NCHRP Project 20-7/Task 309

CHALLENGES AND OPPORTUNITIES: A STRATEGIC PLAN FOR EQUIPMENT MANAGEMENT RESEARCH

Requested by:

American Association of State Highway and Transportation Officials (AASHTO)

Standing Committee on Highways

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September 2011

The information contained in this report was prepared as part of NCHRP Project 20-07, Task 309, National Cooperative Highway Research Program, Transportation Research Board.

ACKNOWLEDGMENTS

This study was requested by the American Association of State Highway and Transportation Officials (AASHTO), and conducted as part of the National Cooperative Highway Research Program (NCHRP) Project 20-07. The NCHRP is supported by annual voluntary contributions from the state Departments of Transportation. Project 20-07 provides funding for quick response studies on behalf of the AASHTO Standing Committee on Highways.

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DISCLAIMER

TABLE OF CONTENTS

INTRODUCTION

The management of highway maintenance equipment is a complex and demanding undertaking. The fact that the United States faces significant challenges in maintaining its aging "public infrastructure," the largest component of which is unquestionably our vast network of roads and bridges, is well documented.[1] Less well understood are the challenges facing the organizations that manage the equipment that is used to maintain and repair this infrastructure.

These challenges stem, in part, from the fiscal pressures confronting state highway and transportation departments, and government jurisdictions in general. The existing backlog of deferred infrastructure maintenance is due, simply put, to a lack of commitment of sufficient financial resources to the maintenance, repair, and replacement of roads and bridges. Not surprisingly, many transportation organizations find it even more difficult to make adequate investments in subsidiary endeavors like fleet management that are viewed as detracting from their primary mission of infrastructure construction and maintenance. It seems safe to say that the effects of the "Great Recession" of 2008 and growing political pressure to curtail government spending of all types will do little to change this view and its ultimate impact on equipment users and managers.

Adding to these challenges is the fact that equipment management is an inherently complex business, involving the acquisition, deployment, and/or use of a variety of capital assets, infrastructure, human resources, suppliers, business processes, and management systems. Melding all of these ingredients into a coherent and cost-effective equipment management approach is a difficult undertaking under the best of circumstances.

The objective of the project described in this report was to identify research needs, referred to in this report as "grand challenges," whose results would assist equipment managers in dealing with both the external and internal challenges that confront them day in and day out. The project was requested by AASHTO (the American Association of State Highway and Transportation Officials) and specifically by the Standing Committee on Highways (SCOH) on behalf of the Subcommittee on Maintenance.

[1] See, for example, *Road Work Ahead: Holding Government Accountable for Fixing America's Crumbling Roads and Bridges*, April 2010, US PIRG (available at http://www.uspirg.org/edfund/reports/reports/transportation-reports/)

APPROACH

The method used to identify and define the grand challenges revolved around the conduct of a workshop or "special meeting" on June 28-29, 2011 at the National Academies' Arnold and Mabel Beckman Center in Irvine, California. Participants in the meeting are listed in Appendix A of this report.

To assist the participants in preparing for the workshop, a paper containing background information on equipment management publications, including prior research reports on this topic, was prepared. This paper can be found in Appendix B of this report. Our brief review of the literature found that there is a considerable body of published information on equipment management in the form of text books, trade association how-to guides and compendia of annual conference papers and educational presentations, and magazine articles from both trade/professional associations and independent publishers. However, relatively little formal research on equipment fleet management has been conducted, and the preponderance of that has been in the areas of the safe operation of equipment and equipment replacement management. Almost none of the prior research appears to touch on fleet service program management activities – for instance, in areas such as fleet resource allocation, equipment cost determination and distribution, and equipment management service provider/equipment user interaction – that we have found to be so critical to controlling the performance and costs of equipment fleets.

The background paper also proposed a definition of the term "equipment management." Broadly speaking, the management of equipment fleets consists of two distinct types of activities: *asset management* activities and fleet services *program management* activities. Activities in the first area focus on the acquisition, operation, utilization, upkeep, disposal, and replacement of the physical assets that make up a vehicle and equipment fleet. Activities in the second area focus on the acquisition and use of the responsibilities, authority, resources, expertise, cooperation, and decisions required to efficiently and effectively operate a fleet services program whose mission it is to furnish assets and asset management services to fleet users.

