to the use of online vendor catalogs. Also, results reveal that most firms recognize the Internet as an integral tool for future parts sourcing.

Volumes issued under *TCRP Report 84* may be found on the TRB website at nationalacademies.org/trb.

CONTENTS

1 SUMMARY

3 CHAPTER 1 Introduction
- Research Approach, 3
- Comments on the Internet Survey Effort, 4

5 CHAPTER 2 Findings
- Supply Chain—Concept Overview, 5
- e-Procurement and Business-to-Business Marketplaces, 6
  - Buying Process Automation, 6
  - e-Markets, 7
  - Buyer Consortia, 7
  - Industry Portals, 7
  - Private Trading Exchanges, 8
- e-Procurement: Adoption Rates and Application Trends, 8
- Supply-Chain Success Stories, 8
  - Public Sector “Just-in-Time” Materials Ordering, 9
  - Commercial Carriers’ Supply-Chain Approach, 9
  - Parts Procurement and Inventory Management—TxDOT and the U.S. Military, 10
  - Inventory and Parts Management—Utility Fleets, 10

12 CHAPTER 3 Interpretation, Appraisal, and Applications
- Supply-Chain Management—Application to Transit, 12
  - Transit e-Procurement, 13
- Transit-Focused e-Procurement, 13
- Core Competency, 14
- Asset Management, 14

15 CHAPTER 4 Conclusions and Suggested Research
- Conclusions, 15
- Suggested Research, 15

17 REFERENCES

A-1 APPENDIX A Non-Transit Fleet Supply-Chain Survey

B-1 APPENDIX B Non-Transit Fleet Supply-Chain Survey Results

C-1 APPENDIX C Bibliography

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e-Transit: Electronic Business Strategies for Public Transportation: Volume 1

SUPPLY CHAIN: PARTS AND INVENTORY MANAGEMENT

SUMMARY

"Supply chain," "supply-chain management," "e-procurement," and other similar terms are commonly used interchangeably although they have different meanings and different levels of applicability for transit agencies. Leveraging these concepts to achieve the desired gains requires a basic understanding of the terminology, the concepts, a self-assessment of agency capabilities, and the will to make the investments needed in technology and personnel—or the willingness to outsource, if necessary.

In theory, the advantage of the supply-chain approach is that a community of trading partners can leverage their respective core competencies, thus producing greater value through their cumulative efforts than would be possible if they were not collaborating. In such an integrated supply chain, the end customer is the focus of the entire supply-chain community, with unfiltered electronic information exchanged freely among community members. This exchange allows trading partners to leverage information to reduce miscommunication (i.e., waste) among firms and enhances internal processes (i.e., increases value). Creating such partnering relationships requires a long-term commitment of time and resources to develop the trust needed to freely share information among organizations and is a major challenge to creating supply-chain communities.

e-Procurement is the business-to-business purchase and sale of supplies and services over the Internet. e-Procurement reflects the application of supply-chain principles to leverage the Internet's ability to provide faster, more cost-efficient means of communicating information between buyers and sellers. Research cites the ability of e-procurement techniques to reduce purchase and transaction costs, but the value and number of e-procurement transactions remains small (less than 10% of all business purchases in the fourth quarter of 2001 [*1*]). However, this share is growing rapidly, with e-procurement viewed as an integral function for large purchasers. Driving this growth are reported savings of 15% to 20% on item costs and up to 80% in process cost savings (*2*,*3*).

e-Procurement takes five primary forms:

1. Automated purchasing systems;
2. Internet market exchanges (i.e., e-markets);
3. Buyers' consortia;
4. Industry portals; and
5. Private trading exchanges.

Of these, automated purchasing systems—typically software purchased from a vendor to standardize buying practices and aggregate purchasing volumes for better pricing—are the most popular. Online auctions are popular with large corporations while governmental, educational, and non-profit entities tend to favor Internet market exchanges (i.e., e-markets)(*4*).

Current transit industry e-markets exist through providers such as iRail.com and iBusXchange.com (both of which are part of the same company), with an American Public Transportation Association–sponsored (APTA-sponsored) industry portal—TransportMAX.com—under development. iRail/iBusXchange's current and TransportMAX's planned service offerings duplicate functions, but only the iRail/iBusXchange services are currently available for use (although TransportMAX is in the testing stage of posting requests for quotations [RFQs]).

Securing seller support and participation in e-procurement activities is a major problem for all e-procurement forms (*5*) and a special problem for the transit industry. APTA's "Procurement Task Force Status Report" indicates that the "health of the [transit vendor] industry is not good," with difficulty in attracting suppliers and vendor complaints of low margins and slow payments resulting in unacceptable levels of risk (*6*). Additionally, the task force observes that current agency purchasing practices often result in the buying of substandard products. As described, this is a particularly challenging environment in which to apply a supply-chain approach to procurement—an environment in which trust is a key component in developing the collaborative environment essential for effective supply-chain partnering.

Project research on non-transit, fleet-focused organizations indicates that few firms have achieved a significant degree of supply-chain integration for parts and materials support, with Internet parts sourcing at most companies limited to the use of online vendor catalogs. Most firms recognize the Internet as an integral tool of future parts sourcing but remain unclear as to how to progress to a higher level of integration consistent with reports from other industries and sources (*7*). However, anecdotal information from fleet-industry insiders suggests that supply-chain integration is more advanced and pervasive at large carrier fleet operations than can be confirmed in the literature.

Success stories identified for fleet-based parts or inventory management generally involved some type of systems implementation, either vehicle maintenance management or warehouse inventory systems. However, available information did not indicate the extent to which these systems were tied to automated purchasing systems that support e-procurement. Management personnel at two less-than-truckload carriers and at a major truck-leasing company acknowledged the use of electronic vendor links by their respective firms. However, these implementations used prime vendors and contractors serving as lead suppliers in handling such procurements, usually on a multiyear contract basis (to defray the start-up costs of integrating information systems). This form of "outsourced purchasing" is conceptually similar to the use of on-site contractors to provide vehicle parts and inventory support, as is used by the U.S. military and the Texas DOT (TxDOT). The strategic basis for such arrangements is the vendor's core competency in areas of parts procurement and inventory management and the superior buying power of such firms.

For fleets, asset-management decisions are the fundamental drivers for equipment parts and inventory needs. Relevant decisions include choices about replacement strategies, degree of standardization, vehicle mix, maintenance source (in-house versus outsourced), and maintenance focus (preventive maintenance or remedial-focused), among others.

CHAPTER **1**

INTRODUCTION

In 2000, TCRP published a research project statement entitled "eTransit: Electronic Business Strategies for Public Transportation." The problem statement identified the objective of this project as ". . . [to] provide flexible, ongoing, quick-response research designed to bring electronic business strategies to public transportation and mobility management." The initial seven tasks for this project involved the following areas:

1. Supply chain (i.e., parts management, inventory management);
2. Regulatory issues;
3. Application service providers;
4. Customer information;
5. Electronic payments and receipts;
6. Training and certification; and
7. Development of a series of electronic magazine (e-zine) articles to achieve more rapid dissemination and application of research results.

This volume (Volume 1) of *TCRP Report 84: e-Transit: Electronic Business Strategies for Public Transportation* provides research on Task 1 (i.e., the supply chain), with an objective of providing transit property managers with insight into how firms with similar fleet operations have used a supply-chain approach to parts and materials inventory management.

RESEARCH APPROACH

The Task 1 work plan identified an Internet-based survey as the focal instrument for gathering information about how non-transit organizations used information technology to support vehicle fleet operations. Secondary information sources (such as periodicals, journals, books, and other reports) would complement the survey results and provide additional insight into findings.

Organizations targeted for this research effort included utility companies, private fleets, and commercial motor carriers. Target information was success stories on improved parts and inventory management through the application of supply-chain principles, understanding how the principles link with suppliers, the kinds of information exchanged, how information is exchanged, to whom information is available, and how it is used to enhance operations. The data gathered through the Internet-based survey would provide the basis for identifying relevant supply-chain practices and would provide adequate information to identify appropriate firms for follow-up interviews.

To provide a baseline for comparing non-transit with transit supply chains, the following transit agencies completed a modified version of a draft web survey form:

- San Francisco Bay Area Rapid Transit (BART),
- Central Ohio Transit Authority,
- Texas' Corpus Christi Regional Transportation Authority,
- Washington State's King County DOT–Metro Transit Division (Metro), and
- Pennsylvania's Lehigh and Northampton Transit Authority (LANTA).

While the sample size was not statistically significant, the survey did highlight the differences between these properties in size, equipment types, age, and parts-procurement practices, encouraging the consultant to focus on e-procurement practices with the broadest application to transit properties.

