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Contractor's Final Report

Inventory Management for Bus and Rail Public Transit Systems

FINAL REPORT

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and
The Michael Kilpatrick Consulting Group

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ABSTRACT

This report documents and presents the results of a study of inventory management for bus and rail public transit systems. A national mail survey was conducted of transit properties. Analysis was then conducted of the relative merits of the full range of organizational structures, policies, and practices used for inventory management. Indices useful for inventory management were then developed and defined. These indices include stockouts, turnover ratios, inventory cost per vehicle, demand satisfaction, number of stock-keeping units (SKUs), shrinkage, and carrying costs based on such qualifying factors as scale, fleet size and standardization, fleet composition, mileage, etc. Significant relationships between performance indices and organizational profiles were also identified. The primary product of this study is a readily usable reference guide to assist transit professionals in better understanding, evaluating, and managing inventory. This Inventory Management Handbook summarizes inventory control techniques appropriate to the transit industry, decision-making techniques, and benchmark references.

SUMMARY

During the past several years, many private sector organizations have responded to competitive pressures and financial constraints by expanding their view of inventory as a potential source of cost reduction and as a measure of production efficiency. More recently, public sector organizations, including public transit agencies, have also begun to focus on improving the management of their inventories.

In order to fully understand and measure the impacts of inventory management on the organization as a whole, increased attention is being paid to identifying new and better ways for measuring performance. Traditionally, many performance measurements have been used to measure inventory efficiency and effectiveness in *absolute* terms. Examples of this type of performance indicator are inventory value and number of stockouts. However, experience has shown that agencies can gain even greater efficiencies when inventory performance is measured in *relative* terms, or when one measurement of performance is presented in relation to some other measure. Examples of relative performance measures are the number of backorders as a percentage of inventory and percent of obsolete and excess inventory as a percentage of inventory costs. The implementation of new and more meaningful indicators of inventory performance, coupled with a focused emphasis on utilizing materials management concepts adapted from the private sector, present substantial opportunities for transit organizations to improve inventory management and operating efficiency.

The objectives of this research are to identify and describe those inventory control techniques appropriate to the public transit industry, to establish benchmarks, and to create a decision modeling guide that can be used by transit professionals for better inventory management.

Strategies used in this research to accomplish these objectives include (1) identifying those inventory management practices and techniques that will best assist transit agencies in meeting inventory management objectives; (2) determining the effects of different organizational structures, policies, and practices used for inventory management on satisfying inventory management goals and inventory service objectives, and; (3) defining the conditions and developing the strategies necessary to ensure the most effective and efficient implementation of inventory control techniques, decision-making techniques, and performance indices appropriate to the transit industry.

APPROACH

The approach followed in conducting this research project consisted of a national mail survey of transit properties followed by data analysis. The survey and data collection and analysis tasks consisted of the following: (1) a national survey of transit agencies; (2) analyses of the relative

regarding the competence and attitude of the individuals actually involved with inventory management at transit agencies. Therefore, the conclusions should be developed into hypotheses for more detailed testing in a more controlled environment where individual effects can be more effectively isolated and quantified.

I. INTRODUCTION AND RESEARCH APPROACH

1.1 THE NEED TO BETTER UNDERSTAND, EVALUATE AND MANAGE INVENTORY IN PUBLIC TRANSIT ORGANIZATIONS

During the past several years, many private sector organizations have responded to competitive pressures and financial constraints by expanding their view of inventory as a potential source of cost reduction and as a measure of production efficiency. More recently, public sector organizations, including public transit agencies, have also begun to focus on improving the management of their inventories.

Unlike many other industries, public transit embraces a diverse mixture of maintenance activities resulting in complex material demand patterns. These activities consist of a combination of preventive maintenance, breakdown maintenance, unit (component) repair/rebuilds, and maintenance projects for a mixture of rolling stock (both revenue and non-revenue), track and structure, and physical facilities. In addition to focusing on the quantity and mix of inventory materials, increased emphasis is being placed on the effect of inventory service levels on the property's ability to meet goals, the impact of carrying costs on inventory value, and the importance of turnover.

Also integral to increasing the ability of transit agencies to more effectively manage inventory, is the recognition of several constraints that may cause unanticipated fluctuations in inventory levels. These constraints include a mixture of fleet series, technologies, and configurations; mandated procurement regulations; federal and state mandates for new technologies required by such legislation as the Americans with Disabilities Act (ADA) and the Clean Air Act; and issues associated with custom equipment, such as long lead times and the lack of available life cycle and component mean time between failure history.

Materials managers have always been faced with dealing with the two conflicting objectives of inventory management, namely, to provide maximum parts availability while keeping inventory investment low. To further exacerbate the problem, different organizations within the transit agency such as maintenance, accounting, and operations, also frequently monitor inventory performance, often using different measures. In order to improve service quality and efficiency, managers are increasingly looking at "new" inventory management concepts such as "materials requirements planning" (MRP), "just-in-time" (JIT), "total quality management" (TQM), and "total cycle time management".

In order to fully understand and measure the impacts of inventory management on the organization as a whole, increased attention is being paid to identifying new and better ways for measuring performance. Traditionally, many performance measurements have been used to measure inventory efficiency and effectiveness in *absolute* terms. Examples of this type of

performance indicator are inventory value and number of stockouts. However, experience has shown that agencies can gain even greater efficiencies when inventory performance is measured in *relative* terms, or when one measurement of performance is presented in relation to some other measure. Examples of relative performance measures are the number of backorders as a percentage of inventory and percent of obsolete and excess inventory as a percentage of inventory costs. The implementation of new and more meaningful indicators of inventory performance, coupled with a focused emphasis on utilizing materials management concepts adapted from the private sector, present substantial opportunities for transit organizations to improve inventory management and operating efficiency.

A review of published literature and research over the past ten years (Appendix A) has identified very little new information on inventory management, specifically as it relates to the public transit industry. Indeed, our literature search found that very little research that has been conducted in the area of maintenance inventory management for any industry. Most of the information found has been included as an adjunct to fleet maintenance or information systems. Nonetheless, the research findings resulting from this project indicate that significant gains can be made even within the constraints discussed above through innovative adaptation and application of the appropriate inventory control techniques.

1.2 RESEARCH OBJECTIVES

The objectives of this research are to identify and describe those inventory control techniques appropriate to the public transit industry, to establish benchmarks, and to create a decision modeling guide that can be used by transit professionals for better inventory management.

Strategies used in this research to accomplish these objectives include (1) identifying those inventory management practices and techniques that will best assist transit agencies in meeting inventory management objectives; (2) determining the effects of different organizational structures, policies, and practices used for inventory management on satisfying inventory management goals and inventory service objectives, and; (3) defining the conditions and developing the strategies necessary to ensure the most effective and efficient implementation of inventory control techniques, decision-making techniques, and performance indices appropriate to the transit industry.

1.3 SCOPE OF THE STUDY

Public transit systems maintain inventories of parts and supplies to support their operations. Successful inventory management requires a comprehensive understanding of how such things as modes, fleet size, fleet age, organizational structure, funding sources, and budgetary constraints impact the type, quantity, usage, and other characteristics of a transit agency's material assets. A wide variety of inventory management practices and techniques are used in the public transit industry, some with greater success than others. However, there is a

lack of consensus on inventory performance measures. Not until those inventory measures are identified that truly provide valuable information to those responsible for managing inventory, will transit managers be able to evaluate the impacts of inventory management on the entire operation. The identification of the most useful inventory performance measures, coupled with performance indices for comparison and a useful decision modeling guide, present substantial opportunity for transit organizations to improve inventory management.

The primary product of this study is a readily usable reference guide to assist transit professionals in better understanding, evaluating, and managing inventory. This Inventory Management Handbook summarizes inventory control techniques appropriate to the transit industry, decision-making techniques, and benchmark references. Because of the wide variance in the size of the transit agencies studied and the services provided, the information presented in the Handbook should be construed as a framework for improving inventory management and customer service.

1.4 RESEARCH APPROACH

The approach followed in conducting this research project consisted of a national mail survey of transit properties followed by data analysis. The survey and data collection and analysis tasks consisted of the following: (1) a national survey of transit agencies; (2) analyses of the relative merits of the full range of organizational structures, policies, and practices used for inventory management; (3) the development and definition of indices useful for inventory management including but not limited to stockouts, turnover ratios, inventory cost per vehicle, demand satisfaction, stock-keeping units (SKUs), shrinkage, and carrying costs based on such qualifying factors as scale, fleet size and standardization, fleet composition, mileage, etc., and; (4) identification of significant relationships between performance indices and organizational profiles.

The critical issues addressed throughout the data collection and analyses tasks included:

- How do fleet demographics (age, size, mix, etc.) affect inventory levels?
- What methods are used in the industry to define, categorize and account for inventory?
- What inventory performance measures or benchmarks are used?
- Where is the inventory control function located in the organization?
- Is there an inventory manager and to whom does he or she report?
- Who is responsible for inventory accountability?
- Who sets inventory levels and stocking policies?
- Who has access to inventory?
- Who is responsible for security?
- Who is responsible for material budgets?
- What are the hours of storeroom operation vs. maintenance?
- Who is responsible for forecasting inventory requirements?

Other issues addressed included the role of automation in inventory management and projects or activities undertaken by agencies to optimize inventory control over the past two years and the planned activities for the next two years.

1.4.1 Transit System Survey

All 300 plus public transit systems that were members of the American Public Transit Association (APTA) during calendar years 1993 and 1994 were surveyed. Salient points addressed in the survey and subsequent data analysis focused on the following areas:

1. Profile of agency service area and operating characteristics;
2. Profile of the agency's vehicle fleet including size, composition, age, number of models, etc.;
3. Organizational structure, responsibilities and reporting relationships;
4. Inventory management practices including definitions of inventory, security responsibilities and measures, and storehouse networks and storekeeping practices;
5. Inventory management and replenishment including methods used, accountability practices and procedures, and composition;
6. Inventory management performance including values and levels, transactions, information available, common issues addressed, and performance measures, and;
7. Technology and information systems currently in use.

The purpose behind the survey was to develop a database of the current inventory management practices employed by a representative sample of the transit industry. A copy of the survey is included in Appendix B.

1.4 ORGANIZATION OF THE REPORT

Chapter 2 presents a generally accepted definition of inventory and the inventory management issues identified in the survey. Chapter 3 presents a discussion of the different organizational structures, policies, procedures, practices, performance measures, and organizational goals and objectives utilized by the transit systems examined. The Chapter also presents an evaluation of the relative merits of the different organizational structures, policies and practices relative to their ability to meet inventory management goals and service objectives. Research findings on the performance indices used for assessing inventory management are contained in Chapter 4. Included in this chapter are discussions of the various indices used, relationships between values of various indices and a decision modeling guide for identifying benchmark values. In Chapter 5, the relationships between performance measures and organizational profiles are presented. Included are discussions of the appropriate thresholds for modifying organizational structures or taking other steps to increase accountability and control.

II. CRITICAL ISSUES IN INVENTORY MANAGEMENT

2.1 TRANSIT SYSTEMS AND INVENTORY MANAGEMENT

The survey and data analysis disclosed a wide discrepancy in not only how transit agencies define inventory but also in the varying methods used to manage, characterize and account for inventory. Many of these differences are a result of the individual transit properties' fleet size and composition, but also the size of the organization as a whole, the placement of the inventory management function within the organization and the use of technology in controlling inventory. The following are the principal questions that emerged as a result of the preliminary data analysis:

Are all inventory management decisions relevant to public transit organizations of all sizes? A majority of the smaller transit systems could not respond to many of the questions regarding inventory performance. While such basic information as number of material issues and receipts is frequently captured, the more sophisticated indicators of inventory performance such as percent of unfilled orders and stockouts are not. This may be due in part to the operating constraints of the smaller organizations and the lack of training in inventory management techniques. Even larger transit systems could not always provide information on such indices as backorders and inventory carrying costs.

How does placement of the inventory management function in the organization relate to inventory performance? Some transit systems do not have a dedicated inventory control function. In other cases, responsibility for inventory management may be spread through more than one organizational unit with no one individual responsible for the organization's overall inventory management performance. In still other situations, responsibility for inventory management may be located at a sub-department level under a department such as administration, operations or finance. Only a small number of agencies reported a dedicated inventory management function at the department level or higher.

How does the definition of inventory as characterized by individual public transit agencies really affect inventory performance? Our survey responses show that the definition of inventory varies widely among transit organizations. Many of the respondents do not have a formal inventory management policy. In addition, inventory was most often defined very simply as either rolling stock parts and supplies or items on-hand. Such inventory parameters as minimum dollar value per item or minimum annual usage were seldom employed. In this study we examine the factors used in defining inventory to determine how critical they are to inventory performance.

On the following pages we discuss the issues identified in the survey and present broad findings. Chapters 3 and 4 present the detailed survey and analyses results.

2.2 PROFILE OF THE INVENTORY CONTROL ISSUES IDENTIFIED IN THE SURVEY

This section of the report presents a summary of the issues identified in the survey in managing, characterizing and accounting for inventory. Each of the seven sections of the survey are addressed separately. Following this section is a discussion on the generally accepted definition of inventory that emerged from the survey.

2.2.1 Agency Service Area and Operating Characteristics

Section I of the survey provides a profile of the transit properties responding to the survey. During the preliminary analysis, this section of the survey was used to determine if the sample of respondents represented a cross-section of the transit industry as a whole. Data examined included service area, operating costs, and material purchases by mode. Other statistics collected, as reported in Section 15 of the 1964 Urban Mass Transportation Act, Amended, "Uniform System of Accounts and Records and Reporting System" included such operating data as annual ridership, annual passenger miles, annual revenue miles, total route miles, total track miles, and total number of employees. Based on our analysis, we determined that the respondents did represent a cross-section of the public transit industry in terms of geographic location and population area served.

2.2.2 Vehicle Fleet Composition

The second section of the survey focused on fleet size, composition, and age. Common issues identified as having a potential effect on inventory include fleet size, fleet mix by vehicle type, percent of vehicles of foreign manufacture, number of different vehicle models, average annual miles per vehicle, and average age of the fleet.

Another variable identified as possibly affecting inventory performance and that demonstrates the complexity of transit fleets is in the percent of foreign manufactured vehicles. Survey results show that over ninety-five percent of buses, commuter rail cars, and commuter locomotives are manufactured in the United States. However, for light and heavy rail cars only seventy-seven percent are manufactured domestically and the number drops to forty-eight percent for trackless trolleys. In later chapters, we discuss the impact, if any, of the variations in the number of vehicle models and percent of foreign manufacture on inventory levels. Our preliminary analysis showed that the respondents represented a cross-section of the public transit industry in terms of the mix of bus, rail, and other modes of transportation.

2.2.3 Inventory Management Organizational Structure, Responsibilities and Reporting Relationships

Of consequence in determining the issues that may affect inventory management is the structure and placement of the inventory management function within the transit organization, the

formal and informal inventory responsibilities of inventory and non-inventory management personnel, and the direct and indirect reporting relationships. Also of interest are the distribution of inventory management responsibilities throughout the organization, particularly those for material planning and forecasting, and accountability practices and procedures.

Approximately forty percent of survey respondents reported the Maintenance Department as the organizational unit responsible for managing inventory. This appears to be related to the size of the transit agency and its fleet of vehicles. Administration, Finance, and Procurement were also identified as responsible organizational units. Less than ten percent of respondents identified a dedicated Materials Management Department as the responsible organization. Ninety-three percent of respondents reported the management level ultimately responsible for inventory as either the executive or department levels.

When asked to provide information on total inventory management costs, many of the respondents did not answer this question. Follow-up interviews confirmed that many of the respondents did not track this information.

Size of inventory management staff provided another area for analysis. As expected, staff size was most frequently tied to the size of the vehicle fleet and the organization. However, some respondents reported some inventory management staff as being located outside of the organization accountable for management of the inventory. Materials management activities identified included (1) inventory planning and forecasting; (2) reorder methods and quantities; (3) material ordering; (4) material issuance; (5) receiving and storing materials; (6) record keeping; (7) physical inventory; (8) cycle counting; (9) inventory adjustments/write-offs; (10) material expediting, and; (11) tracking and filling back orders. Over half of the responding agencies reported no written procedures manual.

2.2.4 Inventory Management Practices

Section four of the survey focused on (1) specific inventory management goals and objectives; (2) storekeeping responsibilities and measures; (3) inventory management and replenishment methods, and; (4) catalog and parts management. The definition of inventory is discussed in Section 2.3.

2.2.4.1 Inventory Management Goals and Objectives

The primary policy objective stated by the survey respondents is to provide increased service level. The second major objective is to decrease inventory levels. These two conflicting objectives demonstrate the criticality of the issues associated with managing inventory. Other objectives given include improving cost effectiveness, increasing security, increasing turnover, improving management information, increasing accuracy, increasing value and quality control, and implementing just-in-time deliveries.

2.2.4.2 Storekeeping

Issues identified as potentially impacting material control, levels, and accountability include number and location of storehouses, storehouse network configuration, security, hours of operation, and inventory information available at the storehouses. For purposes of uniformity in reporting, primary storehouses were defined as major warehouses, central stores, or distribution centers. Secondary storehouses were defined as local on-site stockrooms.

Approximately half of all storehouse networks were reported as consisting of one primary storeroom located in a single maintenance facility. An additional third of storehouse networks consist of a combination of primary and secondary storerooms. Five percent of respondents reported their storehouse network as being comprised of several independent storehouses with the remaining respondents reporting some other type of configuration. Approximately eighty percent of all storehouses are located within maintenance facilities with twenty percent of respondents reporting some storehouses not located in maintenance facilities.

A second issue deals with storehouse security and controlled access versus "open" storerooms. Nearly half of all primary storehouses are controlled while only about one quarter of secondary storehouses have controlled access. Over half of all primary storehouses operate on a five-day schedule with nearly one-third operating on a seven-day schedule. Of specific interest are hours of operation, percent of full coverage, and responsibility for storeroom accountability when no storekeeper is present. Hours of operation range from eight hours per day to twenty-four hours per day. Primary storehouses are fully covered less than half of the time. During those times when no storekeeper is present, responsibility rests with the maintenance supervisor approximately half of the time followed by a mechanic or another individual outside of the maintenance department. As a result, opportunities may exist for less than one hundred percent accountability.

For secondary storehouses, approximately fifty percent operate five days a week with one-third operating seven days a week. Approximately one-third operate on an eight-hour schedule with another third operating twenty-four hours per day. Secondary storehouses are fully covered approximately one-quarter of the time. When a storekeeper is not present, maintenance supervisors are responsible the majority of the time followed by mechanics.

Responsibility for storehouse management is a third issue. In nearly half of the responses, inventory management is responsible for storehouse management. However, maintenance, operations, or some other organization has the responsibility the remaining fifty percent of the time. For secondary storehouses, responsibility is equally divided between inventory management and maintenance.

Availability of inventory information at the storehouses is a final critical issue presented in this section of the survey. Ninety percent of survey respondents have access to information on the number of parts on-hand, usage, and item cost. Seventy percent of respondents have access to information on items on order by date, items received by date, items out of stock, and back orders.

2.2.4.3 Inventory Management and Replenishment

Inventory management and replenishment issues focus on replenishment and inventory stratification methods and the setting of target inventory and service levels. Specific issues include:

- What inventory replenishment methods are used and under what conditions?
- How is inventory stratified?
- What percentage of inventory is classified as safety stock?
- How are obsolete and excess items identified?
- Are target inventory levels and target service levels set and if so, how?

The overwhelming majority of transit properties reported using the min/max method for the daily replenishing of material needs. Often, this method is used in conjunction with maintenance forecasts and project or campaign requirements to meet special needs. ABC classifications were most frequently used for stratifying inventory, followed by commodity class.

Safety stock was defined for the survey participants as "a quantity of stock to protect against fluctuations in demand and/or supply". When asked the percentage of inventory classified as safety stock, only two-thirds of respondents answered. Of those that answered, half identified the percentage of safety stock as ten percent or less. Another twenty-five percent stated that between eleven and twenty percent of the inventory was classified as safety stock. The remaining respondents classified safety stock as comprising between twenty-one and sixty percent of the inventory. The number and range of responses indicates that there may be some uncertainty as to either what constitutes safety stock or the amount of material representing safety stock.

Finally, fifty-eight percent of respondents reported setting target inventory levels but only thirty-six percent reported setting target service levels.

2.2.4.4 Catalog/Parts

This section of the survey focuses on issues regarding the management of inventory and maintenance parts. Only fifty percent of transit agencies publish a parts catalog. While many transit systems manufacture and/or repair components in-house, only thirty percent track these items as "bad-order (failed components) awaiting repair" in inventory. This is in contrast to the eighty percent of agencies that stock repairable components in inventory.

Items designated as "free" or "open" stock include nuts and bolts and grease, oil, and fluids. Items listed as stocking out most often include filters, brake parts, bulbs and electrical items, body parts, cleaning supplies, and nuts, bolts and fasteners. The most common method for valuing parts are average cost, followed by first in first out (FIFO), and last in first out (LIFO).

2.2.5 Inventory Management Performance

Section V of the survey contained questions on the measurements or benchmarks currently used and their values. Most agencies responding to the survey were able to provide information on total inventory dollars on-hand and average dollar usage per month. Similarly, many respondents also routinely measure basic inventory transaction such as issues, receipts, returns to stock, returns to vendors, and transfers between storehouses.