To facilitate the special meeting participants' consideration of possible research topics, 50 specific asset management and program management activities were identified and defined. These activities can be found in the background paper appended to this report. This was not intended to be a comprehensive list of equipment management activities. Rather, it focused on the most important such activities which might also be good candidates for research. It excluded many activities which, while important if not critical to the effective management of a vehicle and equipment fleet, do not seem to lend themselves to *research,* which is defined as "studious inquiry or examination; *especially***:** investigation or experimentation aimed at the discovery and interpretation of facts, revision of accepted theories or laws in the light of new facts, or practical application of such new or revised theories or laws."[2] For instance, the process of defining functional/operational requirements for equipment and determining the most

[2] http://www.merriam-webster.com/dictionary/research

cost-effective means of meeting them is an equipment management activity that lends itself to inquiry into the methodologies and practices used by different departments of transportation; the performance of post-trip inspections and the maintenance of records that comply with FMCSA regulations are activities that do not.

The special meeting began with a review and discussion of the 50 equipment management activities outlined in the background paper. Collectively, the group assigned a rating of “High” or “Low” priority to each activity on the list, based on the potential benefits to equipment managers of conducting research on the activity. As a result of this review, the group earmarked 17 activities, slightly more than one-third of the total, for further, detailed discussion. In several cases, the activities on this list were distinct but interrelated components of a broader area of equipment management, such as utilization management or replacement management.

Two separate working groups were established to further distill and flesh out the research challenges associated with this list of activities. Specifically, the groups were asked to 1) identify and describe the challenge; 2) identify important areas of research that need to be addressed to deal with the challenge; 3) identify anticipated outcomes and benchmarks that would indicate success; and 4) identify any major barriers that would prevent research in this area from being successfully conducted. The results of the working groups’ discussions are presented in the following section of this report.

GRAND CHALLENGES

Using the process described above, the special meeting working groups identified and developed recommendations for pursuing research associated with grand challenges in five broad areas of equipment management, two of which included multiple, interrelated research recommendations. Listed in order of importance, as determined by the participants through a simple scoring process, these are the following:

1. Fleet performance measurement;
2. Equipment cost and financial management;
3. Equipment utilization management;
4. Equipment replacement management; and
5. Equipment disposal and remarketing.

Each of these is discussed in some detail below.

FLEET PERFORMANCE MEASUREMENT

Challenge

Identify opportunities to improve fleet performance and fleet management cost effectiveness using quantitative measures of performance and appropriate internal and/or external benchmarks.

Description

Quantitative performance measurement and benchmarking is a widely recognized tool for monitoring, reporting on, and identifying opportunities to improve the performance of the vehicles and equipment that comprise a fleet and the organizational units that manage and use it. Key performance indicators (KPIs) can be used to assess a wide array of fleet-related performance attributes, including *conditions* (e.g., average asset age; average annual lane miles maintained per truck); *resource availability* (e.g., ratio of vehicle equivalent units to mechanics; percentage of parts requisitions filled from inventory); *resource utilization* (e.g., average annual bulk fuel tank throughput; average annual mechanic productivity rate, average annual vehicle utilization level); *service level* (e.g., average repair turn-around time; average parts requisition fill time, downtime rate); *service quality* (e.g., repair comeback rate, asset breakdown rate); and *cost* (e.g., cost per in-house mechanic labor hour, parts markup, cost per mile).

The proliferation in the last 10 to 15 years of management information systems employing relational database architecture, graphical user interfaces, and data mining tools such as *SQL* and *Crystal*™ have all made it easier for equipment management professionals to examine their fleet operations using quantitative performance measurement and benchmarking techniques. In addition to serving as a valuable diagnostic tool that managers can use to flag and home in on potential problem areas

and to avoid spending unnecessary time or attention on areas of endeavor in which current performance is sound, these techniques add objectivity and consistency to the formation of judgments about the performance of organization units, employees, suppliers, and vehicles. As such, they can take much of the guesswork out of overseeing a large, complex, and geographical dispersed fleet operation.

Having said this, many fleet managers find it almost overwhelming to master the intricacies of *operating* a state-of-the-art fleet management, asset management, or enterprise resource planning system, let alone the *use* of such a system to calculate, disseminate, and make recommendations and decisions based on more than a handful of KPIs. To the extent, moreover, that a manager is asked to compare some attribute of the performance of his or her fleet to that of other state DOT fleets, concerns immediately arise as to whether or not such peer organizations are calculating a given KPI the same way.