Using the information gathered through the transit survey effort and supplemented with information gleaned from prior TCRP reports on current and recommended transit purchasing, inventory and fleet maintenance practices (identified in this report's bibliography and endnotes as appropriate), the research team finalized the Internet-based survey form. On September 26, 2001, the production version of the survey website was launched, ready to capture survey data.

To support information-gathering efforts, the research team made multiple contacts with the following organizations, soliciting and receiving their support of this project both before and during the survey period:

- The National Association of Fleet Administrators (NAFA),
- The National Conference of State Fleet Administrators (NCFSA),
- The Maintenance Council of the American Trucking Association (ATA), and
- The National Private Truck Council.

Additionally, the following monthly periodicals (with readers consisting of the target focus groups) agreed to advise their reporters of this survey effort:

- *Utility Fleet Management Magazine*,
- *Today's Trucking*, and
- *Commercial Carrier Journal*.

Based on conversations with the target organizations, survey response was anticipated to be low until mid-October 2001. After receiving only four satisfactory responses (excluding incomplete, duplicate, or inappropriate surveys) by late October, the research team once again solicited the target organizations for help. In early November, research team members directly contacted 19 trucking companies and 15 utility firms (via their websites) in an effort to bolster survey responses. When provided contact information for 35 utility fleet managers in late November, team members directly e-mailed these individuals asking them to submit surveys. This explains the more recent survey responses. (Appendix B contains the compiled results of all survey responses without identifying the firm or respondent.)

By late November, it was obvious that survey responses were inadequate to provide any statistically significant information. Accordingly, the research focus shifted to the use of secondary sources and industry contacts to achieve project objectives. Researchers searched Internet resources and periodicals and made direct contact with fleet operators to identify fleets demonstrating innovative supply-chain links. This report reflects the results of these efforts.

COMMENTS ON THE INTERNET SURVEY EFFORT

While the response to the web-based survey approach was inadequate, the technology was successful in capturing the requested information from the participating respondents and provided major advantages in efficiency and accuracy compared with alternate approaches of telephone or paper-based surveys. In retrospect, the research team recognizes that non-transit fleets lacked adequate motivation to complete the survey, which was complicated by a reluctance to divulge firm-specific information. Additional factors that may have contributed to the poor response rate include limited access to the Internet and reluctance to use Internet-based surveys. In situations in which these factors are more favorable, Internet-based surveys can gather enormous amounts of data in a very efficient and accurate manner, supporting the kinds of database analysis envisioned in the original work plan.

CHAPTER **2**

FINDINGS

SUPPLY CHAIN—CONCEPT OVERVIEW

The phrases "supply chain" and "supply-chain management" have become a part of the business lexicon although not everyone shares a universal understanding or use of these terms. This report uses the following definitions of these (and related) terms:

- **Supply Chain:** "The network used to deliver products and services from raw materials to end customers through an engineered flow of information, physical distribution, and cash" (*8*).
- **Supply-Chain Management:** ". . . the collaborative effort of multiple channel members to design, implement, and manage seamless value-added processes to meet the real needs of the end customer" (*9*).
- **Supply-Chain Community:** Sets of trading partners that define a complete supply chain.
- **Supply-Chain Design:** The determination of how to structure a supply chain. Design decisions include the selection of partners, the location and capacity of facilities, the products, the modes of transportation, and supporting information systems.

In theory, the advantage of the supply-chain approach is that a community of trading partners can leverage their respective core competencies, thus producing greater value through their cumulative efforts than would be possible if they were not collaborating. In such an integrated supply chain, the end customer is the focus of the entire supply-chain community, with unfiltered electronic information exchanged freely among community members. This exchange allows trading partners to leverage information to reduce miscommunication (i.e., waste) among firms and enhances internal processes (i.e., increases value). Creating such partnering relationships requires a long-term commitment of time and resources to develop the trust needed to freely share information among organizations and is a major challenge to creating supply-chain communities.

The supply-chain approach encourages organizations to adopt a customer-centric approach to streamline business processes and to meet most efficiently the end customer's needs. For many firms, this approach requires reorganizing from a functional business model—one with organizational "silos" for operations, purchasing, maintenance, and so forth—to a process-aligned organization. In such process-focused organizations, each group becomes a supplier to one part of the organization and an internal customer to another, with an overall target of meeting the needs of the end customer. Figure 1 illustrates this concept. For a community of supply-chain partners, extending the process across organizations allows firms to react more quickly and accurately to the end customer's needs, supporting better decisionmaking at each point in the supply chain. This reduces waste and provides opportunities for cost saving or improvements in response time. Enlisting trading partners with a relative advantage in core competency in any required process step provides an opportunity to enhance the value of overall product or service.

To better understand the supply-chain concept, consider the impact of the traditional focus on purchase price when sourcing goods: The price paid for source materials has a direct impact on an organization's profitability and is an attractive performance measure because of its ease of use. However, because most vendors offer reduced unit prices for larger orders, a natural effect of focusing on purchase price is to encourage large-volume buying. Storing inventory requires physical facilities, absorbs resources to monitor and maintain, and subjects materials to damage and "shrinkage" (i.e., theft) while changing product needs threaten unused inventory with obsolescence. Inventory is beneficial only when it allows an organization to meet customer needs more quickly while the indirect costs of having excess inventory are seldom calculated or included in the total price of goods or services (*10*). For example, buying janitorial supplies in large quantities usually results in significantly better pricing but can result in having more supplies on hand than available space supports, creating overcrowded warehouse conditions, which decreases efficiency. Even more importantly, inventory represents funds that could be used for other organizational purposes. Supply-chain management forces the organization to understand the interrelation of such decisions and to focus on activities that add value while avoiding (or minimizing) activities that add cost or absorb resources.

The supply chain–management concept offers a number of highly desirable benefits to organizations, but implementation efforts often face significant obstacles. In a 2001 study entitled *Achieving World-Class Supply Chain Alignment: Benefits, Barriers, and Bridges* (*11*), the authors engaged in a major effort involving literature review, surveys, and case

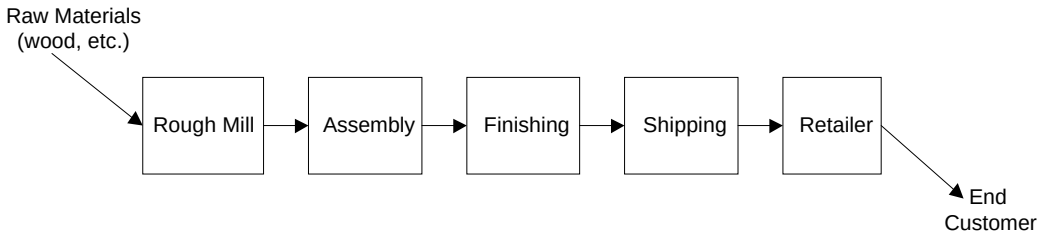

Figure 1. Example of a furniture industry supply chain.

studies to gain insight into the key issues for applying supply-chain strategies. Table 1 identifies report findings on the top 10 benefits, barriers (i.e., issues that harm implementation efforts), and bridges (i.e., success factors) to supply chain–management implementations.

e-PROCUREMENT AND BUSINESS-TO-BUSINESS MARKETPLACES

e-Procurement is the purchase and sale of supplies over the Internet. e-Procurement's role in the supply chain is one of process enhancement because e-procurement enables increased speed, enhanced communications, and reduced costs (in both process and product) for trading partners through technology application.

e-Procurement consists of the following overlapping areas:

1. Buying process automation,
2. E-markets,
3. Buyers' consortia,
4. Industry portals, and
5. Private trading exchanges.

Buying Process Automation

Use of the Internet to purchase indirect (i.e., non-production) materials were the earliest and most successful attempts of the innovation made possible by the Internet. Because such activities were usually decentralized and not closely managed, indirect material purchases typically consumed a disproportionate amount of resources. The new applications promised to

- Automate the buying process,
- Relieve the purchasing workload,
- Reduce administrative cycle time, and
- Reduce errors.

To accomplish these goals, companies created applications (typically using web browsers as the user interface to increase user adoption speed) with the company intranet serving as the communications backbone. While these systems typically succeeded in increasing administrative efficiency, the major savings actually resulted from better information on aggregate buying practices and volumes (which facilitated vendor

TABLE 1 Top 10 benefits, barriers, and bridges to supply-chain management

Benefits	Barriers	Bridges
• Increased customer responsiveness	• Inadequate information sharing	• Senior and functional managerial support
• More consistent on-time delivery	• Poor/conflicting measurement	• Open and honest information sharing
• Shorter order-fulfillment lead times	• Inconsistent operating goals	• Accurate and comprehensive measures
• Reduced inventory costs	• Organizational culture and structure	• Trust-based, synergistic alliances
• Better asset utilization	• Resistance to change—lack of trust	• Supply-chain alignment and rationalization
• Lower cost of purchased items	• Poor alliance management practices	• Cross-experienced managers
• Higher product quality	• Lack of supply-chain vision or understanding	• Process documentation and ownership
• Ability to handle unexpected events	• Lack of managerial commitment	• Supply-chain education and training
• Faster product innovation	• Constrained resources	• Use of supply-chain advisory councils
• Preferred and tailored relationships	• No employee passion/empowerment	• Effective use of pilot projects

pricing negotiations) and enabled companies to standardize indirect buying practices, with significant savings.