For inventory forecasting, however, while two-thirds of transit agencies reported that they do monitor inventory forecasts against actual inventory level or usage, only slightly more than one-third could provide the average inventory forecast error. This implies that there may be no formal mechanism for measuring forecasts against actual usage or that those individuals responsible for the performance are not informed of discrepancies between forecasts and usage.

Other questions measuring inventory performance issues included percent of unfilled orders due to lack of material; percent of user requested items filled from inventory, average time to fill backorders, average number of vehicles held out-of-service due to lack of parts; percent of maintenance hours lost waiting for parts; percent of inventory that is excess or obsolete; turnover rate, and; total number of stockkeeping units (SKU's). While many of the largest properties did provide information for these indices, many of the medium-size agencies measure only about half and the smallest properties do not track these indices.

Survey results indicated that the way in which transit agencies measure and track stockouts is an additional issue in measuring inventory performance. Respondents generally fell into one of two categories: those that measure stockouts as zero items in inventory and those that measure stockouts as no items available when requested. As a further complication, some agencies count only the initial occurrence of the stockout while other agencies report stockouts each time the item is requested until the out of stock item is received into inventory. Either way of measuring stockouts is correct, however, there are opportunities for both over and under reporting stockouts which may result in benchmarking implications.

When survey respondents were asked to describe how such inventory performance indicators as inventory levels, accuracy, customer service, inventory management performance, physical inventory results and unfilled demand were measured, results were mixed. Measurements described for inventory accuracy, physical inventory results, and unfilled demand indicators were generally sound. Measurements described for inventory level, customer service level, and inventory management performance indicated that many properties either do not understand how these indicators should be measured or that they do not have the means to capture such information.

Backorders were another measurement that is an issue for transit agencies. While most respondents indicated that they define backorders as vehicle downtime waiting for parts, most do not actually track this statistic.

When properties were asked to provide information on carrying costs (shrinkage, obsolescence, insurance, cost of capital, spoilage, cost of stores space), most could not report total carrying costs. As a result, many transit agencies are not capturing the true cost of managing inventory.

Questions about cycle counts show that slightly more than one third of respondents have fewer than five percent of items out of balance. An additional thirty percent of respondents reported between five and ten percent of items out of balance. For physical inventories, twice as many respondents reported absolute dollar variance and absolute percent variance figures as reported number and percent of part numbers out of balance.

Survey results for resolution of such common inventory issues as long lead times, scarcity, fragile or short shelf life, foreign manufacture, insurance items, hazardous material, high "street value", and Buy America indicate that a large majority of transit agencies are responding proactively.

2.2.6 Technology and Information Systems

The last section of the survey explored issues associated with the use or lack of automated systems and such technology as bar coding. Nearly ninety percent of respondents use an automated inventory management system to capture some inventory data. Approximately 15 percent use bar-coding for some functions. An additional fifteen percent use such new or emerging technology as swipe cards, light pens, hand held PC's, imaging systems, and scanners.

2.3 GENERALLY ACCEPTED DEFINITION OF INVENTORY

In order to form a basis for developing benchmarks with industry-wide application, the research needed to determine if there is a generally accepted definition of "inventory". Survey respondents were asked to describe (1) how the organization defines inventory; (2) the objectives of the inventory management policy; (3) items excluded from inventory, and; (4) the circumstances under which a non-inventory item can become an inventory item.

Survey respondents identified the circumstances under which a non-inventory item becomes an inventory item as (1) when usage is increased; (2) a new continuing use is identified; (3) upon user request; (4) when increased cost meets the requirement for minimum value; (5) a need for control is identified; (6) the item is identified as "critical", and; (7) a new item is required for on-going maintenance.

Items identified for exclusion from inventory included nuts, bolts, and fasteners; non-recurring items; low value items; bulbs and electrical items; non-revenue vehicle items; office supplies; capital equipment; shop and cleaning supplies; lubricants and fuel; direct purchase items; high value items, and; tires.

Based on the responses, the only common theme that emerged from the survey in defining inventory is: *Parts, materials, and supplies in stock or on-hand.* Certain parameters are applied by transit agencies to make this general definition more meaningful to the individual agency. In particular, these parameters are used to determine which parts, materials and supplies are the responsibility of the inventory management organization and for which of these parts, materials and supplies are detailed records kept on the quantities in stock or on-hand. Based on the survey, we have identified the following parameters:

- Usage frequency -- recurring, one time, project specific
- Minimum and maximum item value levels -- dollar thresholds for materiality (minimum) and fixed assets (maximum)
- Type of assets supported -- rolling stock, facilities, track and structure, non-revenue vehicles, etc.
- Item category -- fuel, office supplies, maintenance parts, cleaning supplies, etc.
- Storage characteristics -- on-site versus with the vendor
- Funding for material and supplies -- purchased with capital or operating dollars
- Asset accounting -- inventory asset versus expensed item
- Criticality -- importance in supporting the organization's mission

Chapters 3, "Organizational Structures for Transit System Inventory Management", Chapter 4, "Performance Indices for Assessing Inventory Management", and Chapter 5 "The Affect of Organizational Structure on Inventory Management Performance", examine the issues identified in this chapter of the report in greater detail.

III. ORGANIZATIONAL STRUCTURES FOR TRANSIT SYSTEM INVENTORY MANAGEMENT

A review of the various organization structures, policies, procedures, practices, performance measurements, and organizational goals and objectives utilized by the transit agencies responding to the mail survey showed five distinct organizational structures. All of the survey respondents, regardless of the size and complexity of the functional units responsible for the management of inventory, could easily be classified into one of these five structures as characterized below:

(1) No formal inventory management function -- inventory responsibility is located in the Maintenance Department;

(2) Formal inventory management function -- inventory management responsibility located in a department other than maintenance at the sub-department level;

(3) Formal inventory management function -- inventory responsibility is located in the Maintenance Department;

(4) Formal inventory management function -- inventory management responsibility located in a department other than maintenance, and;

(5) Formal inventory management function -- a single dedicated inventory management group at the department level.

Each of these organizational structures are profiled below in the context of the organization, inventory management practices, and performance measures utilized by the transit systems examined. The relative merits of the different organizational structures are also evaluated relative to their ability to meet inventory management goals and service objectives.

3.1 ORGANIZATION PROFILES

Organizational characteristics of seventy-five of the eighty-six agencies responding to the survey questionnaire are summarized in the charts on the following pages. For the eleven respondents not included in the organizational profiles, eight either contracted outside the organization for maintenance and inventory services or maintenance was done under the auspices of another organization such as the city or county. An additional three respondents either could not complete the questionnaire or have no inventory management function at all.

Agency and Organization Characteristics	Organization Category				
	1	2	3	4	5
Number of Respondents	8	6	36	9	16
Number of Buses (Average)	23	29	149	262.5	1,222
Number of Buses (Median)	19	29	78	217.5	847
Number of Rail Vehicles (Average)	0	0	26	48.5	1,177
Number of Rail Vehicles (Median)	0	0	26	48.5	859.5
Number of Inventory Organization Employees (Average)	0	1	4	9	104
Number of Inventory Organization Employees (Median)	0	1	3	8.5	47
Number of Total Inventory Employees (Average)	2	2	6	9	118
Number of Total Inventory Employees (Median)	2	2	4	8.5	47
% with a Full-time Inventory Manager	0%	0%	50%	100%	100%
% with a Separate Planning Function	0%	0%	8%	11%	81%
% Including Purchasing	0%	17%	39%	56%	6%
% Decentralized	0%	17%	6%	0%	6%

Inventory Management Practices Characteristics	Organization Category				
	1	2	3	4	5
Number of Respondents	8	6	36	9	16
Number of Storehouses (Average)	1	1	2	2	16.5
Number of Storehouses (Median)	1	1	1.5	2	11.5
Average Percent Stockouts Per Week	1%	7%	.5%	.1%	2%
Average Percent Safety Stock	22%	25%	19%	14%	17%
Percent Setting Target Inventory Levels	38%	83%	56%	78%	69%
Percent Setting Target Service Levels	38%	0%	22%	33%	81%
Percent Authorizing Direct Purchases	100%	67%	64%	67%	50%
Percent with Written Procedures	25%	33%	44%	56%	75%

Average Inventory Management Performance Characteristics	Organization Category				
	1	2	3	4	5
Number of Respondents	8	6	36	9	16
Average Bus Inventory Turnover	1.57	1.22	1.61	1.21	2.6
Average Rail Inventory Turnover	N/A	N/A	N/A	.48	.76
Bus Inventory Dollar Level	$114,713	$184,611	$733,496	$1,286,254	$9,380,930
Rail Inventory Dollar Level	N/A	N/A	N/A	$2,368,677	$27,152,955

Bus Inventory Dollar/Vehicle	$3,175	$7,612	$4,948	$4,403	$5,341
Rail Inventory Dollar/Vehicle	N/A	N/A	N/A	$60,303	$34,696
Bus Inventory Fill Rate	84%	90%	86%	91%	96%
Rail Inventory Fill Rate	N/A	N/A	N/A	80%	94%
% Obsolete/Excess Mat'l (Bus)	6%	22%	6%	15%	13%
% Obsolete/Excess Mat'l (Rail)	N/A	N/A	N/A	1%	9%
% Items Out of Balance	4%	8.5%	6%	15%	10%

In the following sections we discuss each of the five organization structures in terms of the agencies' organization characteristics, inventory management practices, inventory management performance, and relative merits.

3.1.1 Organization Profile #1: No Formal Inventory Management Function -- Inventory Responsibility is Located in the Maintenance Department

Of the five types of organizational structures identified, only one has no formal structure in place for the management of inventory. As shown in Figure 3-1, responsibility for managing, evaluating, and controlling inventory in these agencies rests within the Maintenance Department one hundred percent of the time. In most cases, while the Maintenance Manager has overall responsibility for inventory, a maintenance foreman or mechanic has primary responsibility for the day-today-management, organization, and planning. All of the transit systems utilizing this type of organizational structure are single-mode bus systems with fewer than 60 vehicles.

3.1.1.1 Organization

All of the eight transit systems included in Category 1 share the same organizational characteristics. In each case, the Maintenance Department is the organizational unit responsible for inventory management. While all of the organizations have at least one individual responsible for the inventory, none have an individual whose primary responsibility is inventory management. In most cases, management of the inventory falls to either the senior maintenance manager, a lower level maintenance manager or the foreman or mechanic.

None of the agencies have a separate planning function and none include purchasing as part of the inventory management organization. Finally, all of the organizations are centralized.

3.1.1.2 Inventory Management Practices

Two of the eight Category 1 agencies have two storehouses, the remainder have one. Safety stock levels range from a high of sixty percent to a low of 0. Average safety stock is 22 percent. According to the survey participants, stockouts average only one per week.

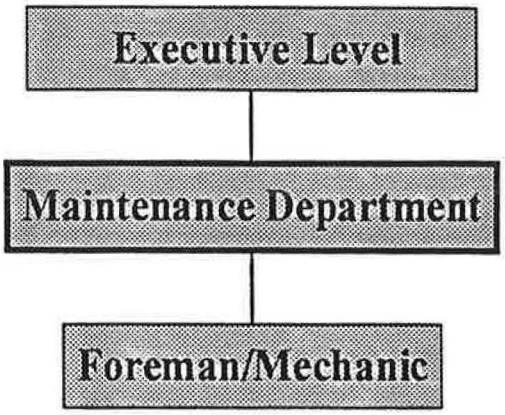

Figure 3-1

Slightly more than one-third of these respondents set target inventory levels. Slightly more than one-third of the agencies responding in this category set target service levels. In three of the eight cases, those agencies that set target inventory service levels also set target service levels. Another three agencies set neither. For the remaining two agencies, one sets target inventory levels but not target service levels and the sixth agency does not set target inventory levels but does set target service levels.

Each of the transit systems authorizes the direct purchase of material and supplies but only two agencies use blanket purchase orders. Two transit systems have a written procedures manual while the remaining six do not.

3.1.1.3 Inventory Performance

For many of the agencies included in this group, turnover figures were not available. However, for those agencies where we were able to calculate turnover rates, the numbers ranged from less than one turn per year to three and one-half turns per year. The inventory dollar level for the six agencies ranged from a low of $5,900 to a high of $325,000 with an average of $114,713 and a median of $89,543. Discussions with the agencies indicated that one reason for the low end dollar figures may be the policy of management to keep inventory dollars low and the ability to purchase many items as needed.

When looking at inventory dollars per vehicle, the largest of the transit agencies in this group maintains an inventory value of $5,702 per vehicle. The lowest figure for this category was $281 per vehicle. For all Category 1 transit systems, the average dollars per vehicle was $3,175 with the median at $3,598. Fill rates for the group average 84 percent. Obsolete and excess inventory items average 6 percent with a maximum fill rate of 10 percent and a minimum of 2 percent. Three of the agencies provided information on percent of items out of balance with the high end being 10 percent and the low end .5 percent. Items out of balance averaged 4 percent, the lowest percentage for the five organization profiles discussed in this chapter.

3.1.1.4 Relative Merits

For small transit systems (those with fewer than 60 vehicles), location of the inventory management function within the Maintenance Department does provide some benefits. For example, many of these agencies operate with a small number of total staff, many of whom wear several hats. In some cases, operations and maintenance may be combined under the same organizational unit. In other cases, purchasing and maintenance may be combined. With a small operating budget and inventory levels that are manageable, it may be appropriate for the Maintenance Department to also plan for and monitor inventory usage.

Since in all cases for Category 1 transit systems, inventory is located within the Maintenance Department, formal measures of target inventory levels and target service levels may not be necessary. Even though these transit agencies may not be as sophisticated as those in some of the other organizational structures profiled later on in this chapter in terms of formally measuring and tracking inventory performance, the small, intimate nature of these organizations may make this less necessary. Also, inventory transaction volumes may not support full-time inventory personnel.

3.1.2 Organization Profile #2: Formal Inventory Management Function -- Inventory Responsibility is Located in a Department Other than Maintenance at the Sub-Department Level

As is the case with our first type of organizational structure, all agencies falling into this category are single mode bus systems with fewer than 60 vehicles. However, unlike Category 1 transit systems, responsibility for inventory management is a formal function located outside of the Maintenance Department. As shown in Figure 3-2, the inventory management function for these systems is located at the sub-department level. Six of the 75 transit agencies fell into this category.

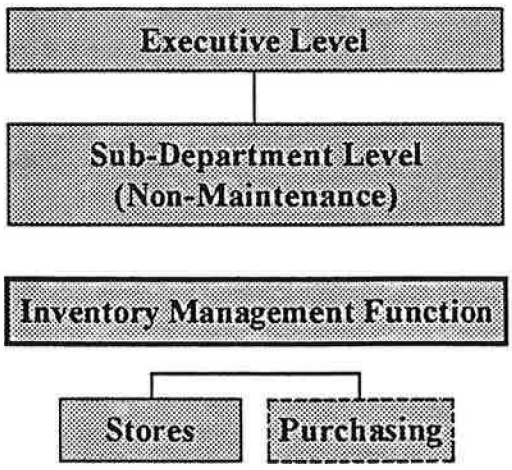

Figure 3-2

3.1.2.1 Organization

As shown in Figure 3.2, and again similar to Category 1 transit systems, none of the Category 2 agencies have a full-time manager of inventory. In addition, none have a separate planning function. When looking at purchasing as part of the inventory management function, five out of the six do not include purchasing within the inventory management function. Five of the six agencies are also centralized. Of interest, the transit system that includes purchasing in the inventory management function is also the only transit system that is decentralized. Three of the six agencies have the inventory management function reporting to Finance and the remaining three report to Administration.

When looking at the total number of staff involved in managing inventory, only two of the transit systems in this category have all inventory management responsibilities located within the inventory management function. The average total number of employees with inventory management responsibilities is 2.33. Both the median and the mode for these agencies is 2. Four of the six agencies have some employees with inventory management responsibilities located outside of the inventory management function. For these agencies, approximately 43 percent, or nearly half, of their employees are located outside of the inventory management function and one of the agencies has no employees fully dedicated to inventory management.

3.1.2.2 Inventory Management Practices

When looking at the storehouse network, all of the transit systems have one storehouse. For the five agencies reporting safety stock levels, the average percent of safety stock at the storehouses is 25 percent, with three of the agencies reporting safety stock levels of 10 percent. Category 2 agencies reported average stockouts of seven per week, the highest of any of the organizations profiled. However, this figure may be slightly skewed since one of the agencies reported a weekly stockout figure of 20 percent.

The number of stockouts were reported by four of the six agencies. Stockouts ranged from less than 1 percent to 20 percent with an average stockout rate of 6.7 percent. The median stockout rate for Category 2 transit systems was approximately 3.5 percent. Target inventory levels were set by five of the reporting agencies, however, none of the agencies reported setting target service levels. Direct purchase authority is authorized at four of the agencies. Two of the six agencies reported having a written procedures manual.

3.1.2.3 Inventory Performance

Data was available to calculate turnover rates for bus fleets for five of the agencies. Bus inventory turnover ranged from slightly more than two turns per year to one turn approximately every four years. Average turnover for bus inventory was slightly more than once per year. For inventory dollar levels, the five agencies reported a low of $32,418 and a high of $296,000. The

average inventory dollar level was $184,611. The median inventory dollar level was $220,585. Inventory dollars per vehicle (bus) were also calculated for the same five agencies. The range for these figures was a low of $1,351 to a high of $15,385 inventory dollars per vehicle. Average dollars per vehicle were $7,612 with a median of $7,345.

All but one of the five agencies reporting inventory fill rates were 90 percent or above. One agency reported a fill rate of only 75 percent. The average fill rate was 90 % and the median and mode for fill rates was 95 percent. Only two agencies reported the percent of items out-of-balance. These numbers were 2 percent and 15 percent resulting in a average of 8.5 percent. This organization category also had the highest percentage of obsolete and excess material at 22 percent. However, the median for this group was three percent. While three of the reporting agencies had percentages of five percent or less, a fourth agency reported obsolete and excess material at 60 percent.

3.1.2.4 Relative Merits

The major advantage of this type of organization structure for the management of inventory is the establishment of a formal inventory management function located outside of the Maintenance Department. An independent inventory management function provides the most effective option for balancing the conflicting objectives of financial control and material availability.

Category 2 transit systems appear to do a relatively good job at monitoring target inventory levels. However, because none of the agencies track target service levels it is difficult to assess how well inventory management is meeting the requirements of Maintenance.

3.1.3 Organization Profile #3: Formal Inventory Management Function -- Inventory Responsibility is Located in the Maintenance Department

Our third organization profile represents the largest group of public transit systems with 36 survey respondents, or almost half of the agencies profiled. Thirty-five of the agencies report bus only fleets. The thirty-sixth agency also has a light rail system in addition to a large bus fleet. Fleet size ranges for a low of 7 vehicles to a high of over 900 vehicles. Average bus fleet size for the group is 149 vehicles with the median and mode at 78 and 59, respectively.

3.1.3.1 Organization

Similar to organizations profiled under Category 1, responsibility for inventory management is located under the Maintenance Department as shown in Figure 3.3. However, unlike Category 1, a formal inventory management organization is in place. The size of staff engaged in the management of inventory is significantly larger than either of the organization

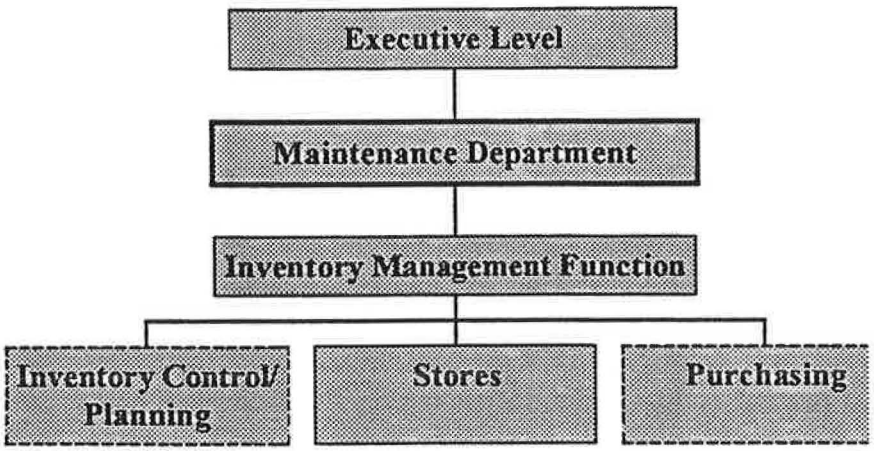

Figure 3-3

structures profiled above. This is consistent with the larger sizes of the Category 3 agencies and the formalized inventory management structure.

The average number of total inventory employees is six with a median of four. For inventory management employees located within the formal inventory management organization, the average drops to four and the median to three. Twenty-two percent of employees with some responsibility for the management of inventory are located outside of the formal organization.

Fifty percent of the 36 organizations employ a full-time inventory manager. This individual devotes 100 percent of his or her time to the management of inventory. The remaining fifty percent spend at least some portion of their time managing other functional areas such as purchasing or maintenance. Only 8 percent or three of the thirty-six Category 3 organizations have a separate planning function within the inventory management organization. Thirty-nine percent or 14 of the organizations include purchasing in the inventory management organization. Only one of the organizations has both a separate planning and a separate purchasing unit within the inventory management organization. Two of the organizations are decentralized.