A case in point is the cost per hour of in-house mechanic labor. Ideally, calculations of such costs should include all direct and indirect costs associated with furnishing an hour's worth of such labor. This includes obvious costs like salaries and fringe benefits, supervisory and administrative support costs, and shop materials and supplies costs. However, it also should include facility and capital equipment costs (whether in the form of book depreciation, debt service, or a federally permitted use allowance); interagency charges (for things like IT support and facility maintenance); and allocated overhead costs (for things like finance and accounting, procurement and contracts management, HR, and legal support costs). However, not all DOTs include all of these costs in their calculations of mechanic labor hour rates – which, in turn, are used to calculate in-house maintenance and repair costs and other cost-based metrics such as vehicle cost per mile or hour of use – and thus find it difficult to compare themselves against one another or against "industry" benchmarks with any confidence.

In short, research is needed on the development of industry-recognized and endorsed performance measurement methods, focusing on both *what* to measure and *how* to measure it.

Area(s) of Research

Develop a methodology for measuring fleet-related performance in quantitative terms that includes a recommended mix of input (e.g., resource availability), output (e.g., resource utilization, service quality), and cost measures for use by DOT equipment managers. The methodology should clearly spell out for each metric or KPI 1) the attribute of performance that it is intended to measure; 2) the relationship between organizational unit, individual employee or asset, asset class, etc. performance in the area being measured and overall organizational success; 3) how the metric is to be computed, in terms of content, data sources, and actual calculation; 4) the types and sources of benchmarks that should be used to assess the acceptability of current performance as indicated by the metric; and 5) how performance measurement results should be disseminated and acted upon.

Develop methodology documentation suitable for endorsement and distribution as an AASHTO guide.

Anticipated Outcomes and Benchmarks

The primary outcome of research in this area would be a methodology that provides equipment management organizations with roadmap for calculating and using “industry-standard” key performance indicators. The endorsement and dissemination of the methodology by AASHTO would hasten its adoption by DOTs.

Metrics that could be used to determine the effectiveness of the recommended research include the following:

- The number of state DOTs who have used the methodology to compute and use recommended performance metrics to improve performance in their organizations.
- The number of equipment managers who have found the methodology to be useful.
- Improvements in performance in the areas recommended for measurement, as reflected in trend analysis of the associated metrics over time.

EQUIPMENT COST AND FINANCIAL MANAGEMENT

Fleet Management Cost of Service Analysis

Challenge

Develop information leading to a full and accurate understanding of fleet resource and service delivery costs so as to educate fleet customers (both internal and external), fleet services providers, and senior decision makers, and assist in identifying opportunities to optimize these costs.

Description

Given the general fiscal challenges confronting governmental entities, state DOTs, and DOT equipment management organizations today; the increasing service demands and challenges imposed on the latter by aging fleets; and the private sector’s demonstrated ability to cost effectively perform many of the fleet asset management functions that historically have been performed in house by most DOTs, it is critical that equipment managers have a thorough understanding of the costs and cost competitiveness of the assets and services that their organizations provide. As has been suggested in previous sections of this report, a proper understanding of fleet asset and asset management costs also is important for determining optimal equipment replacement cycles and associated guidelines; justifying increases in fleet replacement spending so as to reduce fleet total costs of ownership; making repair or rebuild versus replace decisions; and measuring performance both internally and relative to that of other state DOTs.

The key means of developing such an understanding is the regular (e.g., annual) conduct of a cost of service or activity-based cost analysis of these programs. Such analyses can be used to determine both the total and the avoidable costs of furnishing specific fleet-related goods and services. The former costs typically are used as the basis for computing internal cost charge-back rates, benchmarking performance, and analyzing asset lifecycle costs; while the latter typically are used in exploring the potential cost savings associated with outsourcing asset management functions currently performed in house

Area(s) of Research

Develop an activity-based costing methodology for determining, in a standardized manner, the total and the avoidable costs of furnishing specific fleet-related products and services, and for assessing the reasonableness of these costs using appropriate benchmarks.

Develop methodology documentation suitable for endorsement and distribution as an AASHTO guide.

Anticipated Outcomes and Benchmarks

The primary outcome of research in this area would be a methodology that provides equipment management organizations with a tool for quantifying the costs of furnishing fleet-related goods and services in an accurate, standardized manner. The endorsement and dissemination of the methodology by AASHTO would hasten its adoption by DOTs.