Companies have long negotiated standard contracts for materials but enforcing buying decisions tends to be difficult in large organizations, especially for low-value items. When employees ignore directives to make purchases via these contracts, contract provisions for discounts based on purchase volume frequently fail to provide the anticipated benefit. A well-designed process automation application creates a process that provides the user with a faster and easier way to secure needed products while forcing buyers to use common systems and to order standard products from corporate-wide contracts.

Automated purchasing involves one buyer and one seller, with the pricing schedule negotiated in advance. This arrangement is referred to as a "one-to-one" business-to-business (or "B2B") transaction. Other e-procurement transactions may involve "one-to-many" or "many-to-many" transactions.

Purchasing automation systems are available from many suppliers, but all entail additional work to integrate them into existing accounting systems and may require desktop hardware, software, or system upgrades. Alternatives to purchasing and installing such systems include using web-delivered services provided by application service providers (ASPs). This approach reduces the investments in hardware, software, and systems but requires the ongoing payment of subscription fees. More importantly, ASP applications for automated purchasing still need to be integrated into back-office accounting systems in order to provide the same level of business integration as purchased automation systems. Regardless of whether using purchased or ASP-provided automated buying systems, organizations need to revise business processes and provide appropriate training to support such implementations.

e-Markets

"e-Markets" are Internet-based marketplaces created to facilitate bringing buyers and sellers together. Starting as electronic catalogs, e-markets now cover nearly every product and service bought and sold. Depending on the service provided, e-markets may link one-to-one (i.e., catalog buys); one-to-many (Requests for Proposals and auctions); or many-to-many (project collaboration).

Many e-markets have roots in the Internet boom of the late 1990s, with funding frequently provided by venture capitalists. The primary attraction of e-markets is that they are viewed as "neutral"—favoring neither buyer nor seller. This is a significant advantage given that attracting seller participation is a major problem for most e-procurement initiatives (*12*). Additionally, because many e-markets rely on transaction fees as a primary revenue source, these services have a powerful motivation to actively promote the site, solicit new sellers and buyers, and develop additional services. The major concern regarding e-markets is one of viability. The collapse of many Internet-based firms represents a danger to the availability of funding for many of these operations and places pressure on these firms to become profitable quickly. Additionally, challenges from buyers' consortia and industry portals represent competitive threats to these firms.

Among the services developed by e-markets and other electronic exchanges to attract more customers are the following:

- Community information (industry, product, employment, etc.);
- Auctions (forward and backward);
- Demand aggregating;
- Process automation software (note the overlap with the Buying Process Automation category);
- Financing options;
- Transportation and logistics options;
- Product design support;
- Collaborative tools (such as the ability to track project progress online or to conduct Internet-based meetings [i.e., "netmeetings"]); and
- Other specialized services.

e-Markets are typically market- or service-focused. Examples of market-focused e-markets include chemicals or metals; printing is an example of a service-focused e-market.

Buyer Consortia

Buyer consortia are buyer-owned exchanges in which multiple firms share the cost of creating and managing the exchange. Transactions may be one-to-one, one-to-many, or many-to-many. Because of competitive pressures, buyer consortia face difficulties in establishing site operation agreements among participants and maintaining cooperation over time. The source of initial and ongoing funding also tends to be problematic. To secure seller participation, buyer consortia must overcome seller concerns about the perceived imbalance of power between buyer and seller and the threat of increased pressure on seller profit margins.

Industry Portals

Industry portals share similarities with buyers' consortia but tend to be broader-based and are frequently a cooperative effort of industry associations. Most industries now have Internet portals, apparently motivated by the desire to establish an e-commerce presence and to send a positive message about the "technology-savvy" nature of organization members.

Because industry portals typically enjoy some level of broad-based support by industry members, they provide an opportunity to establish communication standards within an industry that could facilitate true supply-chain management. With common standards, companies could more easily share

information among organizations and vendors, easing justification for the investment in time and resources to create such links. Because of this, firms that develop supply-chain and enterprise-resource-planning (ERP) software are aggressively pursuing these portals as a product market.

Private Trading Exchanges

Private trading exchanges (PTXs) are a relatively recent development, reflecting efforts by companies to expand on the supply-chain concept by encouraging more collaboration and integration among trading partners. Key features of a PTX include increased security and control, which support increased confidence and information sharing among participants.

In a PTX, a single company creates an exchange and recommends (or requires) its suppliers to participate. As such, firms using a PTX approach must be able to justify the cost and support the technical complexity of creating and maintaining a PTX and must have sufficient market power to motivate supplier participation. Because of these factors, early adopters of the PTX approach tend to be large firms such as Pitney Bowes, Inc., Harley-Davidson, and Eastman Chemical, which can support expenditures needed to create such systems (*13*).

e-PROCUREMENT: ADOPTION RATES AND APPLICATION TRENDS

e-Procurement is expanding rapidly, driven by reported savings of 15% to 20% on item costs and up to 80% in process cost savings (*14*, *15*). According to a recent survey of business e-procurement activities in the first quarter of 2001, the following are the current and planned use of four types of e-procurement technology (see Table 2) (*16*): automated purchasing systems, e-markets, auctions, and buyer consortia. A survey by the Institute for Supply Chain Management and Forrester Research further supports the growth of e-procurement, noting the following quarter-to-quarter increases in Internet use for indirect and direct material purchases during the fourth quarter of 2001 (see Table 3) (*17*):

While there seems to be a consensus on the importance of the Internet and e-procurement, many firms seem unclear of how to progress. In an article summarizing the findings of the E-Procurement Benchmark Survey (*18*), Pastore indicates that most organizations are taking a "wait-and-see" attitude toward e-procurement, identifying the following as the top issues blocking e-procurement adoption:

1. Need to integrate e-procurement systems with legacy/ERP information systems,
2. Lack of technology standards,
3. Concerns about dealing with anonymous vendors,
4. Difficulty of identifying optimal solutions for each company,
5. Lack of organizational readiness, and
6. Lack of supplier participation.

Pastore further quotes Robert Palmer, a coauthor of the E-Procurement Benchmark Survey, as saying: "If this [e-purchasing/inventory integration] cannot be done within a reasonable time frame, the market's interest in this technology may drop considerably."

SUPPLY-CHAIN SUCCESS STORIES

Two firms are frequently cited as leading examples of supply-chain integration: Wal-Mart and Dell Computer. These firms create long-term teaming arrangements with vendors, which support the information infrastructure investments

TABLE 2 e-Procurement usage by type—first quarter 2001 and 2-year projection

e-Procurement Type	Currently Use or Plan to Use	Projected 2-Year Growth Rate
Automated purchasing systems	43%	445%
e-Markets	24%	116%
Auctions	20%	370%
Buyer consortia	14%	Not indicated

TABLE 3 e-Procurement: percentage of total purchases—third and fourth quarter 2001

Purchase Type	Q3 2001	Q4 2001
Indirect materials	7.1%	9.5%
Direct materials	5.3%	6.2%

needed to provide real-time information at the volumes required by these firms. The availability of such information provides a significant advantage to participating supply-chain partners, allowing suppliers to see the daily demand for their products and to make appropriate business decisions. In return, Wal-Mart and Dell gain the ability to quickly respond to shifts in customer preferences, ensuring that they have the products customers want and allowing these firms to expand their respective market shares. These gains translate into advantageous pricing from suppliers and strengthen Wal-Mart, Dell, and their supply-chain partners' competitive positions.

While the success of companies like Wal-Mart and Dell provide examples of the advantages made possible through leveraging supply-chain practices, it is problematic to attempt to directly apply these companies' experiences to transit agencies. Transit agencies are service-based organizations, primarily operating in the public (or not-for-profit) sector. Even within the private sector, few service-based organizations have adopted a supply-chain approach to providing core business operations. Instead, many service firms apply supply-chain principles to reduce both the direct and indirect costs of support functions such as purchasing, information interchange, and funds transfer. The following cases describe applications of supply-chain strategies for possible emulation at transit agencies.