3.1.3.2 Inventory Management Practices

The largest of the Category 3 properties has a storehouse network consisting of six separate storehouses. The smallest property maintains a single storehouse. Average size of the network is two storehouses. Average stockouts per week are lower than stockout rates for either Category 1 or Category 2 transit agencies. Similarly, the average safety stock percent (19%) is lower than the other categories discussed thus far.

Inventory target levels are currently set by 20, or 56 percent, of the thirty-six Category 3 properties. Inventory service levels are set by eight, or 22 percent of the Category 3 agencies. Of these agencies, only four measure both of these indicators. Sixty-four percent, or 23 of the agencies, permit direct purchases. Less than half of the transit systems (16) utilize a written procedures manual.

3.1.3.3 Inventory Performance

Turnover rates for the bus vehicle fleets average slightly more than one and one-half times per year. Maximum turnover was 4.6 turns per year and minimum turnover was once per year. The maximum bus inventory dollar level for Category 3 transit systems is 4.89 million. The minimum dollar level was $115,238. The average inventory dollar level for bus fleets was $733,496 with the median at $466,850. When looking at inventory dollars per vehicles, the maximum value was $12,709 and the minimum was $1,013. Average dollars per vehicle were $4,948 with the median at $4,424.

Fill rates averaged 86 percent with both the average and median at 95 percent. The percentage of obsolete material is significantly lower at 6 percent than Category 2 agencies and is at same level for Category 1 agencies. Items out of balance averaged 6 percent, the second lowest percentage of the five organization categories profiled in this chapter.

3.1.3.4 Relative Merits

Even though this organizational profile includes responsibility for inventory management under the Maintenance Department, and thus is not as effective as Category 2 transit systems in balancing the conflicting objectives of financial control and material availability, the establishment of a formalized, separate inventory management organization does provide some degree of dissociation from other Maintenance Department activities.

When comparing Category 3 transit agencies in terms of organization, inventory management practices, and inventory management performance to transit agencies in the other four categories, some merits are apparent. For example, close proximity to maintenance personnel may account for the low rates in the percent of obsolete and excess material and the percentage of items out of balance. While these agencies as a group are not the highest in the numbers setting inventory target levels and target service levels, proximity to maintenance "customers" may not make these two indicators as crucial as when the inventory management function is located outside of the Maintenance Department. Conversely, while bus inventory fill rates average near the bottom of the five profile categories, this may be a reflection of the overall inventory management policy set by the Maintenance Department.

3.1.4 Organization Profile #4: Formal Inventory Management Function -- Inventory Responsibility is Located in a Department Other than Maintenance

Category 4 organizations average a bus fleet size of 262.5 buses. Fleet size ranges from a high of 560 buses to a low of 134 buses. Two of the properties utilize rail cars in their fleets. Both the average and median for rail car fleets is 48.5. As shown in Figure 3-4, the organizational structure of Category 4 organizations includes a formal inventory management function reporting to the department level outside of the Maintenance Department.

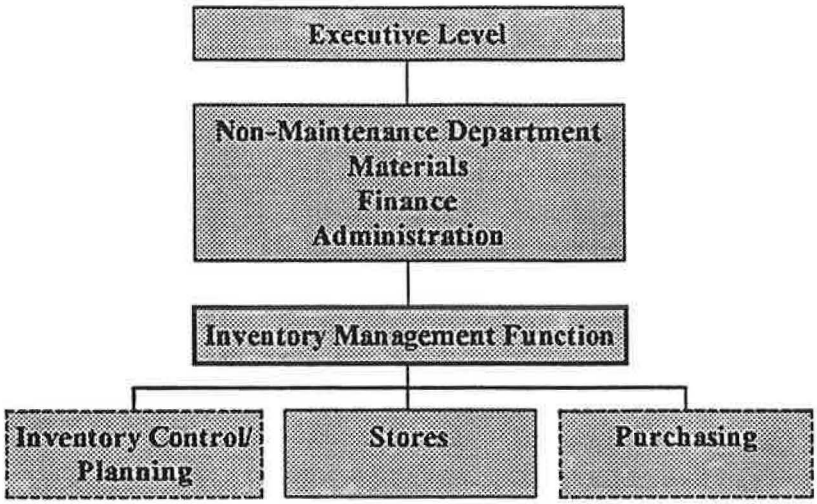

Figure 3-4

3.1.4.1 Organization

The fourth category of organizational profiles includes those transit systems employing a formal inventory management function reporting to a department other than Maintenance. Of the nine transit systems in this category, three report to Materials, three to Finance, two to Administration and one to Purchasing.

The number of inventory organization employees and the number of total inventory management employees are virtually the same. For both groups, the average number of employees is nine with a median of eight. The largest of the transit systems in this category employs a total of sixteen individuals to management inventory, all of who are located within the inventory management organizational unit. Similarly, the smallest of the transit systems employs four inventory management employees, all of whom report to the inventory management organizational unit.

One hundred percent of the Category 4 transit systems have a full-time inventory manager. In addition, all of these transit systems are centralized with respect to a single location for management of the inventory. Five of the nine transit agencies include purchasing within the inventory management function. Only one transit agency has established a separate planning function.

3.1.4.2 Inventory Management Practices

The storehouse network for Category four transit agencies is similar to Category three agencies. The average and median number of storehouses is two. The largest of the transit agencies in this category has a network of four with the smallest transit system utilizing one. Of

The analysis consisted of examining all combinations of the above methods. None of the survey respondents used fixed period methods alone, in combination with a reorder point method, or in combination with maintenance forecasts. Therefore the combinations analyzed are: reorder point only, maintenance forecasts only, reorder points in combination with maintenance forecasts, and a combination of all three methods.

The findings were as follows:

- Agencies that use maintenance forecasts only have lower bus inventory dollars per vehicle than those using all other combinations:

Forecasts only -- $1,569	reorder point only -- $5,727	(99% confidence)
	reorder point & forecasts -- $5,031	(97% confidence)
	all three -- $5,537	(98% confidence)

- Agencies that use maintenance forecasts only have lower annual bus inventory turnover than those that use a combination of reorder points and maintenance forecasts, and those that use all three methods:

Forecasts only -- 0.97	reorder point & forecasts -- 1.76	(99+% confidence)
	all three -- 2.73	(87% confidence)

- Agencies that use maintenance forecasts only have lower percent obsolete bus inventory than those that use a combination of reorder points and maintenance forecasts, and those that use all three methods. In addition, those that use reorder point only have a lower percent than those that use a combination of reorder points and maintenance forecasts.

Forecasts only -- 3.5%	reorder point & forecasts -- 11.0%	(97% confidence)
	all three -- 10.2%	(93% confidence)
Reorder points only -- 6.0%	reorder point & forecasts -- 11.0%	(88% confidence)

- Agencies that use reorder points only take more days to fill bus inventory backorders than those that use all other combinations. In addition, those that use a combination of reorder points and maintenance forecasts take more days than those using maintenance forecasts only and those using all three methods:

Reorder points only -- 24.8	forecasts only -- 8.5	(99% confidence)
	reorder point & forecast -- 14.6	(90% confidence)
	all three -- 8.5	(99% confidence)
Reorder point & forecast -- 14.6	forecasts only -- 8.5 days	(94% confidence)
	all three -- 8.5	(87% confidence)

5.3.3 Inventory Management Goals

The effects of setting target inventory stocking levels (inventory value) and target service levels (inventory availability) was examined. Survey responses yielded information on whether or not transit agencies set goals in these two areas. (The survey results were not sufficient to examine the effect of the actual value of the targets.)

Set target inventory dollar levels:

Agencies that set target inventory dollar levels:

- have higher annual bus inventory turnover -- 2.00 vs. 1.38 (93% confidence)
- have a higher percentage of items out of balance -- 7.0% vs. 4.5% (87% confidence)
- spend more on inventory personnel/inventory dollar -- $.36 vs. $.25 (92% confidence)

Set target inventory service levels (availability):

Agencies that set target inventory service levels:

- have higher annual bus inventory turnover -- 2.51 vs. 1.42 (96% confidence)
- have higher bus inventory fill rates -- 94.2% vs. 90.4% (93% confidence)
- manage more inventory dollars/person -- $206,771 vs. $128,305 (95% confidence)
- have a higher percentage of obsolete bus inventory -- 10.5% vs. 6.0% (92% confidence)

5.3.4 Inventory Replenishment Methods

The mix of methods used for determining when to order inventory items and how many items to order were examined. In addition, the effect of safety stock levels was analyzed.

Mix of replenishment methods used:

The following replenishment methods were analyzed:

Use of reorder point replenishment methods -- whether replenishment is triggered when stocking levels reach a predetermined level, as with min/max or reorder point/economic order quantity methods.

Use of fixed period replenishment methods -- whether replenishment is triggered by fixed periods of time or time intervals, as with weekly orders and seasonal orders.

Use of maintenance forecasts and projections -- whether replenishment is based on projected maintenance activity, projects, campaigns, etc.

Reporting to sub-dept.:	$2,028	reporting to dept. -- $5,298	(99+% confidence)
		reporting to exec. -- $5,095	(99+% confidence)

- Agencies with inventory organizations reporting to the executive level have lower rail inventory dollars per vehicle than those reporting to the department level -- $19,124 versus $70,571 (94% confidence).

- Agencies with inventory organizations reporting to the sub-department level have higher annual bus inventory turnover than those reporting to the department level or executive level:

Reporting to sub-dept. -- 2.71	reporting to dept. -- 1.71	(94% confidence)
	reporting to exec. -- 1.59	(96% confidence)

- Agencies with inventory organizations reporting to the executive level take fewer days to fill inventory backorders (for both bus and rail) than those reporting to the department level. Furthermore, those reporting to the department level take fewer days to fill bus inventory backorders than those reporting to the sub-department level (note: no rail property organizations report to the sub-department level):

Days to fill bus backorders:

reporting to executive level	9.0 days
reporting to department level	18.7 days
reporting to sub-dept. level	27.0 days

executive vs. department --	97% confidence
executive vs. sub-department --	99% confidence
department vs. sub-department --	90% confidence

Days to fill rail backorders:

reporting to executive level --	12.8 days
reporting to department level --	50.5 days

executive vs. department --	97% confidence

- Agencies with inventory organizations reporting to the sub-department level manage fewer inventory dollars per person than those reporting to the department and executive level:

Reporting to sub-dept. -- $40,180	reporting to dept. -- $146,325	(99+% confidence)
	reporting to exec. -- $182,175	(99+% confidence)

- Centralized inventory management organizations manage more inventory dollars per person than decentralized organizations -- $159,070 vs. $110,427 (96% confidence).

Department reporting to -- this attribute was examined two ways: (1) whether or not the inventory organization reports directly to the maintenance department (yes or no), and (2) the specific department to which the inventory management organization reports (e.g. maintenance, operations, administration, finance, etc.).

Agencies that report to the maintenance department have the following findings versus those that do not report to maintenance:

- lower bus inventory dollars/vehicle -- $4,535 vs. $5,756 (86% confidence)
- lower percentage of obsolete bus inventory -- 6.0% vs. 9.8% (92% confidence)
- lower inventory personnel cost/inventory dollar -- $0.25 vs. $0.38 (94% confidence)

However, these agencies also:

- take more days to fill bus inventory backorders -- 20.9 vs. 9.0 (99% confidence)
- manage fewer inventory dollars/person -- $124,457 vs. $193,593 (94% confidence)
- process fewer transactions/week per person -- 114.0 vs. 165.5 (85% confidence)

In addition, the following findings relate to the specific departments responsible for inventory management:

- Agencies with inventory management reporting to the finance department have a higher bus inventory fill rate than those reporting to maintenance -- 96.0% versus 86.0% (99% confidence).

- Agencies with inventory management reporting to the finance department process fewer transactions per week per person than those reporting to all other departments:

Reporting to finance:	73.3	reporting to maintenance -- 114.0	(82% confidence)
		reporting to purchasing -- 223.5	(88% confidence)
		reporting to materials -- 155.6	(90% confidence)
		reporting to administration -- 164.1	(90% confidence)

Level reporting to -- the level within the transit agency to which the inventory organization reports (e.g. board, executive, department, or sub-department).

- Agencies with inventory organizations reporting to the sub-department level have lower bus inventory dollars per vehicle than those reporting to the department level or executive level:

Note: Although all differences between organizational types were not significant at or above the 85% confidence level, as organization type progresses from 1 to 5, the number of inventory transactions processed per person per week increases.

Full-time head of group -- whether the top inventory management person was dedicated full-time to inventory management responsibilities or had additional non-inventory related responsibilities.

Agencies with a full time head of the inventory management group:

- have higher annual bus inventory turnover -- 2.02 vs. 1.37 (93% confidence)
- take less days to fill bus inventory backorders -- 13.2 vs. 20.8 (85% confidence)
- process more transactions/week per person -- 171.8 vs. 97.8 (96% confidence)
- manage more inventory dollars/person -- $198,730 vs. $95,462 (99% confidence)

However, these agencies also:

- have a higher percentage of obsolete bus inventory -- 9.4% vs. 4.3% (99% confidence)
- have a higher percentage of items out of balance -- 7.3% vs. 4.4% (92% confidence)

Separate planning function -- whether the inventory management organization included personnel dedicated to inventory planning functions with no responsibility for storekeeping or other inventory functions.

Agencies with a separate planning function:

- have higher annual rail inventory turnover -- 0.79 vs. 0.50 (85% confidence)
- have higher inventory fill rates -- 94.0% vs. 90.5% (88% confidence)
- manage more inventory dollars/person -- $244,233 vs. $131,296 (97% confidence)

However, these agencies also:

- have higher bus inventory dollars/vehicle -- $7,106 vs. $4,484 (99% confidence)
- have a higher percentage of obsolete bus inventory -- 12.5% vs. 5.6% (98% confidence)
- have a higher percentage of obsolete rail inventory -- 9.2% vs. 2.3% (90% confidence)

Inclusion of purchasing -- whether personnel responsible for executing the purchase of inventory material were included in the same organization as inventory management personnel.

Agencies that include purchasing in the same organization as inventory management:

- have lower bus inventory dollars/vehicle -- $4,230 vs. $5,424 (94% confidence)
- have a lower percentage of stockouts -- 0.33% vs. 2.32% (95% confidence)

Centralized versus decentralized -- whether the inventory organization was centrally managed or whether multiple inventory organizations existed within the transit agency.

Days to fill bus inventory backorder:

Type 3 -- 21.2 days	Type 2 -- 5.5 days	(99% confidence)
	Type 5 -- 7.8 days	(99% confidence)

Days to fill rail inventory backorder:

Not Type 5 -- 40.7 days	Type 5 -- 10.0 days	(89% confidence)

- Agencies with organization Type 5 have a higher percent of obsolete bus inventory than those with organization 1 or 3. Agencies with organization Type 5 also have a higher percent of obsolete rail inventory than those without a Type 5 organization.

Percent obsolete bus inventory:

Type 5 -- 12.9%	Type 1 -- 6.2%	(96% confidence)
	Type 3 -- 5.8%	(98% confidence)

Percent obsolete rail inventory:

Type 5 -- 8.5%	Not Type 5 -- 1.3%	(96% confidence)

- Agencies with no rail and organization Type 3 manage more inventory dollars per person than those with Type 1, 2, or 5. In addition, those with Type 4 manage more than those with Type 1.

Type 3 -- $135,664	Type 1 -- $57,511	(99% confidence)
	Type 2 -- $84,570	(94% confidence)
	Type 5 -- $88,569	(94% confidence)
Type 4 -- $106,869	Type 1 -- $57,511	(92% confidence)

- Agencies with organization Types 1 or 2 process fewer inventory transactions per person per week than those with Types 3, 4, or 5.

Type 1 -- 33.2	Type 3 -- 130.9	(99% confidence)
	Type 4 -- 183.7	(97% confidence)
	Type 5 -- 206.8	(99% confidence)
Type 2 -- 61.2	Type 3 -- 130.9	(96% confidence)
	Type 4 -- 183.7	(94% confidence)
	Type 5 -- 206.8	(99% confidence)

Organizational Type 4 -- formal inventory management function located in a department other than maintenance reporting to the department level

Organizational Type 5 -- a dedicated department level inventory management group

All rail transit properties that responded to the survey have organization Type 5, except for two which have Type 4 and one which has Type 3. Therefore, there were not enough rail property responses in organization types other than Type 5 to perform t-tests for each organization type. As a result, t-tests for rail inventory performance indicators were performed based on two categories: those that use organization Type 5 and those that do not use organization Type 5.

Organization Type. The findings for the effects of organization type are:

- Agencies with Type 1 organization have less bus inventory dollars per vehicle than those with Type 2 and Type 5. Those with Type 4 also have less bus inventory dollars per vehicle than Type 5 organizations.

Type 1 -- $3,175	Type 2 -- $7,612	(86% confidence)
Type 1 -- $3,175	Type 5 -- $6,408	(96% confidence)
Type 4 -- $4,403	Type 5 -- $6,408	(88% confidence)

- Agencies with organization Type 5 have higher annual bus inventory turnover than those with Types 2, 3, or 4.

Type 5 -- 2.61	Type 2 -- 1.22	(91% confidence)
	Type 3 -- 1.61	(85% confidence)
	Type 4 -- 1.21	(94% confidence)

- Agencies with organization Type 5 have higher inventory fill rates than those with Types 1, 3, or 4.

Type 5 -- 95.8%	Type 2 -- 84.0%	(95% confidence)
	Type 3 -- 86.2%	(95% confidence)
	Type 4 -- 87.3%	(89% confidence)

- Agencies with organization Type 4 have a lower stockout percentage than those with Type 5 organizations, 0.14% compared to 1.64% (90% confidence).

- Agencies with organization Type 3 take more days to fill a backorder for bus inventory than those with organization 2 or 5. Agencies without organization Type 5 also take more days to fill a backorder for rail inventory than those with a Type 5 organization.

and five for correlations. The following sections describe each organizational and inventory management factor in detail and present the findings associated with the factor.

5.3.1 Inventory Staffing Levels

The effect of inventory management staffing levels was examined separately for (1) inventory organization personnel - total number of individuals within the inventory management organization, and (2) total inventory management personnel - total number of individuals within the transit agency with inventory management responsibility, regardless of whether they are within the inventory management organization.

Inventory staffing levels were analyzed relative to the total number of vehicles in the transit agency and the agency's total inventory dollars. This allowed the effects of relative staffing levels to be compared across agencies of difference sizes. Based on this analysis, there is no correlation between relative staffing levels and any of the inventory performance indicators.

Furthermore, there is a high correlation between inventory organization employees and total employees involved with inventory management ($r = .997$). Therefore, it is not necessary to include both measures as an inventory performance indicator. Since the total number of employees involved with inventory provides a more comprehensive view of inventory management activities, it is used in inventory performance indicators "per person" (such as transactions per person or dollars per person).

5.3.2 Organizational Structure Type

Five organizational structure types were defined in detail in Chapter III, ranging from no formal inventory management function to a dedicated inventory management group at the department level. In addition to examining the effects of these organizational structure types, selected organizational attributes were analyzed separately, such as the level to which the inventory organization reports, the departments to which the organization reports, the separation of the inventory planning functions, etc. The effects of the organizational types and each attribute is presented separately.

Organizational Type 1 -- no formal inventory management function, inventory responsibility located in the maintenance department

Organizational Type 2 -- formal inventory management function located in a department other than maintenance reporting to the sub-department level

Organizational Type 3 -- formal inventory management function located in the maintenance department

Regressions were run until all variables with a 90% or greater confidence were included in the regression equation. In other words, there is at most a 10% probability the dependent variables that the regression selected from the survey data as significant, are really due to change and should have a coefficient of zero. The dependent variables from this step-wise regression analysis having a confidence of 90% or greater were selected for the next step.

3. Derive the regression equation.

A multiple linear regression analysis was performed on the dependent variables identified in the previous step. This analysis resulted in a regression equation, a coefficient of determination (r^2), an analysis of variance, and other statistics.

4. Determine how well the equation predicts the independent variable.

The coefficient of determination is the percent of variance in the independent variable explained by the regression equation, based on the survey data. This coefficient is a measure of how well the regression equation predicts the independent variable. For example, if a regression is run for annual inventory turnover with an r^2 of .85, the regression equation will explain 85% of the variance in annual inventory turnover.

5. Determine the confidence level of the prediction.

The F-statistic and the F-distribution are used to determine the confidence level of the prediction resulting from the equation. The confidence level measures the confidence that the prediction resulting from the survey data's regression equation is not equal to zero (i.e., the null hypothesis). This is the confidence that all of the coefficients in the regression equation and the constant are not equal to zero. For example, if the confidence level is 92%, one can infer with 92% confidence that the predicted value of an inventory performance indicator is not equal to zero.

6. Determine the significance of each dependent variable.

Just as a confidence level can be calculated for the entire regression equation, a confidence level can also be calculated for each coefficient of each dependent variable. This confidence level is a measure of the probability that each dependent variable's coefficient is not equal to zero.

5.3 THE EFFECT OF ORGANIZATION & INVENTORY MANAGEMENT DECISIONS

This section summarizes findings regarding the effect of each organizational and inventory management factor on inventory management indicators. Only effects with a confidence level of 85% or higher for t-tests, and a correlation coefficient of .70 or higher (-.70 or lower) are identified as significant. Data groups must have at least three responses to be included in t-tests

c is the constant for the equation (or the y-intercept of the line)
x_1 through x_i are the dependent variables (e.g. number of buses)
c_1 through c_i are the coefficients for the dependent variables
i is the total number of dependent variables in the equation

Performing regression analysis involved the following steps:

1. Eliminate redundant variables from the analysis (multi-colinearity).

   In developing the regression equation, it is important to eliminate dependent variables that are highly correlated with each other. These variables will distort the analysis and could lead to incorrect conclusions. For example, a transit agency's total number of buses and the total bus passenger miles per year are highly correlated. These two variables represent redundant data and could distort the analysis, such as resulting in coefficients that mostly offset each other. Since these two variables represent almost the same data pattern, one of the variables is eliminated from the regression analysis.