Metrics that could be used to determine the effectiveness of the recommended research include the following:

- The number of state DOTs that have used the methodology to compute their fleet management service delivery costs.
- The number of equipment managers who have found the methodology to be useful.
- Reductions in unit costs of services without corresponding reductions in service level and/or quality.

Importance and Readiness

To the extent that equipment managers and state DOTs in general want to optimize the performance and costs of their fleets, making these costs transparent and understandable to upper management, elected officials, and the providers and users of fleet resources and services is second in importance only to implementing an effective fleet replacement program in the opinion of the authors. Simply put, fleet management

organizations cannot cost-effectively manage costs that they cannot see and for which, because they are largely invisible, they are not held accountable by their customers.

Ideally, the conduct of a cost of service analysis is part of a larger, strategic approach to managing the costs of a fleet operation and fleet management organization whose centerpiece is an effective cost charge-back system (discussed in the next section of this report). However, it is an extremely valuable performance measurement exercise even if its results are not used as the basis for financing the costs of managing and operating a fleet. Indeed, there is no other form of performance measurement that is likely to have a greater impact on fleet and fleet management performance than this one.

Fleet Cost Charge-Back System Development and Use

Challenge

Develop full-cost charge-back rates that 1) support the allocation of equipment costs to departmental programs and projects; and 2) promote the efficient provision and consumption of fleet resources and services by using rates, billing processes, and accounting methods (e.g., a revolving fund) that produce appropriate pricing signals and cost transparency and create accountability for costs.

Description

Many state DOTs employ fleet cost charge-back systems for the purpose of distributing the costs of owning and operating fleet assets to the organizational units that utilize them. However, the primary objective of most such systems is to allocate the costs of the use of equipment to specific road and bridge construction and maintenance activities, programs, and projects, in part for the purpose of claiming reimbursement for the authorized costs of such activities from FHWA and for the costs of authorized disaster clean-up activities from FEMA. Given this objective, the charge-back rates employed by DOTs typically are *usage-based* (i.e., per-mile or per-hour) rates that are calculated by determining the average annual total cost of ownership of all the assets in the fleet of a particular type and dividing this cost by the projected annual usage of these assets. Charge-back systems that employ *time-based* rates (i.e., all-inclusive monthly amounts for the capital and operating costs of particular types of assets); that deduct a prorated or proportional share of total fleet costs from fleet user organizations based on the distribution of fleet assets across all such organizations; and various permutations and combinations of all of the above cost distribution methods also reportedly are used.

While most of not all of these rate structures may be logical and appropriate for allocating asset usage costs to different activities for activity-based cost accounting and reimbursement claiming purposes, they are not all equally effective, in the experience of the authors, in promoting or facilitating the actual management and control of equipment ownership and operating costs. In order to achieve this objective, a charge-back system employing *service-based* rates and *transaction-based* charges is generally recognized

in the fleet management profession as being the most suitable approach, as it promotes recognition of the costs of the provision (by a fleet management organization) and the use (by fleet user organizations) of specific assets and associated goods and services (fuel, maintenance and repair labor, parts, etc.). Where usage- and time-based rates largely mask the actual costs of specific assets, services, repair transactions, and so forth, service-based rates make them *transparent*, making the effective management of these costs much easier to achieve.

These two types of charge-back rate structures are *not* mutually exclusive. Some DOTs employ both types of rates under a process in which fleet user organizations pay *charges* based on the application of service-based rates, but also are provided with usage-based rates that they can use to allocate the costs of equipment usage to the programs and projects such usage supports.

Area(s) of Research

Survey state DOTs to identify current fleet cost charge-back practices that might impact on the design of a standardized cost charge-back system model suitable for use by any DOT.

Determine the extent to which any additional level of effort associated with developing and using service-based charge-back rates and transaction-based charges would require DOTs to devote additional analytical expertise, personnel, and/or data processing capabilities, and identify recommended strategies and techniques for fleet managers to secure them.

Develop rate computation, billing, and revolving fund management methodologies to support the development and use of a standard model that supports the use of service-based and usage-based and/or other appropriate charge-back rate models and complies with all applicable FHWA and FEMA cost claiming guidelines and requirements.

Develop case studies applying recommended methodologies to confirm the appropriateness of all key methodology components.

Develop methodology documentation suitable for endorsement and distribution as an AASHTO guide.