Public Sector "Just-in-Time" Materials Ordering

To better aggregate state agency purchasing and to provide an easier means of securing office supplies, in January 1997, the California Department of General Services contracted with Office Depot to provide office supplies for all California state agencies. This contract allows employees to order from two different catalogs: the first containing approximately 350 of the most frequently purchased office items with pricing at 50% to 70% off list, and the second containing about 10,000 items that are available at 42% below the list price. The contract requires that office supplies be delivered within 24 h to locations in urban areas and 48 h to outlying areas; with orders processed via telephone, facsimile, mail, or the Internet; and with the purchaser receiving a fax to confirm the pricing. This process allows office supplies to be delivered "just-in-time," minimizing the state's total amount of inventory and providing the state with a "virtual" automated purchasing system (*19*). Additionally, the state now issues only one vendor payment per month, tremendously reducing the cost of issuing payments to multiple vendors.

The California Department of General Services cites the following results from this program: the Office Depot supply contract has increased customer satisfaction through cost-effective access to 8,500 supplies versus the former 350 high-volume standardized products. For standardized products, there are substantial (50% to 75%) cost savings over the former centralized purchasing process. These items were bid at a cost savings of $9 million. For more than 8,000 additional products not in the other catalogs, the buyers receive 38% off the supplier's list price (*20*).

Commercial Carriers' Supply-Chain Approach

Overnite Transportation is a nationwide, less-than-trailerload (LTL) commercial motor freight carrier with 16,783 trailers; 4,564 tractors; and 91 straight trucks (*21*). Overnite uses a modified version of a commercial off-the-shelf (COTS) software package (1) for vehicle maintenance and inventory management and (2) as its system for tracking vehicle maintenance, parts usage, and failure analysis. This system incorporates an electronic parts-ordering function as part of the base-system functionality, with electronic linking to vendors via electronic data interchange (EDI).

Overnite's approach places hand-held scanners and touch-screen devices at each mechanic's workstation, tracking all maintenance by vehicle, part usage, failure code, and so forth. Each station transmits this information to the maintenance system, which includes error checks that ensure the accuracy of the information gathered—for example, a repair code that indicates an alternator failure but does not show the issuance of an alternator would result in an error message. Through the information provided by its vehicle maintenance system, Overnite performs failure analysis to track vehicle, system, and component performance, including searching for problem patterns. Using this information, Overnite addresses problems with vendors, seeking warranty adjustments and adjusting component sources when necessary. These experiences then become part of the new vehicle-specification process. Overnite indicates that by combining vehicle and component performance information with asset-management strategies such as reduced vehicle-replacement cycles, advance-negotiated fleet trade-in values, and increased focus on preventive maintenance, the carrier has been able to significantly reduce the number of maintenance facilities, the size of the mechanic workforce, and investment in parts and inventory while increasing vehicle availability. Overnite personnel would not divulge the total savings achieved through the combination of these actions.

Overnite's integrated parts inventory management system uses an "ABC" stocking system, with minimum and maximum parts stocking levels for all "A" and most "B" parts while many "C" parts are replenished through the use of vendor-managed inventories (VMI). When Overnite's system suggests the need to reorder a part, the district maintenance manager electronically reviews and transmits the requisition to the appropriate vendor. To support this strategy, Overnite negotiates 3-year contracts with prime vendors to provide

multivendor nationwide parts delivery directly to the appropriate maintenance facility within specific time requirements. For VMI items, the vendor may check items on a fixed schedule or may wait to be notified when stock reaches a minimum level. In either case, the vendor directly places items in the location designated (e.g., in the parts room or on the shop floor). Overnite also supplements these contracts with vendor-stocking contracts (basically, items placed on consignment) on certain items such as batteries.

An Overnite strategy that significantly reduced supply-chain needs (and therefore overall maintenance demands) was the abandonment of in-house rebuilding efforts (engines, transmissions, and other components) in favor of purchasing ready-to-install remanufactured items. This represents an asset-management strategy directed toward allowing vehicles to return to service quicker, which reduces the need for spare vehicles. Overnite's experience indicates that spare vehicles tend to absorb disproportionate maintenance resources, as spare vehicles (i.e., "spares") tend to be older and considered less desirable for use by employees. Accordingly, spares have low utilization levels, and employees may try to avoid using spares by identifying minor (or non-existent) problems for correction on those units. Troubleshooting reported problems with spare units absorbs mechanic resources to evaluate and correct the problems. By focusing on strategies that minimize vehicle downtime, the need for spare units is reduced, with positive impact on supply-chain needs—especially when spare units differ significantly in year, make, or model from the majority of the fleet.

Conversations with area managers for Old Dominion Truck Lines (a regional LTL carrier with more than 2,500 tractors and 10,000 trailers) and Penske Truck Leasing (a nationwide truck-leasing and vehicle maintenance firm with customers that include transit operations) suggest that most large commercial fleet operations have maintenance systems that are functionally similar to Overnite's. However, Old Dominion and Penske contacts were unwilling to discuss specifics about their maintenance systems or provide information about results achieved using these systems.

Overnite, Old Dominion, and Penske personnel indicated that the extent to which inventory management involves just vehicle parts or extends to other assets is a major variable with commercial fleet maintenance systems. For operations that must manage significant amounts of non-vehicle items, a warehouse management system may supplement (or provide primary support for) vehicle parts management.

Parts Procurement and Inventory Management—TxDOT and the U.S. Military

TxDOT operates more than 7,600 vehicles and 9,500 pieces of equipment in a decentralized equipment environment (*22*). At its San Antonio–district maintenance operation, TxDOT uses an on-site vendor to operate its equipment parts program. TxDOT refers to this program as the Texas Centralized Auto Parts System (TCAPS). TxDOT began this program in January 1996 and modeled it after the Contractor Operated Parts Store (COPARS) Program, which was started by the U.S. military during the 1960s and is still used to support its vehicles (*23*).

The TCAPS contract required the vendor to purchase the existing TxDOT equipment parts inventory (including any obsolete inventory) and contained specific performance requirements for significantly improved parts availability (compared with previous availability provided by in-house personnel) at no increase in parts pricing. However, the TCAPS vendor received no operational funding from TxDOT, deriving all vendor revenues from the sale of parts. The contract also capped profits from operations and required the vendor to submit monthly performance reports and an annual operations summary to TxDOT.

The TCAPS vendor currently operates the in-house parts operation with two vendor employees (instead of six TxDOT employees) at TxDOT's San Antonio facility, using a vendor-provided inventory and parts procurement system. This program operates within a fraction of the space formerly used when TxDOT managed the parts operation, yet TxDOT indicates fewer parts-related delays and reduced equipment downtime. While total equipment parts expenditures have remained roughly equal to pre-TCAPS levels, significant efficiencies have been realized, including the following:

- TxDOT pays for parts only when used, freeing funds for more productive agency use;
- Six TxDOT employees formerly performing parts-related functions are now performing other agency duties;
- Additional warehouse space is available for alternative uses; and
- TxDOT no longer processes individual purchase orders; instead, TxDOT only processes a single, biweekly invoice from the TCAPS vendor.

During fiscal year 1999, the district would have processed 5,400 purchase orders without TCAPS. Based on TxDOT's estimate of $70 to process a purchase order, this would have cost $378,000 to process (*24*). In contrast, with TCAPS, the district processed 24 invoices during fiscal year 1999, resulting in an annual savings of $376,320 (*25*).

Inventory and Parts Management—Utility Fleets

Like transit agencies, utility fleets face the challenge of maintaining specialized vehicles that may have limited local parts support. Additionally, utility fleets vary considerably in size and scope of operations, with some fleets operating over an entire state (or a multistate area) while others may cover only a single city or county. Asset-management decisions driving parts and inventory support needs and outsourcing

non-core competencies to leverage operations are utility fleet examples of supply-chain strategies.

Asset Management Decisions Drive Parts and Inventory Support Needs

Texas Utilities (TXU)—a large, multinational utility operating more than 7,000 vehicles in Texas—uses equipment leasing to keep its equipment age down, reducing TXU's parts and inventory management demands and supporting a preventive maintenance focus. TXU has only 25 mechanics as employees, relying on external vendors to service most vehicles. According to TXU's transportation manager,

> Our [inventory management] strategy is to keep as little on the shelves as possible, even to the point where we've established agreements with local suppliers that when we need automotive parts, we can just pick up the phone and they'll run them over to us. (*26*)

Outsourcing Non-Core Competencies Can Leverage Operations

In 1992, Baltimore Gas and Electric (BGE) employed 18 people to operate a 5,000–sq. ft warehouse for vehicle parts support. Under pressure to reduce costs, BGE performed a 6-month study to evaluate the cost and service advantages of outsourcing, which it ultimately chose to do. The vendor selected brought its own inventory-management software and bought all BGE's existing inventory. First-year savings for BGE was $500,000, which was attributed to the vendor's expertise in parts procurement and savings available through volume purchasing (*27*).