   The technique used to identify highly correlated variables, or multi-colinearity, was to develop a correlation matrix. This matrix showed the correlation between each variables in the survey with each other variable. As a general rule of thumb, when variables showed a correlation of over .70 (or less than -.70), one of the variables was eliminated from the regression analysis.

2. Select the dependent variables that best predict the independent variable.

   Once multi-colinearity was addressed, the next task was to select the set of variables from the 45 - 50 remaining that best predict the independent variable. Step-wise regression was used for this task. Step-wise regression selects variables one at a time to include or exclude from the regression equation until the best set of variables is found. The significance level can be set as a criteria for including dependent variables. The higher the significance level, the fewer variables will meet the criteria and be included in the equation.

   Step-wise linear regression was run on the remaining survey data variables for each inventory performance indicator. The significance level for including variables in the equation was varied to observe the resulting effect on the variables included in the regression equation, the amount of variance in the independent variable explained by the equation, and the overall confidence level of the prediction. For example, a minimum 99% confidence level may result in an equation with few variables or may not produce an equation at all if no variables exceed the 99% minimum rate. Lowering the minimum rate to 95% may allow additional variables to be included and therefore increase the percent of variance in the independent variable that is explained by the equation. However, if the minimum rate is lowered too much, the confidence in the prediction resulting from the equation decreases, even though the equation explains a higher percent of the variance. Furthermore, there is lower confidence that the dependent variables included in the equation actually have an effect.

analyzing performance indicators representing overall inventory performance, but two yes/no variables were included to identify whether the property "has buses" and "has rail". For example, the total number of vehicles, as well as variables indicating whether the agency has bus and/or rail, were included in analyzing overall inventory accuracy (percent of items out of balance).

Identical responses were eliminated. Variables were excluded when all of the survey responses were the same for the selected performance indicator. For example, all rail properties used a reorder point method to replenish inventory (response = "yes"). Therefore this variable is actually a constant in our survey and cannot be used to analyze the effect on inventory performance. As a result, this variable was excluded from the analysis of rail inventory performance indicators.

5.2.2 Statistical Analysis Methods

Three primary statistical methods were used for this analysis, based on whether the organizational factors were numerical (e.g. number of storehouses) or divided into categories (e.g. reporting to maintenance, finance, administration, etc.). Correlation and regression were used for quantitative data and t-tests were used for category data. Section 4.3.2.1 (Chapter IV) of this report describes correlations and section 4.3.2.2 describes t-tests.

Regression analysis was used to examine the relationship between a performance indicator and a combination of organizational and inventory management decision factors. Regression analysis is a statistical process that defines a formula for predicting the value of a performance indicator using the values of organizational and management decision factors. For example, a regression equation can be derived to predict the value of annual inventory turnover using the number of buses, the number of individuals assigned to inventory management, and whether the authority uses an automated inventory system. Regression analysis will result in the equation that best utilizes the values in the survey to predict inventory turnover. Note that regression analysis does not imply that the number of buses, number of inventory management individuals, and the automated system causes inventory turnover to go up or down. The analysis simply defines the relationship between the variables.

Two regression analysis methods were used in this study: (1) multiple linear regression and (2) step-wise linear regression. Multiple linear regression produces a formula for a line that uses predefined multiple variables to predict the independent variable. All variables are included in the regression equation. Step-wise linear regression builds a linear equation by selecting variables one at a time from a predefined set of variables. This technique selects the best variables for predicting the independent variable and does not necessarily include all variables in the equation. Both of these regression methods develop equations using the "least-squares" method. The least-squares method is a mathematical technique that produces a linear equation that minimizing the sum of the squares of the distance of survey data points from the regression line. The resulting regression equation is of the form:

$$y = c + c_1x_1 + c_2x_2 + c_3x_3 \ldots + c_ix_i$$

Where: y is the independent variable (e.g. annual inventory turnover)

7. Percent of Items Stocked Out per Week
8. Average Days to Fill Bus Inventory Backorders
9. Average Days to Fill Rail Inventory Backorders
10. Percent of Items Out of Balance
11. Percent Obsolete Bus Inventory
12. Percent Obsolete Rail Inventory
13. Total Inventory Dollars per Person
14. Inventory Personnel Cost per Inventory Dollar
15. Total Inventory Transactions per Person

5.2 METHODOLOGY FOR ANALYZING ORGANIZATIONAL EFFECTS

The analysis summarized in this chapter examined the effect of each organizational structure and inventory management decision factor on the inventory performance indicators. The responses to the survey conducted during this study were used as data for this analysis. The inventory performance indicators were derived from survey Section V data. Organizational and inventory management decision factors were derived from sections III, IV, and VI of the survey. Transit agency and fleet characteristics were derived from survey sections I and II.

5.2.1 Preparing Survey Data for Analysis

In performing the above statistical analyses, the data was prepared as follows:

"Yes/No" responses were coded. Factors whose categories were "yes" or "no" were quantified as "1" and "0" for inclusion in correlations and regressions. For example, survey responses as to whether an agency uses blanket purchase orders to replenish inventory were coded as 1 or 0 to represent "yes" or "no". This technique was also applied to each of the five organizational types so that organizational type could be used in quantitative analyses. For example, if an agency's inventory management organization was type 3, then a variable representing organizational type 3 was set to "1", and four variables representing organizational types 1, 2, 4, and 5 were set to "0".

Missing responses were eliminated. Many survey respondents did not answer all questions. As a result, some of the values of the organizational and management decision factors were blank. The entire observation was excluded from analysis when the unanswered question was a variable in the analysis. For example, if a survey respondent did not specify whether blanket orders were used in purchasing inventory material, all of the respondents' answers were omitted from analyses involving the use of blanket orders. Eliminating the entire observation ensured that the value of the performance indicator being examined related only to the values of the organizational and management decisions in the analysis. The observation was eliminated only for those analyses involving the missing response.

Bus and rail responses were applied separately. Rail variables were excluded for bus inventory performance indicators and vice versa. For example, the number of buses was not included in the regression analysis for rail inventory dollars per vehicle. Variables for the total fleet were used for

- Storehouse network configuration and coverage
- Published procedures and catalog
- Physical inventory/cycle counting frequencies
- Repair and stocking of re-usable components
- Use of systems and technology

These factors and the specific attributes that were analyzed are described in detail in section 5.3 of this Chapter.

5.1.2 Transit Agency and Fleet Characteristics

As concluded in Chapter IV, transit agency and fleet characteristics alone have no significant effect on inventory performance indicators, except for some differences between bus and rail inventory. However, the following agency and fleet characteristics were included in the regression analyses to determine if these characteristics have any effects in combination with specific inventory management structures and decisions:

- number of vehicles in fleet (bus, rail, and total)
- dollar value of inventory (bus, rail, and total)
- agency operating cost
- number of vehicle models (bus, rail, and total)
- inventory purchase dollars (bus, rail)
- average annual miles (bus, rail)
- average vehicle age in years (bus, rail, and total)
- average vehicle age in percent of expected life expended (bus, rail, total)
- annual passenger miles (bus, rail)
- percent of vehicle manufactured in the United States (bus, rail, and total)

(See Chapter IV for more information on these factors.)

5.1.3 Inventory Performance Indicators

The following performance indicators, defined in Chapter IV of this report, are used to define inventory performance in this analysis:

1. Bus Inventory Dollars per Vehicle
2. Rail Inventory Dollars per Vehicle
3. Annual Bus Inventory Turnover
4. Annual Rail Inventory Turnover
5. Bus Percent Demand Filled (Fill Rate)
6. Rail Percent Demand Filled (Fill Rate)

V. THE EFFECT OF ORGANIZATIONAL STRUCTURE ON INVENTORY MANAGEMENT PERFORMANCE

5.1 ORGANIZATIONAL STRUCTURE AND INVENTORY MANAGEMENT DECISIONS

The objective of this analysis is to examine the effects of a public transit agency's inventory management organizational structure and inventory management decisions upon the agency's inventory performance. In addition, selected agency and fleet characteristics were included in the analysis to determine if these factors, combined with organizational factors, have an effect on inventory performance.

The organizational and inventory management decision factors, agency and fleet characteristics, and inventory performance indicators used in this analysis are summarized below in sections 5.1.1, 5.1.2, and 5.1.3. Section 5.2 of this chapter describes the approach and statistical techniques that were used in analyzing the effects of the factors and characteristics on inventory performance. Section 5.3 describes the organizational structure and inventory management decision factors in more detail and presents the results of the analysis of their effects on inventory performance indicators. Section 5.4 presents the general relationships between significant groups of factors and the performance indicators resulting from regression analysis. Section 5.5 summarizes the conclusions drawn from the analysis.

5.1.1 Organizational Structure and Inventory Management Decision Factors

For the purpose of this analysis, a transit agency's organizational structure includes the policies and management decisions that define how inventory is to be managed, as well as the personnel reporting relationships, responsibilities, and staffing levels. In particular, the effects of the following factors were examined in this analysis based on responses from the survey conducted during this study:

- Staffing levels for managing inventory, both within and outside of the inventory management organization
- Organizational structure type (based on the five organizational structure types defined in Chapter III) and specific attributes, such as the responsible department and level, the existence of a full-time organizational head, the separation of the inventory planning function, etc.
- Setting inventory management goals for stocking levels and service
- Methods used to replenish inventory material, including safety stock levels
- Purchasing practices for inventory material

retail distribution center's product inventory is not comparable to spare parts inventory, but is included for information. Likewise, the dollars per vehicle for American Airlines is included.

In the next chapter, we discuss the relationships between performance measures and organizational profiles. Included are discussions of the appropriate thresholds for modifying organizational structures or taking other steps to increase accountability and control.

Performance Indicator	Mean	Median	Max	Min	20%	80%
Bus days to fill backorder	16.4	10	90	1	3	30
Rail days to fill backorder	25.3	18	56	1	14	45
Inventory $ per person	$217,980	$146,000	$1,300,000	$32,418	$84,302	$250,578
Person $/Inventory $	$0.31	$0.25	$1.05	$0.05	$0.15	$0.44
Transactions per person	181.8	138.5	798	5	61.1	225.6

4.5 INVENTORY PERFORMANCE INDICATORS IN OTHER INDUSTRIES

The following table shows information on inventory performance indicators in other industries as compared to transit. This information was extracted from the articles included in the literature search conducted at the beginning of this study.

	Annual Inventory Turnover	Inventory Dollars per Vehicle
Electric Utility Fleet Spare Parts	3.3	
Beverage Distributor Fleet Spare Parts -- All	6.1	$15,793
Beverage Distributor Fleet Spare Parts -- SoftDrink	7.8	$13,271
Beverage Distributor Fleet Spare Parts -- Beer	3.4	$22,710
Retail Distribution Center Product Inventory	52	
American Airlines		$1,800,000
Public Transit -- Bus	1.74	$5,027
Public Transit -- Rail	0.71	$37,498
Fleet Spare Parts Inventory (mixture of all fleet types) -- 10-25 vehicles	2.7	$26,040 -$65,100
Fleet Spare Parts Inventory (mixture of all fleet types) -- 26-99 vehicles	5.1	$10,010 -$38,115
Fleet Spare Parts Inventory (mixture of all fleet types) -- 100 or more vehicles	5.7	$37,330 Maximum

The above chart compares public transit bus and rail annual inventory turnover and inventory dollars per vehicle to the same indicators in other industries. The "fleet spare parts" data is from a survey of fleet managers who manage a variety of public and private sector fleets. The annual turnover for a

4.3.5 Benchmark Decision Modeling Guide

The development of a benchmark decision modeling guide was contingent upon isolating the relationships between agency and fleet profile characteristics and the inventory performance indicators. The goal was to develop different benchmark values based on significant relationships. For example, if inventory turnover were significantly correlated with agency operating cost, the benchmark value for turnover would depend on the agency's operating cost.

However, as the analyses summarized in this section show, there were no significant effects between an agency's characteristics and fleet profile and the inventory performance indicators. Therefore, there is no need for a benchmark decision modeling guide. The differences that were found relating to mode (bus and rail) will be accommodated by using different benchmark values for bus and rail.

4.4 BENCHMARK VALUES FOR PERFORMANCE INDICATORS

The benchmark values for the inventory performance indicators are based on the survey responses. Rather than using the average value alone as the benchmark value, the following are presented for each inventory performance indicator:

- Mean -- the average value
- Median -- the middle value (equal number of respondents above and below)
- Maximum -- the highest value
- Minimum -- the lowest value
- 20th percentile -- the value greater than 20% of the responses
- 80th percentile -- the value greater than 80% of the responses

Performance Indicator	Mean	Median	Max	Min	20%	80%
Bus inventory turnover	1.74	1.43	7.36	0.13	0.75	2.54
Rail inventory turnover	0.71	0.56	1.43	0.29	0.51	0.99
Stockout % of SKUs	1.52%	0.17%	20.0%	.013%	.047%	1.54%
Bus inventory $/vehicle	$5,027	$4,604	$15,384	$281	$2,566	$7,234
Rail inventory $/vehicle	$37,498	$27,418	$139,286	$6,785	$12,660	$47,688
% items out of balance	7.83%	5.0%	60%	.005%	1.42%	10%
Bus % fill rate	89.0%	95.0%	100%	10%	85%	98%
Rail % fill rate	86.1%	90.2%	100%	40%	84.4%	98.3%
Bus % obsolete items	9.2%	5%	60%	.01%	2%	13.8%
Rail % obsolete items	6.1%	5%	20%	1%	1.12%	10%

4.3.4.3 The Effect of the % of Fleet that is Manufactured in the US

Correlations were performed between the percent of the agency's fleet that was manufactured in the United States and the inventory performance indicators. Those indicators relating to bus and rail were correlated with the percent of US manufactured buses and rail vehicles, respectively. All correlation coefficients are below .35. Correlations were also performed for the four categories based on number of vehicles with similar results. There is no significant correlation between the percent of US manufactured vehicles and the inventory performance indicators.

4.3.4.4 The Effect of the Number of Different Vehicle Models

Correlations were performed between the number of different vehicle models in an agency's fleet and the inventory performance indicators. In addition, t-tests were run for the average value of the indicators for each value of the number of vehicle models. Most of the correlation coefficients were very low. Only two were over .35; the percent fill rate (.47) and the dollars per vehicle (.56) for rail inventory. These coefficients are not high enough to be significant. In addition, the t-tests did not show a statistically significant difference at the 90% confidence level between the number of models and the inventory performance indicators. Therefore, there is no statistically significant relationship between the number of vehicle models in an agency's fleet and the inventory performance indicators.

4.3.4.5 The Effect of Average Vehicle Age

The effect of the average age of a transit agency's fleet was examined separately for two indicators of age; average years old and percent of expected life expended. In both cases, there were no significant correlations between the average age of an agency's fleet and the inventory performance indicators.

4.3.4.6 Average Annual Miles

Average annual miles was the final fleet profile characteristic that was examined. As with the others, there was no significant correlation between average annual miles and inventory performance indicators.

4.3.4.7 Summary of Fleet Profile Effects

The results of the analysis of fleet profile characteristics (survey Section II) against inventory performance indicators are that fleet profile characteristics, except for mode, have no statistically significant effects on inventory performance indicators. The difference between the bus and rail inventory performance indicators for turnover and dollars per vehicle are significant at the 99% confidence level.

4.3.4.2 The Effect of Fleet Size -- Number of Vehicles

Correlations were performed between the number of vehicles and inventory performance indicators. Those indicators relating to bus and rail were correlated with the number of buses and rail vehicles, respectively. The results were as follows:

Variable	Number of Responses (n)	Correlation Coefficient (r)	Coefficient of Determination (r^2)
Bus inventory turnover	55	.1533	.0235
Bus inventory dollars/vehicle	66	.1231	.0152
Bus % fill rate	52	.1182	.0140
Bus % obsolete items	48	.2494	.0622
Bus days to fill backorders	48	-.0897	.0081
Rail inventory turnover	11	-.0557	.0031
Rail inventory dollars/vehicle	13	-.3015	.0909
Rail % fill rate	9	.5429	.2948
Rail % obsolete items	9	.5477	.3000
Rail days to fill backorders	6	-.3401	.1157
Stockout % of SKUs	40	.1117	.0125
% items out of balance	50	-.0349	.0012
Inventory dollars per person	65	.2385	.0569
Person dollars/inventory dollars	40	.0534	.0029
Transactions per person	61	.1422	.0202

The above results show that there is no significant correlation between the number of vehicles and inventory performance indicators. To test this conclusion further, separate correlations were run between inventory performance indicators and subsets of the survey respondents based on the four categories defined by number of vehicles:

- Small Properties — 50 or fewer vehicles (31 survey respondents)
- Medium Properties — 51 - 300 vehicles (33 survey respondents)
- Large Properties — 301 - 2000 vehicles (15 survey respondents)
- Very Large Properties — over 2000 vehicles (7 survey respondents)

In addition to correlations, t-tests were performed on the average values of inventory performance indicators for each of these categories. The results were the same within these categories as for the entire survey sample. There is no significant correlation between the number of vehicles and inventory performance indicators within any of the above size categories. Furthermore, there is no pattern of statistically significant differences between average inventory performance indicator values for the above groups.

585 t-tests resulted in statistically significant differences in inventory performance indicators, and only 2 out of 35 correlations resulted in high correlation coefficients (.66 and .92). Furthermore, the significant differences appear random and may be the result of chance. For example, at the 90% confidence level used for the t-tests, one could expect that as many as 10% of the tests (58) could randomly result in significant differences. Therefore, agency profile characteristics have no significant effect on inventory performance indicators.

4.3.4 Effect of Fleet Profile Characteristics on Inventory Performance Indicators

The following fleet profile characteristics from survey Section II (Fleet Profile) were analyzed:

- Service Mode (Bus versus Rail)
- Fleet Size -- Number of Vehicles
- % of Fleet that is Manufactured in the US
- Number of Different Vehicle Models
- Average Vehicle Age -- Years
- Average Vehicle Age -- % of Expected Life
- Average Annual Miles

4.3.4.1 Differences Between Bus and Rail (Mode)

The average value of bus and rail inventory performance indicators were compared using t-tests with the following results:

Performance Indicator	Bus	Rail	Confidence Level for Difference
Annual inventory turnover	1.74	0.71	99.998%
Inventory dollars per vehicle	$5,027	$37,497	99.1%
% fill rate	89.0%	86.1%	35.3%
% obsolete inventory	9.2%	6.1%	74.8%
Days to fill backorders	16.4	25.3	64.0%

As the results show, transit agencies carry significantly more inventory per vehicle to support rail service than bus service. In addition, rail inventory is turned over significantly fewer times per year than bus inventory. The differences in other inventory performance indicators are not statistically significant at the 90% confidence level. However, the confidence levels are also not low enough to conclude that there is not a difference.

Rail inventory turnover	10	.0831	.0069
Rail inventory dollars/vehicle	11	.0119	.0001
Rail % fill rate	7	.2293	.0526
Rail % obsolete items	7	.9237	.8532
Rail days to fill backorders	4	-.4211	.1773

Only one inventory performance indicator, the percent of obsolete items for rail inventory, has a significant correlation with material purchases (r = .92). The small sample size of seven reduces the significance of this isolated result. (Removing one data point would reduce r to .74.) There is no consistent pattern of correlation between material purchases and inventory performance indicators.

4.3.3.5 Annual Passenger Miles by Mode

Selected "Section 15" data was gathered using the survey for reference and comparison purposes. The data most likely to affect inventory performance was the annual passenger miles. The bus and rail annual passenger miles was correlated with bus and rail inventory performance indicators with the following results:

Variable	Number of Responses (n)	Correlation Coefficient (r)	Coefficient of Determination (r^2)
Bus inventory turnover	42	.0697	.0049
Bus inventory dollars/vehicle	49	.2534	.0642
Bus % fill rate	37	.1198	.0143
Bus % obsolete items	35	.2840	.0806
Bus days to fill backorders	36	-.0883	.0078
Rail inventory turnover	11	-.0353	.0012
Rail inventory dollars/vehicle	12	-.2356	.0555
Rail % fill rate	8	.3313	.1098
Rail % obsolete items	8	.6682	.4465
Rail days to fill backorders	5	-.2819	.0795

The only indicator showing a correlation of any size is the percent of obsolete items for rail inventory (r = .66). As with material purchases, this small sample size reduces the significance of this result. Based on the above, there is no significant pattern of correlation between annual passenger miles and inventory performance indicators.