Anticipated Outcomes and Benchmarks

The primary outcome of research in this area would be algorithms and/or software programs and associated guidelines that provide state DOTs with a toolkit for developing, implementing, and using service-based and other appropriate cost charge-back rate systems and associated budgeting, accounting, fund management, and financial reporting processes. The endorsement and dissemination of the methodology by AASHTO would hasten its adoption by DOTs.

Metrics that could be used to determine the effectiveness of the recommended research include the following:

- The number of state DOTs that have used the toolkit to develop and implement new cost charge-back systems.
- The number of equipment managers who have found the methodology to be useful.
- Reductions in unit costs of services without corresponding reductions in service level and/or quality.

Importance and Readiness

The activity-based costing methodology and guidelines recommended for development in the previous section would lay the groundwork for pursuing the recommendations presented in this one – and the two objectives could be pursued through the conduct of a single research project. However, the implementation of a new cost charge-back model would be both more beneficial and more complicated in most DOTs than would the implementation of an important benchmarking process that nonetheless is more limited in terms of both impact and stakeholder involvement. Whereas any equipment manager with the necessary time and resources can conduct a detailed cost of service analysis, actually changing the methods used to finance and manage fleet costs is not something that any organization would view lightly. It would involve the participation of many stakeholders, including senior management; budget, finance, and accounting officials; and IT officials, in addition, of course, to fleet management and fleet user organization officials.

Having said this, the requirements for so many stakeholders' involvement reflects the relative impacts on fleet costs of merely *studying* these costs so as to better understand their causes and reasonableness, and changing the way they are budgeted, distributed, and accounted for by both fleet management organizations and their customers. That is, the analysis of costs is a valuable undertaking in its own right, but it is no substitute for the implementation of a cost charge-back system whose design and execution requires fleet users to accept a significant share of responsibility for the managing costs.

EQUIPMENT UTILIZATION MEASUREMENT

Challenge

Facilitate the management of the size and composition of the fleet and its suitability to an organization's business needs by measuring, monitoring, and reporting on asset utilization levels on an ongoing basis.

Description

Ensuring that a fleet is composed of the proper types and quantities of vehicles and equipment to meet an organization's business needs is critical for optimizing overall

fleet ownership and operating costs. There are multiple approaches available to equipment managers for assisting the fleet users they serve in managing fleet size and composition. These include the use of equipment purchase justification, specification, and selection processes to support decision making *before* new assets are added to the fleet (including assets intended to replace equipment already in the fleet); and conducting periodic, ad hoc fleet rightsizing studies aimed at identifying assets *already in* the fleet whose retention is no longer warranted by the organization's business needs. A third approach is to measure equipment utilization on an ongoing basis for the purpose of identifying specific assets whose utilization appears to be low based on a comparison of their utilization statistics (e.g., average monthly or annual use) with suitable benchmarks, and to investigate such exceptions to determine if the continued ownership of these assets is justified.

It goes without saying that an effective fleet utilization measurement process must be flexible enough to accommodate differences in the business applications and thus the usage levels of the many different types of equipment assets that comprise a typical state DOT fleet. Such a methodology also must be able to take into account differences in the utilization levels of like types of equipment assets not only across multiple state DOTs, but often across divisions or districts within individual DOTs. For instance, it probably would be unrealistic for someone to expect New York State DOT trucks of a given type used for a given purpose to achieve the same level of annual usage in, say, the Finger Lakes region of upstate New York as on Long Island, or, for that matter, on the west end (i.e., Queens and Brooklyn) as on the east end (e.g., the North Fork) of Long Island. This implies that utilization guidelines and corresponding benchmarks usually should be stratified by both asset type and domicile location or district/region of use.

Area(s) of Research

Develop a methodology for establishing organization-specific guidelines for measuring equipment utilization on a continuous basis, for assessing the appropriateness of specific asset utilization levels using the statistics produced through such measurement and suitable benchmarks, and for investigating instances of apparent underutilization of assets and taking or recommending remedial action where appropriate to rightsize the fleet.

Develop methodology documentation suitable for endorsement and distribution as an AASHTO guide.

Anticipated Outcomes and Benchmarks

The primary outcome of research in this area would be a methodology that provides equipment management organizations with a process for systematically identifying and facilitating the reassignment or removal from the fleet of underutilized equipment assets. The endorsement and dissemination of the methodology by AASHTO would hasten its adoption by DOTs.