CHAPTER **3**

INTERPRETATION, APPRAISAL, AND APPLICATIONS

SUPPLY-CHAIN MANAGEMENT— APPLICATION TO TRANSIT

As described in Chapter 2, supply-chain management is a collaborative, customer-focused approach, relying on the free exchange of information and the idea that by leveraging the core competencies of trading partners, the supply-chain community can provide products of greater value to the customer than would otherwise be possible. For transit organizations, the "end customers" are existing and potential transit riders; various organizations, agencies, and companies that use and fund transit services are indirect customers (or stakeholders). Enhancing the "value" of transportation services that are provided to these customers' carries a number of potential meanings for transit entities:

- Increased service frequency (reduced headways on fixed-route systems);
- Expanded service (service provided over a greater operating area or over more hours or improved types of service [e.g., wheelchair-equipped, etc.]);
- Better service integration (complementary routes and schedules for the various transportation providers);
- Improved service planning (reduced wait times for demand-response transportation);
- Better schedule adherence (improved on-time performance),
- Increased efficiency (reduced cost per hour, per mile, per trip, etc., including streamlining ways to accomplish support functions); or
- A combination thereof.

To provide value improvements, supply-chain theory suggests that transit organizations would benefit from adopting a process-aligned, customer-centric focus in which the organization focuses on trying to better serve the end customer (i.e., the transit rider). Figure 2 and the accompanying role descriptions provide a basic discussion model for such an organization.

- **Rider:** The transit rider is the operator's (i.e., the driver's) primary customer and the transit supply chain's end customer.
- **Operator:** The operator is the primary service supplier for the transit rider. The operator directly adds service value to the customer through the operation of the transit vehicle. The operator's value contribution varies depending on the quality of its tangible performance (e.g., on time, on schedule, safe driving) and intangible contributions (e.g., customer friendliness), subject to external factors beyond its control (e.g., blocked roads, bad weather, etc.). The operator is an internal customer of operations/dispatch.
- **Operations/Dispatch:** Operations/dispatch directly adds transportation value through coordination of the drivers for maximum service efficiency and effectiveness. Operations/dispatch also indirectly adds service value by acting as a "supplier" to the equipment operator, ensuring that the driver has the resources needed (e.g., vehicles and support infrastructure) to provide the transportation service. Operations/dispatch is the primary internal customer of maintenance.
- **Maintenance:** Maintenance is a supplier to operations/dispatch and has the responsibility of ensuring that equipment receives the required attention to ensure its availability and safe operation. Maintenance indirectly adds transportation value by ensuring vehicles operate efficiently, have no safety defects, and have the maximum service availability, while minimizing the costs of providing these services. Maintenance is an internal customer of parts/inventory.
- **Parts/Inventory:** Parts/inventory provides the maintenance group with the items needed to support the equipment. Parts/inventory indirectly provides transportation value by ensuring that the maintenance group has the parts needed, when needed, to maximize vehicle availability while minimizing parts and inventory investment. Parts/inventory is an internal customer of purchasing.
- **Purchasing:** Purchasing identifies, purchases, and arranges delivery of items meeting the specification, quantity, quality, and schedule needs of the parts/inventory group. Purchasing indirectly provides value by supporting the parts/inventory function while striving to minimize purchase price. Purchasing is the customer of parts and materials vendors.
- **Parts and Materials Vendors:** Parts and materials vendors provide the required information that allows purchasing to make sourcing decisions. If selected, the vendor must supply the items according to the purchase specifications.

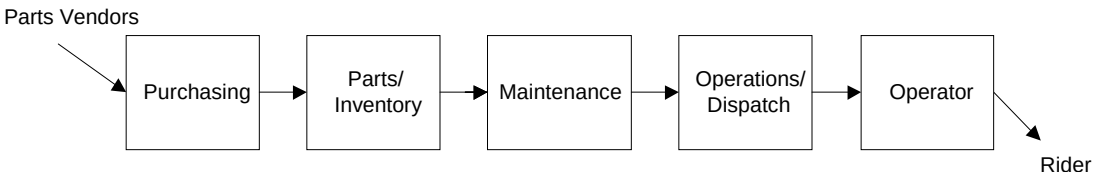

Figure 2. Supply-chain model of a transit organization.

The benefit of this customer-centric, process-aligned approach is that it helps each group understand its organizational role and how that role provides value to the customer. This alignment also helps the different groups understand the need for better communication and cooperation and helps identify activities that may be necessary, but do not inherently add value (e.g., paying invoices or processing payroll). In the case of such non-value-added activities, a process-aligned organization encourages challenging the necessity of these operations while seeking more efficient ways to accomplish these tasks.

Within the existing population of transit operations, it is possible to find the supply chain–model functions being performed by any mix of transit employees, contractors, and vendors. Supply-chain theory suggests that transit organizations should examine these relationships and seek ways of improving communications and collaboration—both inside and outside the organization—and should build an atmosphere of trust among groups. Once successful, extending this approach to include the end customer (i.e., the rider) and other customer stakeholder groups (e.g., social service agencies, housing authorities, etc.) in a true supply chain–community effort to improve transportation service delivery becomes a viable concept.

TRANSIT e-PROCUREMENT

Each transit organization is unique, serving different population bases and geographical areas with varying customer demands and levels of local transit funding support. Accordingly, each transit agency has a different mix of equipment, materials, and infrastructure support needs.

The experiences of other industries suggest that transit agencies could benefit by applying e-procurement to significantly increase the speed and efficiency of conducting business transactions. However, getting suppliers to participate in e-procurement initiatives is a particular concern for the transit industry. The APTA Procurement Task Force identified the following transit industry supplier concerns at APTA's Transit Information Technology Conference in February 2002 (*28*):

- The "health" of the transit supplier industry is not good;
- Suppliers face low profit margins;
- Product development and innovation are limited;
- Many companies do not want to do business with the transit industry;
- Transit procurement practices place excessive risk on suppliers; and
- Transit procurement practices result in substandard products.

Accordingly, the APTA Procurement Task Force identified the following as target objectives for TCRP Project J-9, Task 1 (*29*):

- Improve relationships between buyers and sellers,
- Increase use of standards and standardization,
- Maximize the efficiency of the procurement process,
- Increase the use of technology in the procurement process, and
- Make partnering, collaborative relationships, and risk-sharing commonplace in the industry.

Because leveraging e-procurement and other supply-chain initiatives depends on transit industry supplier participation, APTA's success and speed in accomplishing these goals may determinate the broad-based success of e-procurement in the transit industry.

Transit-Focused e-Procurement

Currently, transit industry e-markets exist through providers such as iRail.com and iBusXchange.com (both of which are part of the same company) and with an APTA-sponsored industry portal—TransportMAX.com—which is currently under development.

iRail has been in operation for more than 2 years and is a joint venture of Singularity, LLC, and Vistaar, Inc. The iRail website identifies a membership base of more than 2,500 users, including transit agencies, bus operators, railroads, suppliers, original equipment manufacturers, and consultants (*30*). iRail currently provides the following e-procurement services through its web e-marketplace, based on an ASP model:

- Automatic bids matching and distribution,
- Auctions,
- RFQs, and
- Marketmaking.

For customers desiring to directly implement these services or to integrate online services with back-office operations, iRail also offers software and consulting services, including

modules for e-procurement, vendor management, inventory management, and financial management.

TransportMAX is in the testing phase of its first service offering—posting RFQs on the Internet. Plans for TransportMAX include developing services and software products of the type provided by iRail, through TransportMAX's development partner, Booz-Allen Hamilton.

CORE COMPETENCY

The central concept that drives value gains in the supply-chain concept is leveraging core competencies among trading partners. This simply means that organizations can improve service, reduce costs, or both, by having functions performed as efficiently and effectively as possible—regardless of whether services are provided in-house or by trading partners.

In the TxDOT example, the switch to an on-site contractor quickly provided better parts availability, reduced space requirements, and provided considerable process efficiencies in-house while avoiding internal investments in systems and freeing funds previously invested in inventory for other uses. In the Overnite Transportation example, the carrier chose to invest in technology (vehicle maintenance and inventory management software and hardware) and training to develop a core competency in those areas, while recognizing the advantage of simplifying its supply chain and achieving process efficiencies by creating partnerships with prime vendors for parts procurement and supplies. California's use of Office Depot and BGE's use of outsourced inventory management represent similar examples in which large, capable organizations recognized that other firms possessed core competency advantages in certain areas and choose to create supply-chain teams with those firms rather than to try to develop internal competencies.