4.3.3.6 Summary of Agency Profile Effects on Inventory Performance Indicators

The analysis of the effects of agency profile data (survey Section I) against the inventory performance indicators shows only scant isolated effects with no consistent patterns. Only 22 out of

4.3.3.3 Agency Operating Cost

Survey responses for total transit agency operating cost serve as one measure of the size of a transit agency. The total operating cost responses were correlated with each of the 15 inventory performance indicators with the following results:

Variable	Number of Responses (n)	Correlation Coefficient (r)	Coefficient of Determination (r^2)
Bus inventory turnover	52	.0747	.0056
Rail inventory turnover	13	.0578	.0033
Stockout % of SKUs	35	.1368	.0187
Bus inventory dollars/vehicle	59	.0002	.0000
Rail inventory dollars/vehicle	12	-.2695	.0726
% items out of balance	47	-.0654	.0043
Bus % fill rate	46	.0756	.0057
Rail % fill rate	10	.3946	.1557
Bus % obsolete items	42	.0333	.1100
Rail % obsolete items	9	.5783	.3344
Bus days to fill backorders	42	-.0995	.0099
Rail days to fill backorders	6	-.2506	.0628
Inventory dollars per person	59	.2368	.0561
Person dollars/Inventory dollars	38	.0629	.0040
Transactions per person	52	.0599	.0036

The above correlation coefficients reveal that there is no significant correlation between agency operating cost and inventory performance indicators.

4.3.3.4 Material Purchases by Mode

Bus material purchases and rail material purchases were correlated with bus and rail inventory performance indicators with the following results:

Variable	Number of Responses (n)	Correlation Coefficient (r)	Coefficient of Determination (r^2)
Bus inventory turnover	44	.2912	.0848
Bus inventory dollars/vehicle	52	.0043	.0000
Bus % fill rate	40	.1157	.0134
Bus % obsolete items	37	.0150	.0002
Bus days to fill backorders	35	-.0687	.0047

Category Set 4:

Bus turnover -- Rural (13) and No Rural (42) -- 94.9%
Bus dollars/vehicle -- Rural (13) and No Rural (53) -- 96.0%

In summary, only 14 of the 360 t-tests resulted in categories that had statistically significant differences in performance indicators. Among the 14 categories, there was no consistent pattern. Although bus dollars per vehicle was affected by five categories, the results were not sufficient to draw a conclusion.

4.3.3.2 Service Area - Population

Survey responses for each of the following service area population categories were analyzed against the others for each of the 15 inventory performance indicators, resulting in 225 t-tests:

Over 1,000,000
500,001 - 1,000,000
200,001 - 500,000
100,001 - 200,000
50,001 - 100,000
Less than 50,000

Using the same criteria, a minimum of three responses per category and a 90% confidence level, the following differences were found:

Bus dollars/vehicle -- 2-500K (15) and 50-100K (6) -- 92.6%
Bus % obsolete -- >1MM (14) and 1-200K (10) -- 99.7%
Bus % obsolete -- 50-100K (4) and 1-200K (10) -- 97.5%
% out of balance -- 500k-1MM (7) and 1-200K (10) -- 90.1%
Inventory dollars/person -- >1MM (21) and 2-500K (15) -- 95.3%
Inventory dollars/person -- >1MM (21) and 1-200K (13) -- 98.8%
Inventory dollars/person -- >1MM (21) and 50-100K (4) -- 92.1%
Inventory transactions/person -- 2-500K (13) and 50-100K (3) -- 92.7%

Only 8 of the 225 t-tests resulted in statistically significant differences in performance indicators. Of these 8, inventory dollars per person appears to be different for agencies serving populations over 1 million than for the other categories. However, upon closer examination, this difference was due to the fact that most properties with rail service are in this category. (As will be shown later, rail properties have higher inventory levels.) When the analysis was corrected for the effect of rail properties, there was no significant difference due to the population area.

	Suburban/Rural
	Urban/Suburban/Rural
Category Set 2	Urban
	No Urban
Category Set 3	Suburban
	No Suburban
Category Set 4	Rural
	No Rural

Average values of the inventory performance indicators listed in section 4.2.3 for each category within a set were tested against others in the set. This resulted in 24 t-tests for each of 15 inventory performance indicators, for a total of 360 t-tests. In order to conclude that the average values of the inventory performance indicators were different between categories, a category had to have at least three (3) responses and the t statistic confidence level had to be at least 90%. Based on these criteria, only a few isolated categories have different average inventory performance indicators. The performance indicators and the categories are listed below with the number of responses (in parentheses) and the confidence level.

Category Set 1:

Bus dollars/vehicle -- Urban Only (31) and Suburban Only (5) -- 98.7%
Bus dollars/vehicle -- Urban Only (31) and Urban/Suburban/Rural (9) -- 94.3%
Bus dollars/vehicle -- Suburban Only (5) and Urban/Suburban/Rural (9) - -99.7%
Bus dollars/vehicle -- Urban/Suburban (18) and Urban/Suburban/Rural (9) -- 97.8%
% items out of balance -- Urban Only (20) and Urban/Suburban (14) -- 94.8%
Inventory transactions/person -- Urban Only (22) and Suburban Only (6) -- 94.4%

Category Set 2:

Bus % obsolete items -- Urban (41) and No Urban (7) -- 96.3%
Inventory dollars/person -- Urban (57) and No Urban (8) -- 92.6%
Inventory transactions/person -- Urban (49) and No Urban (8) -- 99.6%

Category Set 3:

Rail dollars/vehicle -- Suburban (10) and No Suburban (3) -- 90.1%
Stockout % of SKUs -- Suburban (25) and No Suburban (15) -- 96.1%
% items out of balance -- Suburban (27) and No Suburban (23) -- 98.4%

confidence level with which the null hypothesis can be rejected. In other words, if the confidence level is high enough (e.g. 90%), one can conclude that there is a difference in performance indicators for different categories.

For example, the average bus inventory turnover for the 24 responding transit agencies serving only urban areas is 2.00, with a standard deviation of 2.43. The average for the 15 responding agencies that serve both urban and suburban areas is 2.62, with a standard deviation of 2.11. The null hypothesis is that there is no significant statistical difference between the category averages, 2.00 and 2.62. In other words, the null hypothesis implies that the difference between the average bus inventory turnover from the survey sample is due to chance and does not represent a real difference between transit agencies. The resulting confidence level for rejecting the null hypothesis indicated by the t-statistic is 59.4%. Therefore, there is only 59.4% confidence that the difference between the sample averages, 2.00 and 2.62, represents a real difference in bus inventory turnover. Conversely, there is a 40.6% confidence that the difference observed from the survey is due to chance. A minimum confidence level for rejecting the null hypothesis is usually 90%. Therefore, based on this test, we cannot conclude that there is a difference between bus inventory turnover for agencies serving only urban areas and those serving both urban and suburban areas. Even though there is an observed difference of 0.62 in the category averages, the large standard deviations indicate that there is enough variance in both categories to prevent this difference from being statistically significant.

4.3.3 Effect of Transit Agency Characteristics on Inventory Performance Indicators

The following transit agency characteristics from survey Section I (Agency Profile) were analyzed:

- Service Area Characterized as Urban/Suburban/Rural
- Service Area Population
- Agency Operating Cost
- Annual Material Purchases by Mode (Bus, Rail)
- Annual Passenger Miles by Mode (Bus, Rail)

4.3.3.1 Service Area - Urban/Suburban/Rural

The survey responses for urban/suburban/rural were analyzed four ways. First, t-tests were conducted using each unique category of response. Then three sets of t-tests were conducted to examine the inclusion or exclusion of urban, suburban, and rural areas. The following categories were used:

Category Set 1	Urban Only
	Suburban Only
	Rural Only
	Urban/Suburban
	Urban/Rural

4.3.2 Methodology for Analyzing Agency and Fleet Characteristics

The data provided in survey Sections I and II, Agency Profile and Fleet Profile respectively, were used for agency and fleet characteristics. Data from survey Section V, Inventory Management Performance, were used to calculate values for inventory management indicators.

Two primary statistical methods were used for the analysis, based on whether the characteristic being examined was numerical (e.g. annual passenger miles) or divided into "categories" (e.g. rural, suburban, urban, etc.).

4.3.2.1 Correlations for Numerical Data

The *correlation coefficient* and the associated *coefficient of determination* were used to analyze numerical data. The correlation coefficient (r) measures the degree to which variables vary together. The value of r ranges from -1 for variables that are negatively correlated (as one variable goes up, the other goes down), to 0 for variables that are not correlated at all, to +1 for variables that are positively correlated. Values in between indicate the degree of correlation. The closer to +1 (or -1), the higher the correlation between the variables. The coefficient of determination (d) equals r^2 and measures the percent of variance in one variable that can be associated with variance in the correlated variable.

For example, annual bus passenger miles can be correlated with bus inventory dollars per vehicle to quantify the degree of the relationship between these two variables. The resulting value of r, 0.253, measures the degree of the relationship. Although the variables are positively correlated, the degree of correlation is low, since the value of r is not close to 1. The coefficient of determination, d, is r^2, or .064. This indicates that only 6.4% of the variance in bus inventory dollars can be associated with the variance in annual bus passenger miles. This correlation is not high enough to consider annual bus passenger miles as a factor when monitoring bus inventory dollars per vehicle.

4.3.2.2 t-Tests for Category Data

Some survey questions asked the respondent to check a category, such as whether the agency's service area was urban, suburban, rural, or some combination. In addition, some numerical responses were grouped into categories indicating ranges, for example, service area population between 500,001 and 1,000,000. Since the number of survey responses for most individual categories was less than 30, the standard normal distribution could not be used to test the difference between category averages. In addition, the number of responses in each category were different and do not represent "paired" data. Therefore, the *t statistic* for small, unequal sample sizes was used to test whether average values of inventory performance indicators are different for different response categories.

The methodology for the t-test is to hypothesize that there is no difference in inventory performance indicators between categories (null hypothesis), calculate the t statistic, and determine the

9. Average Days to Fill Rail Inventory Backorders
10. Percent of Items Out of Balance
11. Percent Obsolete Bus Inventory
12. Percent Obsolete Rail Inventory
13. Total Inventory Dollars per Person
14. Total Inventory Dollars to Personnel Dollars
15. Total Inventory Transactions per Person

4.3 THE EFFECT OF TRANSIT AGENCY AND FLEET CHARACTERISTICS ON PERFORMANCE INDICATORS

4.3.1 Objectives for Analyzing Agency and Fleet Characteristics

Inventory management indicators can be used to monitor and evaluate inventory management performance. Furthermore, benchmark values for the indicators can serve as a yardstick for comparing inventory management performance between departments, organizations, and entire industries. As part of this comparison, it is important to identify any effects that relate to the characteristics of the organizations being compared. In particular, for comparing benchmark values between public transit agencies, the characteristics of the public transit agency or the agency's fleet may have an impact on inventory performance. For example, the population of the agency's service area, the number of annual passenger miles, the percent of foreign manufactured vehicles, or the average age of the fleet may have identifiable effects on inventory performance indicators. These effects should be taken into account when using benchmarks.

The objectives of analyzing the effects of agency and fleet characteristics are to:

(1) identify which characteristics, if any, affect which inventory management indicators;

(2) isolate and quantify the effects; and

(3) develop a decision modeling guide to assist a public transit agency in identifying the appropriate benchmark values that pertain to the agency, based on the agency's characteristics and fleet profile.

For example, an agency with a fleet size greater than 1000 vehicles that serves urban and suburban ridership may have different benchmark values for inventory turnover than an agency with less than 50 vehicles serving a suburban and rural area.

responsibility. Inventory management and control personnel are the entire inventory staff, including stores personnel, inventory planners, clerical personnel, etc. This indicator provides a measure of inventory management and control staffing levels relative to the size of the inventory, in dollars. It can be used to compare staffing levels across different organizations.

Inventory Dollars to Personnel Dollars

"Inventory dollars to personnel dollars" is the ratio of total inventory dollar value to the total cost (salary and fringe) of the personnel charged with managing and controlling the inventory. This indicator provides a measure of the cost of inventory management and control personnel relative to the size of the inventory, in dollars, that is being managed. It can be used to compare staffing costs across different organizations.

Inventory Transactions per Person

"Inventory transactions per person" is the average number of inventory transactions (issues, receipts, transfers, returns) per person for individuals with inventory management and control responsibility. This indicator measures the activity level of inventory material flow relative to the number of people in the inventory organization. It can be used to compare relative workload of inventory personnel across different organizations.

4.2.3 Inventory Performance Indicators Used for Benchmarks

Many of the inventory performance indicators defined above are absolute measures that are best used to monitor a specific inventory over a period of time, e.g., total inventory dollars. Other indicators measure performance relative to a standard factor, such as inventory dollars per vehicle. These indicators better lend themselves to comparing performance between different inventories and are more meaningful as benchmarks. In addition, the survey data was unavailable or inconsistent for some indicators, such as carrying cost and percent of fleet out of service for parts. Further, the survey quantifies some indicators by mode (bus, rail, and other). Bus and rail responses were acceptable; however, responses in the "other" category were very inconsistent due to broad differences in interpretation by respondents. As a result, benchmark values for the following inventory management performance indicators will be quantified.

1. Bus Inventory Dollars per Vehicle
2. Rail Inventory Dollars per Vehicle
3. Annual Bus Inventory Turnover
4. Annual Rail Inventory Turnover
5. Bus Percent Demand Filled (Fill Rate)
6. Rail Percent Demand Filled (Fill Rate)
7. Percent of Items Stocked Out per Week
8. Average Days to Fill Bus Inventory Backorders

% of Items Out of Balance

The "percent of items out of balance" is the number of items (SKUs) out of balance divided by the total number of items in inventory. It measures the overall accuracy of perpetual inventory balances relative to the size of inventory, in SKUs. This indicator can be used to compare the overall accuracy of inventory balances between organizations or over time, regardless of the number of items stocked in inventory.

Management Cost Indicators

% Inventory Carrying Cost

The "percent inventory carrying cost" is the cost of maintaining inventory divided by the total dollar value of the inventory. The cost of maintaining inventory includes the following components:

- storage cost, the cost of storage space and equipment
- insurance cost, the cost, if any, of insuring inventory
- obsolescence, the cost of items that become obsolete (e.g. due to changes in fleet series)
- shrinkage, the cost of inventory items that become missing, damaged, spoiled, decayed or otherwise unusable
- capital cost, the opportunity cost associated with investing dollars in inventory rather in other assets

This indicator measures the "overhead" costs involved in maintaining inventory. One or more of the above components may be excluded from the calculation if it does not apply. For example, in some cases storage space is absorbed by other transit functions (such as vehicle maintenance).

% Obsolete Inventory

The "percent obsolete inventory" is the cost of obsolete inventory items divided by the total dollar inventory value. Although this indicator is also a component of carrying cost, many organizations track it separately. Items may become obsolete to a transit agency due to changes in the mix of vehicle series in the fleet, changes in parts design, changes in part quality specifications, etc. If these items remain in inventory, the transit agency will incur the cost of carrying items that it cannot use. This indicator assists in measuring the degree to which inventory management anticipates and reacts to changes in fleet mix and parts storage requirements.

Inventory Dollars per Person

"Inventory dollars per person" is the total inventory dollars divided by the number of people with inventory management and control

Inventory Accuracy Indicators

Dollar Variance

The "dollar variance" is the difference between the "total inventory dollars" based on a transit agency's inventory records (book value) and the "total inventory dollars" based on a physical count of inventory items. This indicator measures the effect of inventory accuracy based on the aggregate dollar value the inventory. It tells how inaccurate an agency's records are based on total inventory dollars, and is used to adjust the book value of inventory.

Absolute Dollar Variance

The "absolute dollar variance" is the sum of the dollar variances for each individual inventory item (SKU). It is calculated by summing the absolute value of the difference between the dollar value of each item based on inventory records and the dollar value based on a physical count of the item. In using the absolute value, variances that are negative and positive will not cancel each other out. This indicator provides a more comprehensive picture of the accuracy of individual inventory item values and an overall measure of the accuracy of "total inventory dollar" records.

% Absolute Dollar Variance

The "percent absolute dollar variance" is the "absolute dollar variance" divided by the "total inventory dollars". It measures the overall accuracy of inventory values relative to the size of inventory, in dollars. This indicator can be used to compare the overall accuracy of inventory value between organizations or over time, regardless of the total value of inventory.

Item Variance

The "item variance" is the difference between the number of units on hand of an individual item based on a transit agency's inventory records and the number of units based on a physical count of the inventory item. This indicator measures the accuracy of each item's perpetual balance records, and is used to adjust the "quantity on hand" records for each inventory item. This measure is not normally summed to give a variance for the total number of units, however it can be averaged to give the average variance for an inventory item. This "average item variance" measures the average number of units that an item's physical count varies from the inventory records.

Number of Items Out of Balance

The "number of items out of balance" is the total number of inventory items (SKUs) for which an "item variance" exists. It is determined by counting the number of items for which the physical count does not match the inventory records for quantity on hand. While the average item variance measures the average size of the discrepancy between the physical count and the inventory records, this indicator measures the actual number of items that have a discrepancy.

added or removed from inventory, or between organizations with different numbers of SKUs in inventory.

Number of Open Back Orders

The "number of open backorders" is the number of unfilled requests for inventory material that exist at a given point in time. It is calculated by counting the number of inventory items that have been requested and are currently unavailable from inventory. It is used to focus inventory management activity and to monitor the status of the availability of inventory items at a given point in time.

A similar indicator is the "average number of open back orders". This indicator measures the typical status of inventory availability by averaging the number of open back orders at several points in time.

Time to Fill Backorders

The "time to fill backorders" is the average time it takes to provide an inventory item that is unavailable at the time of request. The time to fill a backorder is the time period beginning with a request for an unavailable inventory item and ending at the time the item is provided to the requester. These instances are averaged over a period of time to yield the "average time to fill backorders". This indicator measures inventory management performance in resolving unavailable inventory items. It can also be used to compare performance across organizations.

Vehicles Out of Service

"Vehicles Out of Service" is the number of times a vehicle is held out of service due to unavailability of inventory items. A vehicle is counted each time it misses a service run, even if the same part is unavailable. This indicator measures the effect of inventory availability on transportation service provided by a public transit agency over a specified period of time.

% of Fleet Out of Service

The "percent of fleet out of service" is the percent of a transit agency's fleet that is held out of service due to unavailable inventory items. It is calculated by dividing the "vehicles out of service" for a service run by the total number of service vehicles. This indicator can be averaged over a period of time to provide the average percent of fleet out of service. This indicator measures the effect of inventory availability on transportation service, relative to the total fleet size. It can be used to compare inventory performance across different fleet sizes and different organizations.

be used during the time period. Like turnover, it attempts to compensate for the effects of demand levels on the size of inventory.

Note: Since months on hand and inventory turnover are mathematically the inverse of each other, only inventory turnover is benchmarked and examined in this report. Any inferences regarding turnover are also valid for months on hand, and benchmark values for months on hand can be determined using the inverse of the benchmark values for monthly turnover (or annual turnover divided by 12).

Availability/Service Indicators

% Demand Filled (Fill Rate)

The percent of demand filled, or the inventory fill rate, is the percent of items requested from inventory that are provided from inventory at the time of the request. It is calculated by dividing the total number of items requested from inventory into the total number of items issued from inventory at the time of request during a given time period. This indicator measures the level of availability of inventory items. It also defines the probability that an item will be available from inventory when it is needed. The fill rate is used to monitor how well the items held in inventory match the items that are needed over a given period of time. It is also used to compare inventory management performance, regarding availability, between organizations.

Number of Stockouts

The number of stockouts is the number of unanticipated times that active inventory items reach a zero balance on hand during a specified time period. This indicator measures the exposure of inventory to potential unfilled requests. Only unanticipated stockouts are counted because, at times, some items are carried at zero balance on a planned basis (such as seasonal items or items that are ordered only on request). Unanticipated stockouts are counted regardless of whether there is an outstanding request for the item. The fill rate measures the ultimate availability of inventory material, but the number of stockouts indicates the degree to which fate is tempted.

% of Items Stocked Out

The "percent of items stocked out" measures the percent of the total number of inventory items (i.e. part numbers) that reach a zero balance during a given period of time. The total number of inventory part numbers are called "stockkeeping units" or SKUs. This indicator is calculated by dividing the number of unanticipated stockouts during a given period of time by the total number of SKUs held in inventory. This indicator provides a measure of exposure to unfilled requests that is relative to the size of the inventory, in SKUs. It provides a measure that can be compared across time regardless of the number of items

annual turnover is calculated by dividing the total dollar value of the items used from inventory during the year by the average total dollar value of items held in inventory during the year. The average total dollar value of items held in inventory for the year can be calculated by taking the average of "total dollar inventory" levels measured at different times during the year (for example, at the end of each month, or the beginning and ending levels for the year). Turnover can be calculated for any time period. For example, monthly turnover is calculated by dividing total monthly dollar usage by the average total dollar inventory for the month.

Inventory turnover indicates inventory size, in dollars, relative to the amount of inventory that is used during a given time period. For example, an annual inventory turnover of 2.5 means that the transit agency uses two and a half times the amount of dollars it holds in inventory. In other words, inventory is "turned over" 2.5 times during the year. Since an objective of inventory management is to minimize inventory levels, the higher the inventory turnover, the more efficiently the inventory level is managed relative to the demand for inventory items (usage). As an indicator, inventory turnover attempts to compensate for the size of demand when monitoring inventory levels, and is widely used to compare inventory performance across time and between different organizations.

Note: The survey respondents provided inventory turnover values based on a variety of time periods and average "total inventory dollars". To ensure consistency, the inventory turnover was calculated for each agency using the 1993 total inventory dollars and the average monthly usage times 12.