Metrics that could be used to determine the effectiveness of the recommended research include the following:

- The number of state DOTs who have used the methodology to develop and implement asset utilization measurement, exception reporting, follow-up investigation, and underutilization remediation processes.
- Increases in average annual asset usage levels.
- Reductions in fleet size and associated capital and operating costs.
- Improvements in age-related fleet performance metrics such as equipment availability and breakdown rates, average return-to-service times, and asset residual values.

Importance and Readiness

One of the ways that elected officials frequently respond to economic downturns is to mandate across-the board reductions in fleet size. As of this writing, the near-term fiscal outlook for state governments continues to be bleak, suggesting that DOT equipment managers and the fleet user organizations they serve will continue to be pressured to reduce fleet sizes. It also is likely that overarching fiscal challenges will continue to put pressure on DOTs to outsource certain business functions, which may reduce the need for some types of vehicles and equipment. On the other hand, these same fiscal pressures have undoubtedly resulted in the aging of some DOT fleets due to underfunding of equipment replacement requests, and this phenomenon typically makes fleet users more resistant to relinquishing back-up assets that they want to hold onto due to the diminishing reliability and availability of front-line units.

In order to stay ahead of these curves, equipment managers should become fully conversant with the proper way to measure equipment utilization and identify unneeded assets. It is widely recognized by fleet management professionals that statistics and benchmarks derived from odometer and hour meter readings do not always provide a accurate indication of the *bona fide* business need for fleet assets. Consequently, the implementation and active use of a highly structured, industry-recognized *process* for rightsizing a fleet on a continuous basis is perhaps the best way for equipment managers to inoculate their customers from potential inappropriate and counterproductive fleet downsizing mandates.

One potential challenge associated with effectively implementing a methodology like the one described above is the capture of accurate meter reading data on a timely basis. Increasingly, however, fleet owners accomplish this through the integration of data captured during equipment fueling transactions by bulk fuel management system and commercial fuel credit card programs, and through the use of GPS-based telematics devices installed in certain types of assets such as plow trucks.

EQUIPMENT REPLACEMENT MANAGEMENT

Replacement Cycle Guideline Development

Challenge

Determine when specific types of assets should be replaced in order to optimize the total cost of their ownership in a particular organization.

Description

Replacement cycle guidelines are critical for guiding long-term fleet replacement planning and near-term replacement budgeting. The purpose of such guidelines is to identify when, in terms of their age and/or accumulated usage, equipment assets should be replaced so as to minimize their total cost of ownership. Ideally, such guidelines should be tailored to the unique cost characteristics of specific types of assets in specific fleet user organizations. Even within a single organization, the optimal replacement cycle for a given type of asset can vary depending on the manner and environment in which it is used. For instance, a given type of truck in the Caltrans or North Carolina DOT fleet might have a different life expectancy depending on whether it is used in the mountains, on the coastal plain, in a heavily urbanized, or in a predominantly rural area of one of these states.

Area(s) of Research

Develop a methodology for determining empirically validated optimal replacement cycle guidelines based on the unique needs, practices, and operating environments of specific state departments of highways and transportation.

Develop documentation for this methodology suitable for endorsement and distribution as an AASHTO guide.

Anticipated Outcomes and Benchmarks

The primary outcome of research in this area would be a methodology and/or one or more software programs that provide equipment management organizations with a tool for determining optimal replacement cycles for specific types of assets in their fleets. The endorsement and dissemination of the methodology/software by AASHTO would hasten its adoption by DOTs.

Metrics that could be used to determine the effectiveness of the recommended research include the following:

- The number of DOTs who have developed empirically validated replacement cycle guidelines using the algorithm/program;
- Increases in equipment replacement funding and/or spending levels.

- Reductions in average asset age by asset class; and
- Improvements in asset age-related fleet performance metrics such as equipment availability and breakdown rates, average return-to-service times, and asset residual values.

Importance and Readiness

In and of themselves, replacement cycle guidelines do not improve equipment replacement decision making. The availability of a standardized, industry-recognized methodology for developing guidelines will have a limited impact on decision making unless it is part of a broader, strategic approach to equipment replacement management that encompasses related activities (i.e., fleet replacement planning and capital financing and funding). Having said this, such guidelines are critical to the proper conduct of these other activities and also are important for establishing and communicating to senior management and elected officials the economic rationale for replacing equipment assets in a timely manner.

The principal impediment to the effective implementation of the recommended methodology is a lack of consistency in the way DOTs quantify in-house maintenance and repair costs, the timing and magnitude of which have a significant impact on the determination of optimal replacement cycles. Since most equipment fleet maintenance and repair activities are performed in house, uniform methods are needed for DOTs to determine their fully loaded in-house maintenance and repair costs – particularly those associated with maintenance technician labor.