In the examples above, a major benefit of the supply team approach was the ability of the supply-chain partner to quickly bring proven solutions and trained personnel to perform relevant functions, providing a much more rapid impact than would be possible through internal investment in technology and training. Transit agencies certainly have the option of developing new or enhanced core competencies in supply-chain management to leverage their parts and inventory investments. However, specialty firms have the ability to leverage both systems investments and organizational learning over multiple entities. This leveraging ability is difficult for any single organization to match, and such investments must compete with other such organizational needs. These factors help explain why many highly capable firms look to such partnerships for these skills. Nevertheless, even examples of successful supply-chain partnering cannot ignore the challenges of gaining organizational support for such teaming initiatives, creating good lines of communication, and avoiding other "blockers" (as identified by Fawcett and Magnan [*31*]).

ASSET MANAGEMENT

The experiences of the commercial trucking and utility fleet industries emphasize how fundamental asset-management decisions (such as when to replace vehicles or the extent of fleet standardization in suppliers, models, and age) have a tremendous influence on maintenance demands and supply-chain needs. For these fleets, "providing value to the customer" means that fleet purchasing and maintenance practices focus on maximizing vehicle availability so that fleet operations (the maintenance department's customer) has the greatest capability to provide transportation service.

Gleaned from project research and interviews is the following list of asset-management considerations for reducing parts and inventory (and, therefore, supply-chain) needs:

- The greater the extent of fleet standardization, the lower the total number of parts items that need to be stocked and the easier it is to attempt "just-in-time" parts-purchasing strategies.
- Firms successful in achieving a preventive-maintenance focus greatly enhance their ability to predict parts demands because scheduled services identify future work needs (such as brake, tire, hose replacement, etc.) for correction during the next maintenance cycle. This approach allows securing needed parts in advance, which allows work completion with minimum loss of equipment availability and avoids breakdowns (in-service failures).
- Reducing the number of spare fleet units maintained (typically, older equipment awaiting replacement) can disproportionately free maintenance personnel and inventory resources.
- Purchasing vehicles with extended warranty provisions and negotiated schedules for parts availability, speed of delivery, and pricing can significantly reduce overall parts and inventory investment.
- The use of equipment leasing, maintenance outsourcing, or both can shift maintenance, inventory, and administrative burdens to vendors, allowing organizations to focus on operations.

While use of these strategies significantly reduces parts and inventory demands on the organization, it does not eliminate these needs. In fact, the simplified supply chains resulting from good asset-management decisions can actually enhance vendor interest (because of fewer items but more volume per item, reducing the sourcing workload and increasing the potential for volume-purchasing discounts). Accordingly, use of supply-chain strategies such as vendor-stocking programs, teaming with "prime vendors," e-procurement, and others remain viable approaches to leveraging transit (or other fleet) operations—even in well-managed fleets.

CHAPTER **4**

CONCLUSIONS AND SUGGESTED RESEARCH

CONCLUSIONS

Supply-chain management is a powerful concept for making organizations more customer- and process-focused. Successful supply-chain implementations rely on creating mutual trust between trading partners, allowing the open and honest sharing of information—a prerequisite for moving beyond traditional customer-vendor relationships into true supply-chain partnering.

Advances in communication technology provide the infrastructure for organizations to expand improvement efforts across multiple firms. However, technology does not create a successful chain community; it takes people and firms willing to look past organizational boundaries to make the concept work. When successful, the supply-chain community can leverage the core competencies of trading partners to produce better products or services than would be possible if the partners were not collaborating. In practice, this means that organizations must be willing to allow outsource functions to other trading partners if partners can provide services more efficiently—a concept many public agencies have been slow to embrace.

Research indicates that many firms recognize the importance of the Internet and various types of e-procurement, but remain unsure of how to proceed. A variety of technical and organizational issues hamper e-procurement expansion, but common problems include the need to integrate e-procurement into inventory and financial systems and the difficulty of attracting suppliers (*32*). However, reported item and process cost savings continue to drive interest.

As indicated in the Overnite Transportation example, fleet-maintenance systems can provide invaluable information in identifying equipment, maintenance, or vendor problem areas and providing management the information needed to take appropriate action. Such systems support true "cradle-to-grave" tracking of equipment costs, repair records, and component failures by type, vendor, and so forth, enabling managers to make objective decisions about actions designed to reduce fleet costs. These systems also provide the infrastructure to support major process enhancements in collecting, processing, and providing maintenance information to both management and mechanics. However, actual performance improvements still depend on management personnel to act on this information, whether changing equipment specifications, maintenance intervals, or even vendors.

The supply-chain success stories cited in this report generally involved some form of partnership between inventory-management and parts-procurement specialists and fleet operators, with technology providing an enabling role for increased process efficiency. An advantage of this approach is that it leverages the strategic partner's supplier network, which addresses one of the biggest obstacles for most e-procurement efforts—difficulties in attracting supplier participation. Additionally, this approach lowers the risk associated with major systems investments in technology and personnel training while allowing the organization to quickly achieve implementation benefits by using partner-supplied proven technology solutions and experienced personnel. Challenges to this approach include gaining organizational support, creating good lines of communication, and avoiding other barriers (*33*).

SUGGESTED RESEARCH

Transit assets have long life cycles, which means that asset-management decisions have a long-term impact on agency operations. Supporting the need for additional research in this area are the reported poor health of transit industry vendors and the impact level of asset-management decisions on transit operations costs. Related subtopics include the following:

- **Examining the economic and operational considerations of using alternate forms of equipment procurement,** such as
  - All types of leasing, including track, full-service, and lease-to-purchase;
  - Using grant anticipation bonds to fund early equipment replacement;
  - Using manufacturers' "buy-back" programs (i.e., repurchase agreements that are negotiated at the time of initial purchase);
  - Using manufacturers' "guaranteed operational cost" programs; and
  - Negotiating for parts pricing and availability as part of equipment-procurement negotiations.
- **Comparing operational and economic impacts various maintenance strategies,** such as

- Using a preventive-maintenance focus versus relying on remedial repairs, and
- Using outsourced versus in-house maintenance.

This research could help transit properties make better informed asset-management decisions, which could reduce operating costs, improve equipment availability, and increase overall service levels. Involving transit industry vendors in this research effort could help identify strategies for lowering asset life-cycle costs while providing an opportunity to see how transit agencies could better ensure the long-term health of the industry's vendor base.

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APPENDIX A

NON-TRANSIT FLEET SUPPLY-CHAIN SURVEY

This appendix contains the Internet survey form used to collect information on the supply-chain link at non-transit heavy-vehicle fleets. This survey was designed to be completed online with survey results collected in a data file for import into a spreadsheet. The web link for this survey was www.transtechmanagement.com/surveyform.htm.

TCRP J-9 Supply Chain Survey

(All numeric fields require the use of whole numbers only - no dollar symbols, commas, periods, etc.)

1. Salutation
   First Name
   Last Name
   Position
   Email Address

   Note: A copy of the final report for this project will be sent to the email address entered.

2. Company/Organization Name

3. Fleet Type

4. Approximate amount of equipment supported by parts inventory.

Equipment type	Number of Units	Average Age	Percentage Leased	Number held as breakdown spares	Units held for spare parts
Automobiles			%		
Buses			%		
Class 7 & 8 truck/tractors			%		
Light-Duty trucks (pickups)			%		
Medium and Heavy-Duty trucks (dump, straight-bed, utility)			%		
Trailers - van or refrigerated			%		
Vans and SUVs			%		

5. Maintenance Operations
   - Number of maintenance locations
   - Average spacing (distance in miles) of maintenance locations
   - Percentage of maintenance performed In-house %

6. Parts Inventory
   - A. Number of parts stocking locations
   - B. Approximate value of annual parts purchases $
   - C. Total value of current parts Inventory $
   - D. Any parts locations not collocated with maintenance facilities? ○ Yes ◉ No
   - E. Inventory Control
     - i. Computerized parts tracking used? ○ Yes ◉ No
     - ii. Use bar coding for parts? ○ Yes ◉ No
     - iii. Have stock classification system such as High-turnover, seasonal, critical, obsolete, or use and ABC inventory system? ○ Yes ◉ No
     - iv. Are non-stock parts tracked? ○ Yes ◉ No
     - v. Are non-stock parts recorded to equipment history? ○ Yes ◉ No
     - vi. Parts usage tracking (by work order and equipment unit)% ○ Yes ◉ No
     - vii. Annual value of stock lost due to theft, loss, deterioration, or obsolescence $
     - vii. How frequently is a physical inventory audit performed?
   - F. Please indicate whether your organization uses the following part inventory performance measures:

Vehicle hours (days) lost waiting for parts	○ Yes	◉ No
Percentage charge or markup on the price of parts	○ Yes	◉ No
Total parts turnover (total parts used / average parts on hand)	○ Yes	◉ No
Annual value of stock lost due to theft, loss, deterioration, or obsolescence	○ Yes	◉ No
Average cost to process a purchase order	○ Yes	◉ No
Number of inventory adjustments	○ Yes	◉ No
Number of lines (and dollar values) of parts inactive in past six months	○ Yes	◉ No
Percentage of repairs delayed due to stock-outs / lack of parts	○ Yes	◉ No
Percentage of parts requests filled from inventory (fill rate)	○ Yes	◉ No
Number of open backorders by line, value, and age	○ Yes	◉ No

7. Parts Sourcing
   A. What percentage of Parts expenditures are standard, off-the-shelf parts? [ ]%
      B. Percentage of off-the-shelf parts purchased locally. [ ]%
         i. Source of parts. Use the drop-down menu to identify the frequency by ranking. Only rank the applicable methods.
            First [ ]
            Second [ ]
            Third [ ]
            If "other" was selected, please list the source here: [ ]
         ii. How parts are selected.. Use the drop-down menu to identify the frequency by ranking. Only rank the applicable methods.
            First [ ]
            Second [ ]
            Third [ ]

If "other" was selected, please list the selection method here:

iii. How ordered?. Use the drop-down menu to identify the frequency by ranking. Only rank the applicable methods.

First
Second
Third
Fourth

If "other" was selected, please list ordering method here:

iv. How delivered?. Use the drop-down menu to identify the frequency by ranking. Only rank the applicable methods.

First
Second
Third

v. How paid?. Use the drop-down menu to identify the frequency by ranking. Only rank the applicable methods.

First
Second
Third

C. Percentage of off-the-shelf parts purchased from outside local area.

%

i. Source of parts. Use the drop-down menu to identify the frequency by ranking. Only rank the applicable methods.

First
Second
Third

If "other" was selected, please list the source here:

ii. How parts are selected.. Use the drop-down menu to identify the frequency by ranking. Only rank the applicable methods.

First
Second
Third

If "other" was selected, please list the selection method here:

iii. How ordered?. Use the drop-down menu to identify the frequency by

ranking. Only rank the applicable methods.

First
Second
Third
Fourth

If "other" was selected, please list ordering method here:

iv. How delivered?. Use the drop-down menu to identify the frequency by ranking. Only rank the applicable methods.

First
Second
Third

v. How paid?. Use the drop-down menu to identify the frequency by ranking. Only rank the applicable methods.

First
Second
Third

E. Do you have repair parts that require reengineering and/or fabrication? ○ Yes ◉ No

i. If yes, please indicate what percentage of reengineering and fabrication are done **in-house**

In-house Reengineering: %

In-house Fabrication %

Thank you for completing this survey. A copy of the completed report will be sent to the email address entered in question one.

Submit

APPENDIX B

NON-TRANSIT FLEET SUPPLY-CHAIN SURVEY RESULTS

This appendix contains the data collected from the Internet survey form on the supply-chain link at non-transit heavy-vehicle fleets. Survey response was insufficient to support any additional analysis of this data.

salutation	first_name	last_name	emp_position	submit_by	company_name	fleet_type	auto_number_of_units	auto_average_age	auto_percent_leased	auto_percent_owned	auto_number_held	auto_number_spare	bus_number_of_units	bus_average_age
(none)	Dave	Schiller	Operations & Equipment Mgr.	dave.schiller@dnr.state.mn.us	Minnesota Dept. of Natural Resources	Public Fleet	100	3					2	4
Mr.	Andrew	Aiton	Director - Fleet Services	andy.aiton@gnb.ca	Vehicle Management Agency	Public Fleet	135	4	5				1200	6
Mr.	Cary	Tower	Fleet Superintendent	cxtower@cityofdenton.com	City of Denton, Tx.	Public Fleet	200	3			10		13	5
Mr.	David	Pitts	Fleet Manger	David.Pitts@fulton.co.ga.us	Fulton County Central Maintenance Facili	Public Fleet	1700	4					100	5
(none)	Dennis	Saijo	Manager - Fleet Maintenance	dennis_saijo@bc.com	Boise Cascade Trucking	Private Fleet								
Mr.	David	Holland	Director, Fleet Services	David_Holland@eott.com	EOTT Energy Corp.	Private Fleet								
(none)	Keith	Moyle	Director-Fleet Services	kmoyle@wpsr.com	Wisconsin Public Service Corp.	Utility Fleet								
Mr.	Gerald	Krueger	Fleet Administrator	jerrykrueger@alliant-energy.com	Alliant Energy	Utility Fleet	10	4			1			
Mr.	Joseph	Hall	Supervisor Fleet Parts and Warranty	joseph.e.hall@bge.com	Baltimore Gas Electric	Utility Fleet	297		75				1	

fleet_type	bus_percent_leased	bus_percent_owned	bus_number_held	bus_number_spare	class7_8_number_of_units	Class7_8_average_age	Class7_8_percent_leased	Class7_8_percent_owned	Class7_8_number_held	Class7_8_number_spare	light_duty_number_of_units	light_duty_average_age	light_duty_percent_leased	light_duty_percent_owned	light_duty_number_held	light_duty_number_spare	meduim_heavy_duty_number_of_units	medium_heavy_duty_average_age	medium_heavy_duty_percent_leased	medium_heavy_duty_percent_owned	medium_heavy_duty_number_held	medium_heavy_duty_number_spare	trailers_vans_number_of_units	trailers_vans_average_age	trailers_vans_percent_leased	trailers_vans_percent_owned	trailers_vans_number_held	trailers_vans_number_spare	vans_suv_number_of_units	vans_suvs_average_age	vans_suv_percent_leased	vans_suv_percent_owned	vans_suv_number_held	vans_suv_number_spares	number_of_maint_locations	average_spacing_of_locs	percent_of_in_house_maint	percent_of_out_sourced_maint	number_of_parts_stocking_locations	value_of_parts_purchases	tot_value_of_parts_inv	parts_collocated
Public Fleet					4	8					1400	5			25		120	7	5		5		4	10					100	4	5				8	90	25		3	600000	30000	
Public Fleet			120	50	3	4					1060	4					570	8					10	5					200	5					30	40	85		30	7500000	5000000	
Public Fleet			2		5	2					300	4			5		87	4			3		150	5					30	3					2	5	85		1	800000	200000	
Public Fleet					100	6					200	5					200	6					75	6					200	5					3	25	75		3	800000	1500000	
Private Fleet					68	4	30				4	4											367	6	10										3	400	80		1	425000	101000	
Private Fleet					247	3	100		20		52	4					8	8																	14	250	40		14	400000	185000	
Utility Fleet					2	4					400	5			20		300	5			10		2	4					100	5					15	30	90		2	1500000	200000	Yes
Utility Fleet					5	6					450	5			30		260	8			10		350	10			5		150	5			5		4	65	90		4	1900000	400000	
Utility Fleet					9						447		90				523		50																6	10	90		6	2000000	200000	

fleet_type	computerized_parts_tracking	bar_code_parts	stock_class_system	non_stocked_tracked	non_stock_recorded	parts_usage_tracking	annual_stock_lost_dollars	frequency_of_inv_audit	vehicle_hours_lost	pct_charge_or_mark_up	total_parts_turnover	annual_value_of_stock_lost	average_cost_to_process_po	number_of_inventory_adjustments	number_of_lines_inactive	percentage_delayed_lack_of_parts	percentage_filled_from_inventory	nunber_of_open_backorders	part_standard_pct	parts_custom_pct	pct_parts_local	rank1_source_method_local
Public Fleet						Yes	1000	Annually		Yes									30		90	Local Parts Distributors
Public Fleet	Yes		Yes	Yes	Yes	Yes	25000	Quarterly			Yes	Yes	Yes	Yes	Yes		Yes	Yes	70		75	Local Parts Distributors
Public Fleet	Yes	Yes	Yes	Yes	Yes	Yes	5000	Cycle-count method used	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes		50		75	Local Parts Distributors
Public Fleet	Yes			Yes	Yes	Yes	12000	Quarterly						Yes	Yes				50		90	Local Equipment Dealers
Private Fleet							8000	Cycle-count method used											75		90	Local Parts Distributors
Private Fleet	Yes		Yes		Yes	Yes	5000	Annually							Yes				85		95	Local Parts Distributors
Utility Fleet							2000	Infrequently, less than once a year											50		75	Local Parts Distributors
Utility Fleet	Yes			Yes	Yes	Yes	10000	Annually			Yes			Yes	Yes				80		75	Local Parts Distributors
Utility Fleet	Yes	Yes	Yes	Yes	Yes	Yes		Annually	Yes	Yes	Yes	Yes	Yes		Yes	Yes	Yes	Yes	80		80	Local Parts Distributors