Months on Hand

"Months on hand" is the number of months that a transit agency's inventory will last if no additional items are added to inventory. Months on hand is the inverse of monthly inventory turnover. It is another way to measure the size of inventory relative to the demand for inventory over a specific time period. It is calculated by dividing the average "total inventory dollars" for a month by the total dollars used from inventory during the month. The fewer months that a transit agency must keep on hand to support the demand for inventory items, the better the performance relative to minimizing inventory levels. This indicator can also be calculated for different time periods, such as "days on hand" or "years on hand".

Months on hand is a figurative rather than a literal indicator in that it is a measure of how long an agency's inventory dollars will last. This measure assumes that the items on hand are exactly the items that will

As the above table shows, only 41% of the survey respondents use inventory amount indicators, 36% use availability or service level indicators, 57% use inventory accuracy indicators, and only 5% use indicators for the cost of managing inventory. Many of the respondents stated that inventory performance is tracked less formally, using annual personnel performance reviews and complaints or comments from inventory "customers".

Although many of the survey respondents do not regularly track the above indicators, most were able to provide values in response to the survey questions. The respondents also provided information to calculate and examine additional indicators, such as the percent of obsolete inventory and the number of inventory personnel per vehicle. Therefore, the survey provides sufficient information to analyze and benchmark inventory performance indicators, even though some indicators may not currently be in widespread use in the public transit industry.

4.2.2 Definition and Calculation of Performance Indicators

In some cases, the survey respondents defined or calculated performance indicators differently. In addition, there are some indicators that were not explicitly solicited in the survey, but can be calculated from other survey data. This section presents standard definitions and calculation methods for the inventory management performance indicators and describes the inventory management attributes that each measures.

Inventory Amount Indicators

Total Inventory Dollars — "Total inventory dollars" is the total cost to the transit agency of all items held in inventory at a given point in time. It is calculated by multiplying the number of units for each item times the item's unit cost, and summing across all items. This indicator measures the size of inventory in terms of the dollars that the transit agency has tied-up in inventory assets. It is best used to monitor changes in the size of inventory (increases and/or decreases) by examining the value at different points in time.

Inventory Dollars per Vehicle — Inventory dollars per vehicle is the average amount of inventory dollars on-hand at a point in time to support a vehicle in the transit agency's fleet. It is calculated by dividing the "total inventory dollars" by the number of vehicles using items from the inventory. This indicator measures the size of inventory, in dollars, that the transit agency holds to support a vehicle. It eliminates the effect of fluctuations in fleet size when monitoring inventory levels across time. It is also useful when comparing the relative size of inventory across fleets with different numbers of vehicles, different makes and models, different modes, etc.

Inventory Turnover — Inventory turnover is the number of times the "total inventory dollars" is used by inventory customers in a given period of time. For example,

4.2 PUBLIC TRANSIT INVENTORY MANAGEMENT PERFORMANCE INDICATORS

4.2.1 Use of Inventory Management Performance Indicators -- Survey Response

Our survey shows that most public transit properties use a small number of indicators to monitor inventory performance. Moreover, many properties, particularly those with less than 50 vehicles, do not formally monitor inventory performance. These properties merely set minimum and maximum levels for inventory items to control replenishment and address parts shortages as they occur. The table below shows the inventory performance indicators named in the survey and the percent of survey respondents in each size category that use the indicators. The size of the properties is based on the number of vehicles as follows:

Small Properties	50 or fewer vehicles (31 survey respondents)
Medium Properties	51 - 300 vehicles (33 survey respondents)
Large Properties	301 - 2000 vehicles (15 survey respondents)
Very Large Properties	over 2000 vehicles (7 survey respondents)

Performance Indicators	Small	Medium	Large	Very Large	Total
Inventory Amount Indicators	**19%**	**48%**	**47%**	**57%**	**41%**
Total Inventory Dollars	19%	39%	27%	57%	31%
Dollars per Vehicle	0%	9%	20%	0%	10%
Inventory Turnover	0%	9%	7%	29%	7%
Availability/Service Indicators	**10%**	**45%**	**47%**	**86%**	**36%**
% Demand Filled	0%	3%	13%	57%	8%
Number of Stockouts	0%	21%	27%	0%	13%
Number of Back Orders	6%	21%	27%	86%	22%
Time to Fill Backorders	3%	0%	0%	0%	1%
Vehicles Out of Service	0%	6%	7%	14%	5%
Inventory Accuracy Indicators	**32%**	**73%**	**60%**	**86%**	**57%**
Dollar Variance	10%	42%	27%	29%	27%
Item Variance	23%	54%	47%	71%	43%
Management Cost Indicators	**0%**	**9%**	**7%**	**0%**	**5%**
% Inventory Carrying Cost	0%	9%	7%	0%	5%

IV. PERFORMANCE INDICES FOR ASSESSING INVENTORY MANAGEMENT

4.1 INVENTORY MANAGEMENT PERFORMANCE OBJECTIVES

Inventory management theory defines two conflicting objectives of inventory management: minimize the amount of inventory and maximize (or maintain) the availability of inventory items. These objectives are conflicting since increasing inventory can have the effect of increasing availability and reducing inventory can lead to a reduction in availability. The primary task of inventory management is to effectively balance these two objectives so that inventory is available to sufficiently support the demand for inventory items, while at the same time controlling the dollars tied up in inventory.

Inventory management performance indicators usually measure the performance of one of the two primary objectives. For example, "total inventory dollars" measures the amount of inventory, while the "percent of demand" that is filled measures the availability (or service level) provided by the inventory. A third category of performance indicators measures the level of effort and cost required to manage inventory. Minimizing the cost of managing inventory is also an objective of inventory management. Examples of performance indicators for this category include the personnel cost per inventory dollar of personnel assigned to inventory functions and the percent inventory carrying cost. The fourth category of performance indicators measures the accuracy of inventory records, such as the percent of items whose perpetual balance is incorrect.

Section 4.2 of this chapter defines the inventory management performance indicators that are commonly used by the public transit industry, based on our survey results. In addition, Section 4.2 defines other useful performance indicators that can be derived from the survey data.

Section 4.3 of this chapter examines the effects of agency characteristics (such as the population served, operating budget, and number of annual passenger miles) and fleet characteristics (such as the number of foreign manufactured vehicles, the average age, etc.). These characteristics can be found in Sections I and II of the survey, respectively.

Section 4.4 presents the values of the performance indicators, based on the survey responses. These values can be used for benchmarking by individual transit properties.

Section 4.5 compares the values of the performance indicators for the public transit industry with the values normally found in other industries.

Category 5 transit agencies appear to be the most successful in managing safety stock levels, setting target inventory and service levels, and in formalizing written inventory procedures in a written manual. Category five agencies also appear to have the best inventory turnover and fill rates for both bus and rail fleets.

In the next chapter, we define the inventory management performance indicators commonly used by the public transit industry. Chapter IV also examines the effects of agency and fleet characteristics and presents the values of the performance indicators, based on the survey responses. Finally, the chapter compares the values of some of the performance indicators used by the public transit industry with those found in other industries.

3.1.5.2 Inventory Management Practices

Category 5 transit agencies have, by far, the most extensive storehouse network. Average size of the network is 16.5 storehouses. The median is 11.5 storehouses. For the 16 properties in this category, storehouses networks range in size from 75 to one. Stockouts per week average higher than any other organization type profiled except one. The average stockout rate is 2. Average percent safety stock is better than most other profile categories with a percentage of 17.

Sixty-nine percent, or 11 transit agencies, set target inventory levels. Eighty-one percent, or 13 transit agencies, set target service levels. Of interest, is the fact that all transit agencies who set target inventory levels, also set target service levels. Only 50 percent of Category 5 transit systems authorize the direct purchase if inventory parts and material. This is the lowest percentage of the five organization types profiled. Conversely, this category has the highest percentage (75%) of transit agencies with written inventory management procedures.

3.1.5.3 Inventory Management Performance

Category 5 transit systems have, on average, the highest inventory turnover rates for bus fleets. These transit systems turn over inventory approximately 2.6 times per year. The highest level of turnover in the category was 7.36 and the lowest was .63. Category 5 transit systems also turned over rail inventory quicker than those in Category 4. The rate for Category 5 transit systems was .76 as opposed to .48 for Category 4 transit systems.

Average inventory was approximately $9.4 million for bus fleets and approximately $27 million for rail fleets. Inventory dollars per vehicle averaged $5,341 for bus fleets with the median at $4,875. Highest for the group was $13,246 and lowest was $959. For rail fleets, inventory dollars per vehicle averaged $34,696 with a median of $19,684. The range for the group was a high of $139,286 and a low of $6,785.

Inventory fill rates for both bus and rail were the highest of all transportation modes in all five of the organization types profiled. Bus fill rates averaged 96% and rail inventory fill rates averaged 94%. The percentage of obsolete and excess bus material averaged 13%. Two of the other organization types profiled were higher and two were lower than the average. Obsolete and excess material for rail inventory averaged 9 percent, eight percentage points higher than Category 4 rail fleets. Finally, Category 5 transit systems averaged 10 percent items out of balance. Only category 4 transit systems had a higher percentage (15%).

3.1.5.4 Relative Merits

A dedicated inventory management group at the department level gives the most complete control over the management of inventory. Such an independent inventory management organization provides the most effective option for balancing the conflicting objectives of financial control and material availability.

Category 4 transit systems appear to do a relatively good job at keeping both the number of stockouts and the percentage of excess and obsolete inventory items low. This group also does well in setting target inventory levels and providing staff with a written procedures manual.

Inventory turnover for both bus and rail were the lowest for all five organizational types profiled and percent of items out of balance was the highest. However, bus inventory dollars per vehicle and bus inventory fill rates were among the highest of the groups.

3.1.5 Organization Profile #5: Formal Inventory Management Function -- A Single Dedicated Inventory Management Group at the Department Level

Sixteen out of the 75 organizations profiled have a single dedicated inventory management group located at the department level as shown in Figure 3-5. Category 5 organizations average a 200 buses with a median of 847. Ten of the sixteen properties have rail car fleets. Rail fleets range in size from 84 to 5,806. Rail car fleets average 1,177. The median size for rail car fleets is 859.5.

3.1.5.1 Organization

All of the 16 Category 5 organizations employ a full-time inventory manager. Thirteen (81%) of the agencies include planning within the organization but only one includes purchasing. Similarly, only one of the organizations is decentralized.

Figure 3-5

For total number of staff involved in managing inventory material, 89 percent of all staff are located within the inventory management organization. Within the inventory management organization, staff sizes range from a high of 913 to a low of 6. Staff sizes average 104 with a median of 47. When looking at all staff involved with the management of inventory, staff sizes range from 978 to 7. Average staff size is 118 and the median is 47. Within the transit agency, six of the inventory management organizations in this category report as part of administration, five as part of purchasing and the remainder as part of materials, finance or operations. All of the organizations report to the executive level.

the five organizational types profiled in this chapter, this category has the lowest number of stockouts per week (.1 percent). This group also has the lowest percentage of safety stock (14 percent).

Seven out of the nine Category 4 transit agencies set target inventory levels. As is the case with the other organization types profiled thus far, only three out of the nine transit agencies set target inventory service levels. These three agencies utilize both types of measurement. Sixty-seven percent, or six of the nine transit agencies authorize direct purchase for inventory material. Written procedures are in place at 56 percent, or five of the agencies.

3.1.4.3 Inventory Management Performance

Differences in bus and rail turnover rates exist for both Category 4 and Category 5 properties. The average bus fleet turnover rate for Category 4 agencies is slightly more than once per year, For rail inventory, the figure is approximately once every two years. The difference between the two rates may be explained by such factors as longer lead times for ordering rail fleet parts and material and higher costs for safety stock and insurance items.

The inventory dollar level for bus fleets ranged from a high of nearly $3 million to a low of $222,000. The average and median for the group was $1.3 million. When looking at bus inventory dollars per vehicle, the average was $4,403, the second lowest figure for all organizational types profiled. For the group, the maximum dollar level was figured at $7,661 and the minimum at $1,586. Both of the Category 4 rail fleets provided information on inventory dollar levels. The average and median inventory dollar level for the two rail fleets in Category 4 was $2.4 million since the total inventory dollars were very close for both agencies. However, when looking at rail inventory dollars per vehicle, the two figures were $82,771 and $37,835.

The average bus inventory fill rate for the group was 91 percent with a high of 99 percent and a low of 85 percent. For rail, the fill rates were both 80 percent. The percent of obsolete and excess material was much higher for the bus fleets than the rail fleets. Obsolete and excess material averaged 15 percent for bus fleets and only 1 percent for rail fleets. The percent of items out of balance for all Category 4 rail systems was 15 percent. This number represents the highest percentage of items out of balance for all five organizational types profiled.

3.1.4.4 Relative Merits

Like the organizations profiled in Category 2, the major advantage of Category 4 organizations in managing inventory is the establishment of a formal inventory management function located outside of the Maintenance Department. Unlike Category 2 agencies, however, these agencies' inventory management functions report to a department level, rather than a sub-department level.

- Agencies that use maintenance forecasts only manage fewer inventory dollars per person than those using all other combinations:

Forecasts only -- $42,215	reorder point only -- $135,840	(97% confidence)
	reorder point & forecasts -- $151,758	(98% confidence)
	all three: $291,141	(95% confidence)

- Agencies that use a combination of reorder points and maintenance forecasts process more inventory transactions per week per person than those using reorder points only and those using all three methods:

Reorder point & forecast -- 164.3	reorder point only -- 101.0	(95% confidence)
	all three -- 114.4	(88% confidence)

Number of different methods used -- the total number of methods used to trigger inventory replenishment. (Note: Many survey respondents indicated that multiple methods were used depending on the material and its planned use.)

There was no correlation between the number of different replenishment methods used and any of the inventory performance indicators.

Target safety stock percentage -- the average percent of units of an item that is set aside as "safety stock" to cover uncertainties while the item is being replenished. Safety stock reduces the probability that an item will stockout due to such uncertainties as fluctuations in vendor lead time, unanticipated demand for a part, goods damaged in shipment, etc.

There was no correlation between the target safety stock percentage and any of the inventory performance indicators. However, the survey respondents were grouped as follows:

No safety stock (0%)
Less than 10%
10% or greater, but less than 20%
20% or greater, but less than 40% (bus) or 50% (rail)

Conducting t-tests on inventory performance indicators between these groups led to the following findings, all relating to the 20% or greater group.

Agencies with target safety stock levels of 20% or greater:

- have higher rail inventory dollars per vehicle ($67,092) than those with less than 20% ($19,181) -- 91% confidence.

- have lower annual rail inventory turnover (0.45) than those with less than 20% (0.86) -- 81% confidence.

- take more days to fill bus inventory backorders (29.3 days) than those with less than 20% (12.5 days) and those with less than 10% (9.8 days) -- 91% and 95% confidence, respectively.

- have higher percent obsolete bus inventory (12.6%) than those with less than 20% (5.2%) and those with less than 10% (7.1%) -- 97% and 87% confidence, respectively.

- have a higher percentage of items stocked out (4.5%) than those with less than 20% (0.7%), those with less than 10% (0.8%), and those with no safety stock (0.2%) -- 87%, 86%, and 91% confidence, respectively.

5.3.5 Inventory Purchasing Practices:

The effect using the following factors regarding the purchase of inventory material was examined:

Direct purchasing authority -- whether inventory management personnel have authority (within dollar limits) to purchase inventory material directly without involving purchasing personnel.

Agencies with direct purchasing authority:

- manage fewer inventory dollars/person -- $126,295 vs. $201,119 (95% confidence)
- spend less on inventory personnel/inventory dollar -- $.27 vs. $.38 (87% confidence)

Use of blanket purchase orders -- whether the transit agency establishes blanket purchase orders for selected inventory items, and allows inventory management personnel to purchase material through releases against the blanket orders.

Agencies that use blanket purchase orders to purchase inventory material:

- have higher annual rail inventory turnover -- 0.75 vs. 0.53 (88% confidence)
- manage more inventory dollars/person -- $222,513 vs. $96,465 (99+% confidence)
- have higher bus inventory dollars/vehicle -- $6,050 vs. $4,247 (97% confidence)
- have higher rail inventory dollars/vehicle -- $41,989 vs. $21,031 (87% confidence)

Percent of inventory material purchased using blanket purchase orders -- the percent of inventory part numbers that are covered by blanket orders (if the agency uses blanket purchase orders to purchase inventory material).

There was only one finding relating to this factor:

- The percentage of inventory items covered by a blanket order is negatively correlated with the rail inventory fill rate. The correlation coefficient is -.71, and the coefficient of

determination is .50. In other words, 50% of an agencies variance in rail inventory fill rate can be explained by variance in the percent of inventory items covered by blanket purchase orders. The higher the percentage of items covered, the lower the rail inventory fill rate.

5.3.6 Storehouse Configuration and Coverage

The effect of the following attributes of the agency's storehouse configuration and coverage policies were examined:

Number of storehouses -- the number of storehouses used to stock inventory material was examined in two ways: (1) whether the agency used a single storehouse or multiple storehouses to store inventory material, and (2) the total number of storehouses used by the agency.

All rail properties responding to the survey have multiple storehouses, so this factor could not be used to analyze rail inventory performance indicators. In addition, the total number of storehouses has no correlation with any inventory performance indicators (rail, bus, or total). The only findings are that agencies with multiple storehouses:

- have a higher percentage of obsolete bus inventory -- 9.0% vs. 6.1% (85% confidence)
- manage more inventory dollars/person -- $192,563 vs. $110,947 (99% confidence)

Storehouse network configuration -- the configuration of the storehouse network, such as one central storehouse, a central storehouse supplying separate smaller storehouses, multiple independent storehouses, or "other" (usually a combination or hybrid of the other configurations).

The findings relating to the storehouse configuration were:

- Agencies with "other" storehouse configurations have a higher bus inventory fill rate (98.9%) than those with one central storehouse (88.6%) or those with a central and separate satellite storehouses (87.8%) -- 99+% and 99% confidence, respectively.

- Agencies with independent storehouses have a lower percent stockout (0.3%) than those with a central and separate satellite storehouses (1.7%) -- 86% confidence.

- Agencies with a central storehouse supplying satellite storehouses have a higher percent of items out of balance than all other configurations. In addition, those with one central storehouse have a higher percent than those with independent or "other" configurations:

Central/satellite -- 16.0%	central only -- 5.6%	(94% confidence)
	independent -- 1.5%	(99% confidence)
	"other" -- 2.2%	(98% confidence)

Central only -- 5.6%	independent -- 1.5%	(99+% confidence)
	"other" -- 2.2%	(98% confidence)

- Agencies with a central storehouse supplying satellite storehouses manages more inventory dollars per person ($227,401) than those with one central storehouse ($110,155) and those with "other" configurations ($122,202) -- 99% and 94% confidence, respectively.

Percent of secured storehouses -- the percentage of storehouses that were locked with access limited to designated individuals.

The survey responses were arranged into three groups so that there would be enough responses in each group to perform t-tests: unsecured storehouses (0%), less than 100% secured, and 100% secured. The findings based on these three groups were:

- Agencies with 100% secured storehouses have higher annual bus inventory turnover (1.84) than those with unsecured storehouses (1.26) -- 85% confidence.

- Agencies with less than 100% secured storehouses manage more inventory dollars per person ($252,648) than those with unsecured storehouses ($144,365) and those with 100% secured storehouses ($140,723) -- 87% and 90% confidence, respectively.

Percent of storekeeper coverage -- the percentage of time that storehouses are attended by storekeepers or other personnel.

The survey responses were grouped as follows:

0% coverage
Less than 50% coverage
50% or greater, but less than 75%
75% or greater, but less than 100%
100% coverage

The findings were:

- Agencies with 100% storehouse coverage have higher bus dollars per vehicle ($6,032) than those with less than 100% ($4,458) and those with less than 75% ($4,562) -- 87% and 88% confidence, respectively.

- Agencies with less than 100% coverage have higher annual bus inventory turnover than those with less than 75%, less than 50%, and 0%:

less than 100% -- 2.24	less than 75% -- 1.48	(85% confidence)
	less than 50% -- 1.41	(86% confidence)
	0% -- 1.27	(93% confidence)

- Agencies with 0% storehouse coverage have lower bus inventory fill rates (83.8%) than those with 100% (92.9%) and less than 100% coverage (92.7%) -- 90% and 89% confidence, respectively.

Department responsible for stores -- the department responsible for stores coverage (e.g. maintenance, inventory management, operations, or other).

The findings were:

- Agencies with maintenance responsibility for stores process fewer transactions per week per employee (91.1) than those with stores reporting to an inventory management organization (163.1) -- 96% confidence.

- Agencies with maintenance responsibility for stores manage less inventory dollars per employee ($107,359) than those with stores reporting to an inventory management organization ($170,919) -- 95% confidence.

- Agencies with maintenance responsibility for stores manage take more days to fill bus inventory backorders (26.3) than those with stores reporting to an inventory management organization (14.0) -- 97% confidence.

- Agencies with maintenance responsibility for stores have less percent obsolete bus inventory (4.3%) than those with stores reporting to an inventory management organization (10.9%) - 98% confidence.

5.3.7 Published Procedures and Catalog:

The effect of the existence of (1) written inventory management policies and procedures, and (2) a published catalog of inventory material were examined.

Written policies and procedures:

Agencies with written policies and procedures:

- manage more inventory dollars/person -- $210,352 vs. $100,948 (99+% confidence)
- have higher percent obsolete bus inventory -- 9.1% vs. 5.9% (90% confidence)

Publish an inventory material catalog:

Agencies that publish a material catalog:

- manage more inventory dollars/person -- $186,000 vs. $122,173 (94% confidence)
- have higher percent obsolete bus inventory -- 8.7% vs. 5.9% (87% confidence)

5.3.8 Physical Inventory/Cycle Counting:

The effect of regularly counting inventory items was examined both for (1) the frequency of a complete physical inventory (counting all items), and (2) the frequency of cycle counting (counting selected items based on a schedule).