Equipment Repair/Rebuild Versus Replace Decision Making

Challenge

Determine the circumstances under which performing major repairs or service life extension services on an asset that meets established criteria for replacement is cost effective.

Description

Due to the general fiscal pressures facing many state DOTs and the widespread practice of financing the acquisition of replacement equipment through outright cash purchase, repairing and/or rebuilding assets so as to keep them in service beyond the point when it would be most economical to replace them is a common practice in state DOTs. If the only means available to an organization to finance the acquisition of a replacement asset is to pay the full cost of its purchase up front, repairing an aging asset will always be cheaper than replacing it from a short-term fiscal (i.e., budgetary impact) perspective, even though it often makes no sense from a long-term economic one. Equipment managers need a structured methodology for determining when it is cost effective to repair an asset of a given type that has met the established guideline for replacement.

Area(s) of Research

Develop a methodology for making empirically validated repair/rebuild decisions for individual fleet assets on a case-by-case basis.

Develop methodology documentation suitable for endorsement and distribution as an AASHTO guide.

Anticipated Outcomes and Benchmarks

The primary outcome of research in this area would be a set of algorithms and/or a software program that provide equipment management organizations with a tool to determine the optimal course of action where repair/rebuild is believed to be a potentially viable option. The endorsement and dissemination of the methodology/ software by AASHTO would hasten its adoption by DOTs.

Metrics that could be used to determine the effectiveness of the recommended research include the following:

- The number of state DOTs who have used the algorithm/program to support repair versus replace decision making.
- The number of equipment managers who have found the tool to be useful.
- Reductions in equipment repair and rebuilding costs.
- Increases in equipment replacement funding and/or spending levels.

Importance and Readiness

Given the difficulties that many DOTs have experienced in recent years in securing a sufficient amount of money to replace their equipment assets in a timely manner, the development of a standardized methodology and/or tool to assist equipment managers in this area may actually be more beneficial in the near term than developing methods or tools for determining optimal equipment replacement cycles. Ideally, this should be but one component of a strategic approach to, and “tool kit” for managing equipment replacement. However, it is one that would assist organizations in better dealing with the near-term fiscal exigencies that are particularly problematic for many equipment managers at the present time.

The principal impediment to the effective implementation of the recommended methodology is, again, a lack of consistency in the way DOTs quantify in-house maintenance and repair costs, the magnitude of which have a significant impact on repair versus replace decision making. It is easy to envision how organizations that use artificially low (i.e., not fully burdened) in-house maintenance technician labor rates can erroneously conclude that the repair or rebuilding of an asset is cost effective when this actually is not the case. Uniform methods are needed for DOTs to determine their fully

loaded in-house maintenance and repair costs – particularly those associated with maintenance technician labor.

Equipment Replacement Planning

Challenge

Quantify long-term fleet replacement costs to measure the effectiveness of past replacement decisions, support the development and substantiation of replacement funding requests, identify and manage the year-over-year logistical demands of acquiring and disposing of fleet assets; facilitate analysis of alternative capital financing approaches, and support the development of replacement rates under a sinking (replacement reserve) fund financing approach.

Description

The year-to-year replacement costs of virtually all equipment fleets are inherently volatile or lumpy due to the varying capital costs and life expectancies of the many different types of assets that comprise them. Depending on the method used to finance these costs, replacement funding requirements may be equally lumpy, and most organizations do not deal with variable spending requirements very effectively due to the relatively static nature of their funding sources. One of the most critical elements of an effective fleet replacement program is a replacement planning process that quantifies long-term replacement costs. Absent a clear picture of how much it will cost both in specific future years and on an average annual basis to replace equipment assets in accordance with recommended replacement cycles, organizations can easily underestimate and thus underfund these costs. Once these costs have been underfunded to any significant degree in one or more years, a backlog of replacement spending needs develops.

Developing a fleet replacement plan is critical for determining the magnitude of such a backlog and educating decision makers as to why it should not be left unattended. Such a plan also is important for identifying specific assets in a fleet whose planned replacement dates (based upon the application of recommended replacement criteria for the particular assets in question) can be expedited or deferred so as to even out (to some degree) year-over-year fleet replacement costs, and better manage the logistical challenges and fleet management organization resource requirements associated with acquiring, in-servicing, decommissioning, and disposing of highly variable quantities of assets from year to year.