fleet_type	rank2_source_method_local	rank3_source_method_local	other_Souce_method_local	rank1_selection_method_local	rank2_selection_method_local	rank3_selection_method_local
Public Fleet	Local Equipment Dealers	Other	specialty vendors, such as law enforcement equipment	From parts catalogs	Other	Via the internet
Public Fleet	Local Equipment Dealers	(none)		From parts catalogs	(none)	(none)
Public Fleet	Local Equipment Dealers	Local Parts Distributors		From parts catalogs	Via the internet	(none)
Public Fleet	Local Parts Distributors	(none)		From parts catalogs	Other	(none)
Private Fleet	Local Equipment Dealers	(none)		From parts catalogs	(none)	(none)
Private Fleet	Local Equipment Dealers	(none)		(none)	(none)	(none)
Utility Fleet	Local Equipment Dealers	Other	OEM supplier	From parts catalogs	(none)	(none)
Utility Fleet	Local Equipment Dealers	Other	Manufacturer	From parts catalogs	(none)	(none)
Utility Fleet	Local Equipment Dealers	(none)		(none)	(none)	(none)

fleet_type	other_selection_method_local	rank1_ordering_method_local	rank2_ordering_method_local	rank3_ordering_method_local	rank4_ordering_method_local	other_ordering_method_local	rank1_delivery_method_local
Public Fleet	from vendor stock	By Telephone	By Fax	By Internet	(none)	mailorder	Delivered by vendor
Public Fleet		By Telephone	By Fax	(none)	(none)		Delivered by vendor
Public Fleet		By Telephone	By Fax	By Internet	(none)		Delivered by vendor
Public Fleet	phone solicitation	By Telephone	By Fax	(none)	(none)		Picked-up by employee
Private Fleet		By Telephone	(none)	(none)	(none)		Delivered by vendor
Private Fleet		By Telephone	By other electronic means	By Fax	(none)		Delivered by vendor
Utility Fleet		By Telephone	(none)	(none)	(none)		Delivered by vendor
Utility Fleet		By Telephone	By other electronic means	(none)	(none)		Picked-up by employee
Utility Fleet		By Fax	By Telephone	By Internet	(none)		Delivered by vendor

fleet_type	rank2_delivery_method_local	rank3_delivery_method_local	rank1_payment_method_local
Public Fleet	Picked-up by employee	Delivered by third party (such as courier or freight company)	Issue P.O. and pay invoice
Public Fleet	Picked-up by employee	Delivered by third party (such as courier or freight company)	Issue P.O. and pay invoice
Public Fleet	Picked-up by employee	Delivered by third party (such as courier or freight company)	Company credit card/ purchasing card
Public Fleet	Delivered by vendor	Delivered by third party (such as courier or freight company)	Issue P.O. and pay invoice
Private Fleet	Picked-up by employee	(none)	Prepaid via company check
Private Fleet	Delivered by third party (such as courier or freight company)	Picked-up by employee	Company credit card/ purchasing card
Utility Fleet	Picked-up by employee	Delivered by third party (such as courier or freight company)	Company credit card/ purchasing card
Utility Fleet	Picked-up by employee	Delivered by third party (such as courier or freight company)	Company credit card/ purchasing card
Utility Fleet	Picked-up by employee	Delivered by third party (such as courier or freight company)	Company credit card/ purchasing card

fleet_type	rank2_selection_method	rank3_selection_method	other_selection_method2	rank1_ordering_method	rank2_ordering_method	rank3_ordering_method	rank4_ordering_method	other_ordering_method	rank1_delivery_method
Public Fleet	From parts catalogs	(none)		By Telephone	By Fax	By Internet	(none)		Delivered by vendor
Public Fleet	(none)	(none)		By Telephone	By Fax	(none)	(none)		Delivered by third party (such as courier or freight company)
Public Fleet	Via the internet	(none)		By Telephone	By Internet	By Fax	(none)		Delivered by vendor
Public Fleet	(none)	(none)		By Telephone	By Fax	(none)	(none)		Picked-up by employee
Private Fleet	(none)	(none)		By Telephone	(none)	(none)	(none)		Delivered by third party (such as courier or freight company)
Private Fleet	(none)	(none)		By Telephone	(none)	(none)	(none)		Delivered by vendor
Utility Fleet	(none)	(none)		By Telephone	By Fax	(none)	(none)		Delivered by third party (such as courier or freight company)
Utility Fleet	(none)	(none)		By Telephone	By Fax	(none)	(none)		Delivered by third party (such as courier or freight company)
Utility Fleet	(none)	(none)		By Fax	By Telephone	By Internet	(none)		Delivered by vendor

fleet_type	rank2_payment_method_local	rank3_payment_method_local	pct_parts_non_local	rank1_source_method	rank2_source_method	rank3_source_method	other_souce_method	rank1_selection_method
Public Fleet	Company credit card/ purchasing card	(none)	5	From regional/natioinal distributor	From regional/natioinal distributor	(none)		From parts catalogs
Public Fleet	Company credit card/ purchasing card	(none)	25	From regional/natioinal distributor	From manufacturer	(none)		From parts catalogs
Public Fleet	Issue P.O. and pay invoice	(none)	25	From regional/natioinal distributor	From manufacturer	(none)		From parts catalogs
Public Fleet	Company credit card/ purchasing card	(none)	10	From regional/natioinal distributor	From manufacturer	(none)		From parts catalogs
Private Fleet	(none)	(none)	15	From manufacturer	(none)	(none)		From parts catalogs
Private Fleet	Issue P.O. and pay invoice	(none)	5	From manufacturer	From regional/natioinal distributor	(none)		From parts catalogs
Utility Fleet	Issue P.O. and pay invoice	(none)	20	From manufacturer	From regional/natioinal distributor	(none)		From parts catalogs
Utility Fleet	Issue P.O. and pay invoice	(none)	40	From regional/natioinal distributor	From manufacturer	(none)		From parts catalogs
Utility Fleet	Prepaid via company check	Issue P.O. and pay invoice	10	From regional/natioinal distributor	(none)	(none)		From parts catalogs

fleet_type	rank2_delivery_method	rank3_delivery_method	rank1_payment_method
Public Fleet	Delivered by third party (such as courier or freight company)	(none)	Issue P.O. and pay invoice
Public Fleet	(none)	(none)	Issue P.O. and pay invoice
Public Fleet	Picked-up by employee	Delivered by third party (such as courier or freight company)	Company credit card/ purchasing card
Public Fleet	Delivered by vendor	Delivered by third party (such as courier or freight company)	Issue P.O. and pay invoice
Private Fleet	(none)	(none)	Issue P.O. and pay invoice
Private Fleet	Delivered by third party (such as courier or freight company)	(none)	Issue P.O. and pay invoice
Utility Fleet	(none)	(none)	Company credit card/ purchasing card
Utility Fleet	Delivered by vendor	(none)	Company credit card/ purchasing card
Utility Fleet	Picked-up by employee	Delivered by third party (such as courier or freight company)	Company credit card/ purchasing card

fleet_type	rank2_payment_method	rank3_payment_method	requires_fabrication_or_reengineering	in_house_reengineering_pct	outsourced_reengineering_pct	in_house_fabrication_pct	outsourced_fabrication_pct	Survey Date	Survey Time
Public Fleet	Company credit card/ purchasing card		Yes	75		75		#######	17:02:58
Public Fleet	(none)		Yes	25		60		#######	11:35:33
Public Fleet	Issue P.O. and pay invoice					50		#######	9:20:19
Public Fleet	Company credit card/ purchasing card		Yes	10		10		#######	16:01:22
Private Fleet	(none)							#######	12:23:39
Private Fleet	(none)							#######	8:35:45
Utility Fleet	Issue P.O. and pay invoice		Yes	5		50		#######	14:01:05
Utility Fleet	Issue P.O. and pay invoice							#######	16:21:58
Utility Fleet	Prepaid via company check	Issue P.O. and pay invoice	Yes			20		#######	9:10:45

APPENDIX C
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Abbreviations used without definitions in TRB publications:

AASHO	American Association of State Highway Officials
AASHTO	American Association of State Highway and Transportation Officials
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
FAA	Federal Aviation Administration
FHWA	Federal Highway Administration
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
IEEE	Institute of Electrical and Electronics Engineers
ITE	Institute of Transportation Engineers
NCHRP	National Cooperative Highway Research Program
NCTRP	National Cooperative Transit Research and Development Program
NHTSA	National Highway Traffic Safety Administration
SAE	Society of Automotive Engineers
TCRP	Transit Cooperative Research Program
TRB	Transportation Research Board
U.S.DOT	United States Department of Transportation