- There is no significant difference in the percent of items that are out of balance for transit agencies that conduct a complete annual physical inventory, semi-annual physical inventory, or never conduct a complete physical inventory:

  annual - 7.8% out of balance
  semi-annual - 8.2% out of balance
  never - 7.4% out of balance

  There is no difference in annual and semi-annual (94% confidence), annual and never (94% confidence), and semi-annual and never (90% confidence).

- Transit agencies that conduct quarterly cycle counts have a significantly lower percent of items out of balance than those that conduct cycle counts daily, weekly, and monthly:

  daily -- 9.2% out of balance
  weekly -- 5.9% out of balance
  monthly -- 5.2% out of balance
  quarterly -- 1.8% out of balance

  The quarterly out of balance percentage is lower than daily (95% confidence), weekly (95% confidence), and monthly (96% confidence).

5.3.9 Repair and Stocking of Components:

The effect of a transit agency's handling of components (e.g. engines, transmissions, starters, pilot motors) was examined, specifically, whether an agency: (1) repairs or rebuilds components , and (2) stocks spare components in inventory.

Repair/rebuild components:

Agencies that repair and rebuild components:

- manage more inventory dollars/person -- $165,275 vs. $67,383 (99+% confidence)
- process more transactions per week/person -- 147.8 vs. 81.4 (88% confidence)
- take more days to fill bus inventory backorders -- 17.6 vs. 9.3 (90% confidence)

Stock repaired/rebuilt components:

Agencies that stock repaired and rebuilt components:

- have higher bus inventory dollars/vehicle -- $5,300 vs. $3,895 (93% confidence)

5.3.10 Use of Systems and Technology:

The effect of an agency's use of automated systems and technology in managing inventory was examined as follows:

Use of an automated versus a manual system -- whether an agency uses an automated computer system to track and manage inventory or a manual system (e.g. cardex, signout sheets, etc.).

- Transit agencies with automated inventory systems process more transactions per week per inventory person (based on total persons involved with inventory management) than agencies with manual systems: 149.6 compared to 73.1 (85% confidence).

- Transit agencies that use a combination of both automated and manual systems for inventory management have a higher percent of inventory items out of balance (12.6%) than agencies that use automated (5.2%) and manual (4.9%) systems solely. (93% and 92% confidence, respectively)

- Transit agencies that use an automated inventory system solely have higher annual inventory turnover than those that use a combination of automated and manual systems. This is true both for bus and rail properties:

Bus inventory turnover:	automated - 2.26	both -- 1.19	(99+% confidence)
Rail inventory turnover:	automated - 0.98	both -- 0.45	(96% confidence)

- Bus properties that use manual systems solely have lower dollar inventory levels per vehicle ($1,877) than those using an automated system solely ($5,232) or a combination of both ($5,426). (99+% confidence for each difference)

Use of bar code -- whether an agency uses bar code capabilities for inventory tracking and management.

- Bus properties using bar code have a higher average fill rate, 95.2% compared 91.0% for bus properties not using bar code. (94% confidence)

Use of other technology - whether an agency uses other technology, such as light pens, wands, key cards, etc. in tracking and managing inventory.

- Rail properties using "other technology" have a higher annual inventory turnover rate, 0.87 compared to 0.53 for rail properties not using "other technology". (88% confidence)

- Transit agencies using "other technology" control more inventory dollars per inventory organization employee, $369,717 compared to $164,368 (93% confidence) and more dollars per total employee involved in inventory management, $286,159 compared to $129,463 (93% confidence). However, this result may be due to a higher percent of rail properties (57%) using other technology than bus properties (16%). (Rail properties have a significantly higher inventory than bus properties, as noted in chapter III.)

Information available to stores -- the level of information available to store personnel, as defined by the number of different reports/screens that stores personnel can access.

There is no correlation between the amount of information available to stores personnel and the inventory performance indicators.

5.4 RELATIONSHIPS BETWEEN INVENTORY ORGANIZATION MANAGEMENT DECISIONS AND INVENTORY PERFORMANCE

This section describes the quantitative relationships between inventory performance indicators and inventory organization and management decision factors. Selected agency and fleet characteristics were also included in the analysis to determine if these characteristics are significant when combined with organization and decision factors. The relationships were derived using regression analysis and are expressed as first order (linear) equations. The regression analysis process is described in section 5.2.2 of this chapter. The sections below present a regression equation for each inventory performance indicator. The sections also identify the inventory organization and management decision factors, and agency and fleet characteristics that are statistically significant in projecting the value of the performance indicator. Specifically, each section contains the:

constant for the regression equation -- the constant is the starting point for predicting the value of the inventory performance indicator using the regression equation.

factors that were identified as the best predictors -- these were factors that were selected for the regression equation, based on the step-wise regression analysis and the confidence level of their coefficients.

coefficient for each factor -- each factor in the equation is multiplied by its coefficient and then summed along with the constant to calculate the predicted value of the inventory performance indicator.

confidence level for each coefficient -- indicates the degree of confidence that the coefficients are significant (not equal to zero). For example, if a coefficient has a confidence level of 95%, there is a 95% probability that the coefficient value derived from the survey sample is

representative of the population. Conversely, there is only a 5% probability that the value derived from the survey sample was due to chance, and that the value is really zero for the population. Only coefficients with a high degree of confidence (e.g. greater than or equal to 90%) are accepted and included in the equation. (Note: Some coefficients for rail inventory performance indicators are included at a lower confidence level due to the relatively small sample of rail properties in the survey - 14 responses).

coefficient of determination (r^2) -- defines the amount of variance in the inventory performance indicator that is explained by the factors in the regression equation, based on the survey data.

adjusted coefficient of determination -- the coefficient of determination adjusted for the degrees of freedom in the sample data. It reflects the percent of variance explained when applying the equation to the population of transit agencies, rather than the survey sample. It provides an unbiased estimate of the population coefficient.

confidence level for the regression equation -- indicates the degree of confidence that the value predicted by the regression equation is significant (not equal to zero).

In general, the regression equations were derived to balance the significance of the individual coefficients with the amount of variance explained. For example, factors with a lower confidence level can be added to the equation. The result will be a greater amount of variance explained (higher coefficient of determination), but a lower confidence level for the prediction and the individual coefficients.

5.4.1. Bus Inventory Dollars per Vehicle

The following table summarizes the regression equation for bus inventory dollars per vehicle based on the factors that were determined to be the best predictors:

Factor	Coefficient	Confidence Level
Constant	2767	99+%
Bus inventory dollars	.000361	99+%
Organization type 2	7715	99+%
Use manual inventory system	-6007	99+%
Report to maintenance	1951	97%
Decentralized organization	-2992	95%
Separate inventory planning	2731	98%
Annual bus material purchases	-.000056	96%

The coefficient of determination (r^2) for the regression equation is 55.3%, therefore 55.3% of the variance in bus inventory dollars per vehicle is explained by the above factors, based on the survey. The coefficient, adjusted to reflect the population of transit agencies rather than the survey sample, was 48.1%. The confidence level for the regression equation is 99+%.

5.4.2. Rail Inventory Dollars per Vehicle

The factors selected to predict rail inventory dollars per vehicle were:

Factor	Coefficient	Confidence Level
Constant	55623	91%
Avg. vehicle age (years)	-4649	99%
% coverage of storehouses by storekeeper	538	86%

Coefficient of determination (r^2):	61.2%
Adjusted r^2:	52.6%
Regression confidence level:	99%

5.4.3. Annual Bus Inventory Turnover

The factors selected to predict annual bus inventory turnover were:

Factor	Coefficient	Confidence Level
Constant	3.411	99+%
Separate inventory planning	-3.118	99+%
Organization type 5	4.736	99+%
Cost of inventory personnel	-0.00000005	99+%
Avg. annual bus miles per vehicle	-0.0000112	99+%
Stock components in inventory	-1.104	99+%
Percent of inventory items on blanket POs	0.022	99+%
Purchasing included in inventory organization	0.506	92%
Total bus inventory dollars	-0.00000005	91%

Coefficient of determination (r^2):	85.6%
Adjusted r^2:	80.2%
Regression confidence level:	99+%

5.4.4. Annual Rail Inventory Turnover

The factors selected to predict annual rail inventory turnover were:

Factor	Coefficient	Confidence Level
Constant	-0.59	99+%
Cost of inventory personnel	-0.00000003	99+%
Number of rail vehicle models	0.041	99+%
Total number of replenishment methods used	0.18	99+%

% coverage of storehouses by storekeeper	0.0058	99+%
Have direct purchase authority for inventory	0.19	99+%
Set target inventory levels	0.10	98%

Coefficient of determination (r^2): 99.9%
Adjusted r^2: 99.6%
Regression confidence level: 99+%

5.4.5. Bus Percent Demand Filled (Fill Rate)

The factors selected to predict bus percent fill rate were:

Factor	Coefficient	Confidence Level
Constant	77.8	99+%
Percent safety stock	-0.27	95%
% coverage of storehouses by storekeeper	0.14	98%
Have direct purchase authority for inventory	13.76	99%
Total employees involved in inventory mgt.	0.13	94%
Publish a catalog of inventory material	-8.23	91%

Coefficient of determination (r^2): 27.4%
Adjusted r^2: 19.5%
Regression confidence level: 99%

5.4.6. Rail Percent Demand Filled (Fill Rate)

Only two factors were selected to predict the rail percent fill rate. These were the only factors with over 90% confidence that the coefficients were not equal to zero. The next closest factor was the percent of secured storehouses with only 31% confidence that the coefficient was not equal to zero.

Factor	Coefficient	Confidence Level
Constant	87.7	99+%
Percent of inventory items on blanket POs	-0.50	99+%
Number of rail vehicle models	1.14	99%

Coefficient of determination (r^2): 93.9%
Adjusted r^2: 91.4%
Regression confidence level: 99+%

5.4.7. Percent of Items Stocked Out per Week

There were two regression equations that can be used to predict the percent of items stocked out per week. In the first equation, two factors were selected as significant, however there is only a 43% confidence that the constant is not equal to zero. In the second equation, only one factor was selected as significant.

Factor	Coefficient	Confidence Level
Constant	0.36	43%
Total employees involved with inventory management.	0.024	91%
Organization type 2	6.31	99+%

Coefficient of determination (r^2):	28.8%
Adjusted r^2:	25.0%
Regression confidence level:	99+%

Factor	Coefficient	Confidence Level
Constant	0.94	91%
Organization type 2	5.78	99+%

Coefficient of determination (r^2):	23.0%
Adjusted r^2:	20.9%
Regression confidence level:	99+%

5.4.8. Average Days to Fill Bus Inventory Backorders

Only one factor was selected to predict the average days to fill bus inventory backorders. This was the only factor with over 90% confidence that the coefficient was not equal to zero. The next closest factor was the use of an automated inventory system with only 67% confidence that the coefficient was not equal to zero.

Factor	Coefficient	Confidence Level
Constant	24.8	99+%
Use maintenance forecasts for replenishment	-11.2	96%

Coefficient of determination (r^2):	8.5%
Adjusted r^2:	6.6%
Regression confidence level:	96%

5.4.9. Average Days to Fill Rail Inventory Backorders

Only one factor was selected to predict the average days to fill rail inventory backorders. This was the only factor with over 90% confidence that the coefficient was not equal to zero. The next closest factor was whether the agency set target service levels with 83% confidence that the coefficient was not equal to zero.

Factor	Coefficient	Confidence Level
Constant	82.8	97%
% coverage of storehouses by storekeeper	-0.71	93%

Coefficient of determination (r^2):	59.6%
Adjusted r^2:	49.5%
Regression confidence level:	93%

5.4.10. Percent of Items Out of Balance

The best regression equation for predicting the percent of items out of balance has a 68% confidence that the constant is not equal to zero. To derive an equation with a confidence level for the constant that is greater than 90%, all factors except "inventory organization reports to maintenance" must be eliminated from the equation.

Factor	Coefficient	Confidence Level
Constant	9.03	68%
Inventory organization reports to maintenance	-6.51	96%
Have multiple storehouses	10.93	99%
Have buses	14.97	94%
Total number of replenishment methods used	-2.35	94%
Stock components in inventory	-9.60	94%
Set target inventory levels	-5.48	91%

Coefficient of determination (r^2):	23.7%
Adjusted r^2:	13.0%
Regression confidence level:	94%

5.4.11. Percent Obsolete Bus Inventory

The factors selected to predict percent obsolete bus inventory were:

Factor	Coefficient	Confidence Level
Constant	5.91	99+%
Decentralized organization	54.5	99+%
Use "other" technology	21.8	99+%
Total bus inventory dollars	0.0000013	99%
Total employees involved with inventory mgt.	-0.22	97%
Organization type 5	8.5	99%
Total bus material purchases	-0.00000022	99%
Organization type 4	8.1	98%

Coefficient of determination (r^2):	86.7%
Adjusted r^2:	83.5%
Regression confidence level:	99+%

5.4.12. Percent Obsolete Rail Inventory

Only two factors were selected to predict the percent obsolete rail inventory. These were the only factors with over 90% confidence that the coefficients were not equal to zero. The next closest factor was the amount of information (number of reports/screens) available in the storehouse with only 58% confidence that the coefficient was not equal to zero.

Factor	Coefficient	Confidence Level
Constant	3.10	98%
Total rail inventory dollars	0.00000047	99+%
Use "other" technology	-3.95	94%

Coefficient of determination (r^2):	91.9%
Adjusted r^2:	89.2%
Regression confidence level:	99+%

5.4.13. Total Inventory Dollars per Person

The factors selected to predict total inventory dollars per person were:

Factor	Coefficient	Confidence Level
Constant	98075	99+%
Have written policies and procedures	97274	99%
Have rail vehicles	257481	99+%
Use fixed period replenishment method	210105	99+%

Set target inventory levels		-74418	96%
Coefficient of determination (r^2):	57.5%		
Adjusted r^2:	54.9%		
Regression confidence level:	99+%		

5.4.14. Inventory Personnel Cost per Inventory Dollar

The factors selected to predict inventory personnel cost per inventory dollar were:

Factor	Coefficient	Confidence Level
Constant	0.13	99%
Average fleet age (years)	0.00043	99+%
Use manual inventory system	0.88	99+%
% coverage of storehouses by storekeeper	0.0028	99+%
Organization type 4	0.13	95%
Separate inventory planning	-0.085	90%
Use fixed period method	0.18	98%
Use blanket POs for inventory	-.085	93%
Coefficient of determination (r^2):	78.4%	
Adjusted r^2:	73.2%	
Regression confidence level:	99+%	

5.4.15. Total Inventory Transactions per Person

No regression equation that could be derived to predict the total inventory transactions per week per person that contains a coefficient with a confidence greater than 90%. The highest confidence was for the factor "organization type 4" at 65%. As a result, 65% was also the highest confidence for the entire regression equation.

5.5 CONCLUSIONS

The conclusions presented in this section are general conclusions implied by the findings outlines in the previous sections. Conclusions are grouped by the organizational and inventory management decisions examined in this study.

Conclusions regarding **organizational structure:**

- Organization type 5 provides some service level benefits over other organization types, such as higher fill rates and fewer days to fill back orders. However, these gains appear

to be at the expense of higher inventory levels (e.g. dollars per vehicle) leading to higher percent of obsolete items.

This is an illustration of the traditional trade-offs between the conflicting goals of increasing service level while lowering inventory investment. The higher turnover experienced by organization type 5 is a by-product of the higher service levels, and appears to imply that service level increases more than compensate for the higher inventory levels.

- The more evolved inventory organization structures appear to process inventory transactions more efficiently. However, this transaction efficiency does not necessarily translate into efficiency in managing inventory dollars.

  In general, the organization types represent an evolution from no formal inventory organization (type 1) to a dedicated materials management group at the department level (type 5). The average number of inventory transactions per person increases from type 1 through type 5 (although not all differences have high confidence levels). However, the inventory dollars managed per person does not follow this pattern. Organization types 3 and 4 manage more dollars per person than the other types.

- Other differences between organizational type were isolated and inconclusive.

  For example, agencies with type 4 organization have a lower stockout rate than those with type 5. However, this was not a consistent pattern and no significant differences in stockout rate were found between any other combination of organization types.

- The existence of a full-time head and a separate inventory planning function appear to be key organizational attributes leading to the service level gains of inventory organizations. In addition, these attributes appear to contribute to more efficient management of inventory dollars.

  Inventory organizations with these attributes take less time to fill backorders and have a higher fill rate, respectively, and organizations with either or both attributes have higher annual turnover. These attributes appear to allow organizations to manage more inventory transactions and dollars per person. These attributes are also consistent with the higher inventory levels and percent of obsolete items observed in organizations with higher service performance.

- Including purchasing in the same organization as inventory management appears to lead to lower inventory levels and stockout rates.

- A centralized organization manages significantly more dollars per person than a decentralized organization.

- Inventory organizations that report to the maintenance department have better performance relating to inventory levels, but manage inventory with lower efficiency.

  These organizations have lower inventory dollars per vehicle and a lower percent obsolete items. However, inventory organizations reporting to maintenance manage less inventory dollars per person and process fewer inventory transactions per person.

- Agencies with inventory organizations reporting to the finance department have a higher service level than those reporting to maintenance, but process fewer transactions per person than those reporting to any other department.

- In general, the higher in the agency that the inventory organizations reports, the faster the organization responds to user needs.

  Organizations reporting to the executive level take significantly fewer days to fill backorders than those that report to the departmental level, and those reporting to the departmental level take significantly fewer days than those reporting to the sub-department level.

- Sub-departmental organizations have lower inventory dollars per vehicle and a higher turnover rate than other organizations. However, these organizations manage significantly fewer inventory dollars per person than organizations reporting to higher levels.

Conclusions regarding **setting goals:**

- Agencies that set target service levels achieve a higher level of service than organizations that do not set target service levels.

  Inventory organizations that set target service levels have a higher fill rate and higher annual inventory turnover. These agencies also manage more inventory dollars per person and have a higher percent obsolete inventory.
- Agencies that set target inventory levels have higher annual inventory turnover, but do not achieve lower inventory levels.

  There is no significant difference in inventory levels between those organizations that set target inventory levels and those that do not.

Conclusions regarding **replenishment methods:**

- No replenishment method or combination of replenishment methods resulted in higher inventory service levels, however the use of maintenance forecasts only appears to lead to lower inventory levels.

The lower inventory levels for organizations using only maintenance forecasts are accompanied by lower inventory turnover, a lower percent obsolete items, and fewer inventory dollars managed per person.

- Several detrimental effects on inventory performance are associated with having a safety stock percentage of 20% or greater, including a higher percent of stockouts.

  Organizations with 20% or greater safety stock have higher inventory levels and lower turnover for rail inventory, take more time to fill backorders, and have a higher percent obsolete items. In particular, since these organizations have a higher percent stockouts, the high safety stock levels do not accomplish the primary goal of safety stock (to reduce stockouts).

Conclusions regarding **purchasing practices:**

- The use of blanket orders and direct purchasing authority to replenish inventory material has minimal effect on inventory performance.

  There was no general pattern on which to draw conclusions. Only isolated effects were observed relating to these variables. Using blanket orders resulted in higher inventory dollars per vehicle for both bus and rail inventories, and the more rail inventory material covered by blanket orders, the lower the service level (fill rate from inventory). Organizations using direct purchasing authority manage less inventory dollars per person, although the opposite is true for those using blanket orders.

Conclusions regarding **storehouse configuration and coverage:**

- There was no storehouse configuration that consistently resulted in higher inventory performance, only a few isolated effects.

  Agencies with a hybrid configuration (a mixture of those tested in the survey) have a higher inventory fill rate, and independent storehouses have lower stockout rates. A central storehouse with satellites manages more inventory dollars per person, but also has a higher percent of items out of balance.

- Whether a storehouse was secured or not had no significant effect on inventory accuracy.

  Again, there were only a few isolated effects on inventory performance relating to secured storehouses. Agencies with secured storehouses have higher inventory turnover, and those with less than 100% (but more than 0%) manage more inventory dollars per person.

- Unmanned storehouses contribute to lower inventory service levels, but 100% coverage leads to higher inventory levels.

The two ends of the spectrum, no coverage and 100% coverage, adversely effect inventory performance in one of the major conflicting goals of inventory management. Storehouses with no storekeepers contribute to lower inventory fill rates and storehouses that are 100% covered contribute to higher inventory dollars per vehicle, respectively. Storehouses with 75% or greater coverage (but less than 100%), have the highest annual inventory turnover.

- Storehouses run by maintenance are run less efficiently than those not run by maintenance.

  Maintenance run storehouses process fewer transactions per person and manage fewer inventory dollars per person. These storehouses also take longer to fill inventory backorders, but have a lower percent obsolete items.

Conclusions regarding **published procedures and catalog:**

- Written policies and procedures have minimal effect on inventory performance, but assist in the efficiency of managing inventory.

  Written policies and procedures and a published inventory material catalog both allow organizations to manage more inventory dollars per person, but contribute to a higher percent obsolete items.

Conclusions regarding **physical and cycle counting:**

- Conducting a complete physical inventory has no effect on inventory accuracy, regardless of the frequency.

  The percent of items out of balance was the statistically the same for agencies that conducted annual and semi-annual physical inventories, as well as those that never conducted complete physical inventory.

- Quarterly cycle counting appears to result in significantly higher inventory accuracy than other frequencies.

  Those agencies that conducted quarterly cycle counts had a lower percent of items out of balance than those counting at other frequencies (daily, weekly, monthly).

Conclusions regarding **repairing and stocking components:**

- Agencies that repair and rebuild components are able to absorb the additional inventory activity and dollars with increased staff responsibility.

  Agencies that stock repaired and rebuilt components have significantly higher inventory levels than those that do not. The additional inventory transactions and inventory dollars

resulting from components lead to processing more inventory transactions and managing more inventory dollars per person rather than to higher staffing levels.

Conclusions regarding **use of systems and technology:**

- Automated inventory systems and other technology allow organizations to operate more efficiently and turnover inventory more often, but manual systems contribute to lower inventory levels.

  Agencies with automated inventory systems and/or "other" technology process more inventory transactions per person, manage more inventory dollars per person, and have higher turnover for both bus and rail inventory. Agencies with manual system have lower inventory dollars per vehicle, and those with both have higher percent of items out of balance.

- Bar code technology contributes to higher inventory service levels.

  Agencies using bar code technology for inventory have higher inventory fill rates than those that do not use bar code.

Summary:

In general, no inventory organization factor, decision factor, agency or fleet characteristic has a comprehensive and consistent effect on inventory performance. Those factors that tend to favor higher service levels often do so at the expense of higher inventory levels and percent obsolete items. In addition, none of the factors affect more than one service level performance indicator (e.g. inventory fill rates, days to fill back orders). Those that effect the efficiency of managing inventory seldom have more than minimal effects on performance factors relating to inventory investment or service level.

This mixture of effects is further supported by the regression analysis and resulting equations. In 15 equations (one for each inventory performance indicator), 32 separate variables were selected as significant. Four of these variables appear in three equations, and one appears in five equations. The other 27 variables appear in two equations at most. The variable that does appear in five equations, (percent of storehouses covered by a storekeeper) has a positive effect in three equations and a negative effect in two.

The survey process yields valuable information regarding the inter-relationships between inventory management and organizational decision factors. However, the conclusions based on this information are preliminary at best. There are some inherent shortcomings in any survey process and the related statistical analysis. Most of the statistical tests applied during this study test a pair or group of factors and assume that "other things are equal". In addition, there was no way to verify the accuracy of survey responses beyond the application of common sense tests to the range of response values, comparing related responses in difference sections of the survey, and comparing an individual response to the normal range of responses. Finally, a survey cannot effectively capture information regarding the competence and attitude of the individuals actually involved with inventory management

at transit agencies. Therefore, the conclusions should be developed into hypotheses for more detailed testing in a more controlled environment where individual effects can be more effectively isolated and quantified.

Appendix A

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Appendix B

Survey

INVENTORY MANAGEMENT FOR PUBLIC TRANSIT SYSTEMS SURVEY

Thank you for answering this survey on inventory management practices. Your assistance will allow the Transportation Cooperative Research Program to provide all transit properties with insights to improve their inventory performance.

Please answer all questions as accurately as possible. If information is not available for a question or if the question is not applicable to your authority, please respond with N/A. Also, feel free to provide additional comments to support your answers. Unless otherwise specified, please assume all questions refer to the Authority's total inventory (rolling stock and non-rolling stock). For multi-modal authorities, please provide separate answers for bus and rail, if appropriate.

All surveys will be held in complete confidence. If you have any questions, please call Alan Robinson at Klick, Kent & Allen at (703) 683-1120.

I. AGENCY PROFILE

1. Name of transit agency _____

2. Name of survey respondent: _____ Phone: ( ) ____-_____

3. Position _____

4. Please characterize your service area. Check all that apply.

☐ a. Urban ☐ b. Suburban ☐ c. Rural

5. Please identify the population of your service area:

☐ a. 1,000,000 + ☐ b. 500,001-1,000,000 ☐ c. 200,001-500,000

☐ d. 100,001-200,000 ☐ e. 50,001-100,000 ☐ f. Less than 50,000

6. What was the Agency's FY 1993 operating cost? $_____

	Bus (000)	Rail (000)	Other (000)
7. Please provide the FY 1993 material purchases by mode (total inventory and non-inventory).	$_____	$_____	$_____

8. Please provide the following statistics regarding the Authority's operation for Fiscal Year 1993 (as provided in Section 15 data).

	Bus	Rail	Other
a. Annual ridership (passenger trips)			
b. Annual passenger miles			
c. Annual revenue vehicle miles			
d. Total route miles			
e. Total track miles	N/A		
f. Total number of employees			

II. FLEET PROFILE

9. Please describe your vehicle fleet in the table below.

Vehicle Type	Total No. of Vehicles	No. of Vehicles. Purchased Service**	No. of Vehicles for Peak Service	No. of U.S. Manufac. Vehicles
a. Motor bus				
b. Heavy rail cars				
c. Light rail cars				
d. Commuter rail cars				
e. Commuter locomotives				
f. Vans				
g. Trackless Trolley				
h. Other*				

* automated guideway cars, cable cars, inclined plane cars, monorail cars, ferry boats, etc.

** number of vehicles provided by outside contractors from which you have purchased service

10. Please describe your vehicle fleet in the table below.

Vehicle Type	No. of Different Vehicle Models	Annual Average Miles Per Vehicle.	Average Age (Years)	Expected Life	
				Miles	Years
a. Motor bus					
b. Heavy rail cars					
c. Light rail cars					
d. Commuter rail cars					
e. Commuter locomotives					
f. Vans					
g. Trackless Trolley					
h. Other*					

*automated guideway cars, cable cars, inclined plane cars, monorail cars, ferry boats, etc.

III. INVENTORY MANAGEMENT ORGANIZATION PROFILE

11. To what organizational unit does the inventory management unit report?

☐ a. Maintenance ☐ b. Administration ☐ c. Operations
☐ d. Finance ☐ e. Other _____

12. What is the title of the senior inventory management individual? _____

_____

13. What is the title of the individual to whom the senior inventory manager reports? _____

_____

14. At what level in the organization is this individual?

☐ a. Board level ☐ b. Executive Management
☐ c. Departmental Management ☐ d. Other _____

15. Please provide your total inventory management costs for FY 1993. $_____

16. In the table below, please identify the number of people, by position, involved in managing inventory.

Function	No. of Staff
a. Management	_____
b. Inventory planning	_____
c. Storekeeping	_____
d. Receiving	_____
e. Expediting	_____
f. Counter service	_____
g. Reordering	_____
h. Data Entry	_____
i. Other _____	_____

17. How many of these individuals are located outside of the inventory management organization? _____

18. Please provide organization charts (1) for inventory management personnel; and (2) showing where the inventory management function fits into the Authority's overall organization.

19. Do you have a written procedures manual for inventory management practices? ☐ a. Yes ☐ b. No
If yes, please attach a copy of the table of contents.

20. For each of the positions, please show area(s) of responsibility by checking the appropriate cells in the table below. If more than one position is responsible for an activity, please include all positions. If the activity is conducted by someone outside the inventory management organization, please note.

ACTIVITIES	FUNCTION								
	Manage-ment	Inven. planning	Store-keeping	Receiv-ing	Counter service	Expedit-ing	Data Entry	Reorder-ing	Other
a. Inventory planning and forecasting	____	____	____	____	____	____	____	____	____
b. Determine reorder methods and quantities	____	____	____	____	____	____	____	____	____
c. Order inventory material	____	____	____	____	____	____	____	____	____
d. Issue material to users	____	____	____	____	____	____	____	____	____
e. Receive and store material	____	____	____	____	____	____	____	____	____
f. Inventory recordkeeping	____	____	____	____	____	____	____	____	____
g. Physical inventory	____	____	____	____	____	____	____	____	____
h. Cycle counting	____	____	____	____	____	____	____	____	____
i. Inventory adjustments/ write-offs	____	____	____	____	____	____	____	____	____
j. Material expediting	____	____	____	____	____	____	____	____	____
k. Track and fill back orders	____	____	____	____	____	____	____	____	____

IV. INVENTORY MANAGEMENT PRACTICES

21. How does your organization define inventory? _____

_____

_____

_____

22. What are the objectives of your inventory management policy? _____

_____

_____

_____

23. What types of items are excluded from inventory? _____

_____

_____

24. Under what circumstances can a non-inventory item become an inventory item? _____

_____

_____

_____

Storekeeping

The following questions pertain to storehouses containing inventory for rolling stock. For this survey, please include both primary and secondary storehouses. Primary storehouses are defined as major warehouses, central stores or distribution centers. Secondary storehouses are defined as local on-site stockrooms.

25. Total number of storehouses: a. Primary _____ b. Secondary _____

26. How many of your storehouses are secured? (controlled access)
a. Primary _____ b. Secondary _____

27. Total number of maintenance facilities: _____

28. Are all storehouses located within maintenance facilities? ☐ a. Yes ☐ b. No If no, how many are not located at maintenance facilities? _____

29. What organization has responsibility for managing the storehouses:

Primary storehouses	Secondary storehouses
☐ a. Inventory Management	☐ e. Inventory Management
☐ b. Maintenance	☐ f. Maintenance
☐ c. Operations	☐ g. Operations
☐ d. Other _____	☐ h. Other _____

30. Please check the box that best describes how your storehouse network is configured.

☐ a. One central storehouse
☐ b. One central storehouse supplying several smaller secondary storehouses
☐ c. Several independent storehouses
☐ d. Other (please specify)

_____

31. What are the average hours of operation for your primary and secondary storehouses?

Primary storehouses		Secondary storehouses	
a. Days per week	_____	c. Days per week	_____
b. Hours per day	_____	d. Hours per day	_____

32. What percentage of the time are primary storehouses covered by a storekeeper when maintenance is being performed? _____%

33. What percentage of the time are secondary storehouses covered by a storekeeper when maintenance is being performed? _____%

34. If no storekeeper is present, who is responsible for issuing parts? Check all that apply.

Primary Storehouses	Secondary Storehouses
☐ a. Maintenance foreman/supervisor	☐ d. Maintenance foreman/supervisor
☐ b. Mechanic	☐ e. Mechanic
☐ c. Other _____	☐ f. Other _____

35. Do vendors keep parts on hand for your use? ☐ a. Yes ☐ b. No If yes, please specify the types of parts: _____

_____

36. Do you keep vendor parts on consignment in your storehouse (pay vendor for only what you use)?
☐ a. Yes ☐ b. No If yes, please specify the types of parts _____

_____

37. How is storehouse space assigned? Please check all that apply.

- ☐ a. Usage
- ☐ b. Item size (cube space)
- ☐ c. Item class or commodity
- ☐ d. Bin availability (dynamic bin allocation)
- ☐ e. Other _____

38. What inventory information is available at the storehouses? Please check all that apply.

- ☐ a. Usage (issues)
- ☐ b. Number parts on-hand
- ☐ c. Item cost
- ☐ d. Items stocked out
- ☐ e. Transfers to other storehouses
- ☐ f. Transfers from other storehouses
- ☐ g. Items on order by date
- ☐ h. Items received by date
- ☐ i. Back orders
- ☐ j. Other _____

Inventory Management and Replenishment

39. In the following table, please identify the replenishment method(s) used by checking the appropriate box(s). If a method is chosen, please identify the condition under which the method is used.

Replenishment Method	Condition
☐ a. Reorder point/economic order quantity	_____
☐ b. Reorder point/fixed order quantity	_____
☐ c. Min/max	_____
☐ d. Fixed interval	_____
☐ e. Fixed period quantity	_____
☐ f. Maintenance forecasts	_____
☐ g. Workorder/project requirements	_____
☐ h. Project/Campaign	_____

40. How do you stratify inventory? Please check all that apply.

- ☐ a. Usage (ABC)
- ☐ b. Commodity class
- ☐ c. Unit cost
- ☐ d. Demand patterns (dependent vs. independent)
- ☐ e. Other _____

41. How often are replenishment methods and quantities reviewed?

Replenishment Methods	Quantities
☐ a. Monthly	☐ f. Monthly
☐ b. Quarterly	☐ g. Quarterly
☐ c. Semi-annually	☐ h. Semi-annually
☐ d. Annually	☐ i. Annually
☐ e. Other _____	☐ j. Other _____

42. What percentage of inventory is safety stock? (Safety stock is defined as a quantity of stock to protect against fluctuations in demand and/or supply) _____%

43. How is inventory expensed? ☐ a. when purchased ☐ b. upon issue

44. How are parts charged when used? Please check all that apply.

- ☐ a. To the using department
- ☐ b. To a vehicle number
- ☐ c. To a repair order
- ☐ d. To an individual mechanic or repairman
- ☐ e. Other _____

45. Are target inventory levels set? ☐ a. Yes ☐ b. No If yes, how? _____

_____

46. Are target service levels set for providing inventory material to users (e.g., percentage of time orders are filled)? ☐ a. Yes ☐ b. No If yes, how? _____

_____

47. How are obsolete items identified?

- ☐ a. Time since last use
- ☐ b. Part only used for obsolete vehicles
- ☐ c. Part design changes
- ☐ d. Other _____

48. How are excess items identified?

- ☐ a. Historical usage
- ☐ b. Forecasted demand
- ☐ c. Other

49. Does inventory management have the authority to directly purchase material and supplies?
☐ a. Yes ☐ b. No If yes, what are the dollar limits? $_____

50. Are blanket purchase orders used to purchase material? ☐ a. Yes ☐ b. No If yes, what percentage of inventory dollars are covered by blanket orders? _____%

Catalog/Parts

51. Is a parts catalog published? ☐ a. Yes ☐ b. No

52. Are parts stored as "kits" for standard jobs such as preventive maintenance ? ☐ a. Yes ☐ b. No

53. Are repairable components stocked in inventory (i.e., engines, transmissions)? ☐ a. Yes ☐ b. No

54. Are "bad order items (failed components) awaiting repair" tracked in inventory? ☐ a. Yes ☐ b. No

55. Do your maintenance shops manufacture and/or repair components/parts? ☐ a. Yes ☐ b. No

56. How are repaired or manufactured components valued in inventory?
☐ a. Average purchase price ☐ b. Repair cost ☐ c. Other _____

57. What items are designated as "free" or "open" or "floor" stock? Check all that apply.

☐ a. Nuts and bolts
☐ b. Grease, oil and fluids
☐ c. None
☐ d. Other _____

58. What items stockout most often? _____
_____

59. How are items valued in inventory? Check the method that applies.

☐ a. Average cost
☐ b. FIFO (first in first out)
☐ c. LIFO (last in first out)
☐ d. Other _____

60. Is state/federally funded inventory physically separated from operating inventory in storehouses? ☐ a. Yes ☐ b. No

V. INVENTORY MANAGEMENT PERFORMANCE

For the following questions, bus refers to rolling stock bus, rail to rolling stock rail, and other refers to all other inventory.

61. Please provide the following:

		Bus	Rail	Other
a.	Total inventory dollars on-hand at fiscal year end 1993	$ _____	$ _____	$ _____
b.	Total inventory dollars on-hand at fiscal year end 1992	$ _____	$ _____	$ _____
c.	Average dollar usage/month for fiscal year 1993	$ _____	$ _____	$ _____
d.	Average dollar usage/month for fiscal year 1992	$ _____	$ _____	$ _____

62. Do you monitor inventory forecasts against actual inventory level or usage? ☐ Yes ☐ No
If yes, what is your average inventory forecast error? _____%

63. How many inventory transactions do you average per week ? Please fill in the table below.

		Bus	Rail	Other
a.	Issues			
b.	Receipts			
c.	Return to stock			
d.	Return to vendors			
e.	Transfers between storehouses			

64. Please provide the following information about your inventory:

		Bus	Rail	Other
a.	Percent of unfilled orders due to lack of material			
b.	Percent of user requested items filled from inventory			
c.	Average time to fill back orders			
d.	Average number vehicles held out-of-service for parts per day			
e.	Percent of maintenance hours lost waiting for parts			
f.	Percent of inventory that is excess or obsolete material			
g.	Turnover rate			
h.	Total number of stockkeeping units (SKU's)?*			

*A stockkeeping unit is defined as a unique inventory item, regardless of the number of storage locations.

65. How does your organization define stockouts?

☐ a. Zero item in inventory
☐ b. No items available when requested
☐ c. No items available when work starts
☐ d. Number of open orders
☐ e. Other _____

66. What are the average number of stockouts per week? _____.

67. How are the following inventory performance indicators measured?

	Indicator	Measure
a.	Inventory levels	
b.	Inventory accuracy	
c.	Customer service level	
d.	Inventory management performance	
e.	Physical inventory results	
f.	Unfilled demand	

68. Please check the box that best describes how you track the effect of back orders. Back orders are defined as user requests for out-of-stock parts.

☐ a. Vehicle downtime waiting for parts
☐ b. Capital project delays for lack of parts
☐ c. Percent of operating schedule met (runs)
☐ d. Other _____

69. If you calculate carrying costs, what percentages do the following components represent?

	Components of Carrying Cost	Percentage
☐	a. Shrinkage	_____ %
☐	b. Obsolescence	_____ %
☐	c. Insurance	_____ %
☐	d. Cost of capital	_____ %
☐	e. Spoilage	_____ %
☐	f. Cost of stores space	_____ %
☐	g. Total carrying cost	_____ %

70. What percentage of inventory value is lost annually due to the following:
a. Shrinkage _____% b. Obsolescence _____% c. Spoilage _____%

71. How frequently are physical inventories conducted?

☐ a. Quarterly ☐ b. Semi-annually ☐ c. Annually
☐ d. Never ☐ e. Other _____

72. How frequently are cycle counts conducted?

☐ a. Daily ☐ b. Weekly ☐ c. Monthly
☐ d. Quarterly ☐ e. Never ☐ f. Other _____

73. What percentage of items are out of balance when conducting a cycle count (on average, the number of items that are in error based on cycle counts)? _____%

74. In the table below, please indicate the results of the last two physical inventories.

	Physical Inventory Measurements	FY 199___	FY 199___
a.	Absolute dollar variance	_____	_____
b.	Absolute percent variance	_____	_____
c.	Number of part numbers out of balance	_____	_____
d.	Percent of part numbers out of balance	_____	_____

75. Is inventory performance linked to compensation of inventory management personnel?
☐ Yes ☐ No If yes, how? _____

_____

76. How do you handle the following common inventory management issues? Please respond to all that apply.

Issues	Resolution
a. Long lead times	
b. Scarcity	
c. Fragile or short shelf life	
d. Foreign manufacture	
e. Insurance items	
f. Hazardous material	
g. High "street value"	
h. Buy America	
I. "Salient" characteristics	

77. In the last two years, what have you done to improve inventory management and what were the results?

_____

_____

_____

78. What are your future plans to improve inventory management? _____

_____

_____

_____

VI. TECHNOLOGY AND INFORMATION SYSTEMS

79. What information systems do you use for inventory? Please check all that apply.

- ☐ a. Manual cardex files
- ☐ b. Manual parts sign-out sheets
- ☐ c. Automated inventory management system
- ☐ d. Other manual _____

80. In the table below, please check the functions supported by automated and/or manual systems.

Functions	Manual	Automated
☐ a. Storeroom transactions (issues, receipts, etc.)		
☐ b. Material replenishment methods and quantities		
☐ c. Inventory forecasting		
☐ d. Inventory adjustments		
☐ e. Bin location/bin assignment		
☐ f. Inventory management reporting		
☐ g. Capital project material tracking		
☐ h. On-hand quantities/on-order quantities		
☐ i. Cycle counting		
☐ j. Material Requirements Planning (MRP)		

If you do not use an automated system, please go to Question 85.

81. If you use an automated system, is it:

- ☐ a. custom designed and developed
- ☐ b. a commercial software package (please specify name) _____

82. On what hardware does your automated system operate?

- ☐ a. Mainframe
- ☐ b. Mini computer
- ☐ c. Stand alone personal computer
- ☐ d. Networked personal computer

83. If you use an automated system, is it batch or on-line? ☐ a. Batch ☐ b. On-line

84. Please check the systems with which your automated inventory systems are integrated, if any.

- ☐ a. Purchasing
- ☐ b. Maintenance
- ☐ c. Accounts Payable
- ☐ d. General Ledger
- ☐ e. Other _____

85. How many years have the current manual and/or automated system(s) been in use? _____ years

86. Please indicate the reports you regularly use to manage inventory (check all that apply)

- ☐ a. "Hot" list
- ☐ b. Reorder report
- ☐ c. Stock status report
- ☐ d. Usage report
- ☐ e. Material catalog
- ☐ f. Cycle count sheets
- ☐ g. Transaction reports
- ☐ h. Receiving report
- ☐ i. Other _____

87. Do you use bar-coding for any of the following? Please check all that apply.

- ☐ a. Identifying parts
- ☐ b. Issuing parts
- ☐ c. Physical inventory
- ☐ d. Receiving parts
- ☐ e. Job orders
- ☐ f. Other _____

88. What percentage of parts received contain vendor provided bar-codes? _____%

89. What other technology do you use for inventory management? Check all that apply.

- ☐ a. Swipe cards or magnetic cards
- ☐ b. Light pens
- ☐ c. Hand-held computers
- ☐ d. Other _____

Thank you for your assistance in completing this questionnaire. Please return the survey in the self-addressed stamped envelope to:

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