Long-term replacement plans also provide the foundation for calculating replacement rates when a sinking fund is used to finance fleet replacement costs, and for modeling and comparing the economic and fiscal impacts of alternative capital financing approaches such as outright cash purchase, a sinking fund, debt financing, and leasing. A long-term replacement plan can also be used as the basis for projecting future changes in fleet capital and operating costs and environmental impacts (e.g., carbon

footprint) associated with future changes in fleet size, composition, replacement cycles, and asset ages.

Area(s) of Research

Develop a methodology for determining future fleet replacement *costs* based on the application of asset class-specific purchase prices, purchase price inflation rates, and replacement cycle guidelines to the fleet inventory, and for prioritizing specific assets for replacement in the next few fiscal periods pursuant to asset acquisition and/or disposal -related logistical requirements and/or annual replacement cost smoothing objectives.

Develop methodology documentation suitable for endorsement and distribution as an AASHTO guide.

Anticipated Outcomes and Benchmarks

The primary outcome of research in this area would be an algorithm and/or software program that provides equipment management organizations with a tool to develop multi-year replacement plans and near-term replacement budget requests for their fleets. The endorsement and dissemination of the methodology/software by AASHTO would hasten its adoption by DOTs.

Metrics that could be used to determine the effectiveness of the recommended research include the following:

- The number of state DOTs who have developed multi-year fleet replacement plans using the algorithm/program;
- Increases in equipment replacement funding and/or spending levels.
- Reductions in average asset age by asset class; and
- Improvements in asset age-related fleet performance metrics such as equipment availability and breakdown rates, average return-to-service times, and asset residual values.

Importance and Readiness

Based on the authors' experience, this is the most important of the three areas of replacement management research discussed so far due to the ability of a properly designed replacement planning process to help equipment managers 1) develop a clear "snapshot" of replacement program effectiveness at any given point in time; 2) substantiate replacement funding requests to decision makers who might otherwise hold a very myopic view of fleet replacement costs and of the importance of complying with such requests; and 3) perform an array of other fleet-wide calculations and projections of costs and performance levels that are highly correlated with fleet size, composition, and age.

While developing replacement plans based on empirically validated replacement cycle guidelines (using a methodology like the one recommended for development in the *Replacement Cycle Guideline Development* section above) is the ideal, the absence of such guidelines is not a major impediment to developing effective plans.

There also are no significant or systemic data availability or codification limitations in the state DOT equipment management community that would impede the development of effective plans given the availability of a properly designed planning methodology and/or tool.

Equipment Replacement Financing

Challenge

Ensure the availability of funds to replace equipment in accordance with sound replacement plans based on appropriate replacement cycle guidelines and other assumptions by employing capital financing methods that minimize year-to-year volatility in funding requirements and the resulting likelihood that 100 percent of each year's fleet replacement needs will not be funded .

Description

The methods organizations use to finance the capital costs of their equipment fleets have a greater impact on fleet replacement program effectiveness than any other factor. Organizations that use a "pay-before-you go" approach such as outright cash purchase almost always have old fleets. This is because the marginal cost (i.e., short-term budgetary impact) of replacing an asset whose full capital cost is paid up front is almost always higher than the marginal cost of retaining it, even if the asset requires major repairs that make no sense from an economic or total cost of ownership perspective. The relative budget impacts of the two potential courses of action typically encourage organizations to defer the replacement of equipment assets as long as possible. In addition, the potential residual values of assets tend to be ignored in making retain versus replace decisions because the capital cost of an asset that was borne at the time of its acquisition several years in the past typically is viewed by stakeholders as a sunk cost that is not germane to such decisions. The application of these two types of thinking usually results in older-than-optimal fleets with higher-than-necessary total costs of ownership.

There are a number of "pay-as-you-go" approaches to financing fleet capital costs that permit these costs to be paid as fleet assets are used up and thus do a better job of aligning the fiscal and economic impacts of equipment replacement decisions, thereby better encouraging and enabling organizations to replace assets in a consistently timely manner. These include sinking funds, loans, and leases.

Area(s) of Research

Develop one or more methodologies suitable for varying types of on- and off-road vehicles and equipment for determining future fleet replacement *funding requirements* associated with the use of any available alternative capital *financing* approaches and for identifying the best financing approach based on a comparative analysis of fiscal and economic impacts.

Develop methodology documentation suitable for endorsement and distribution as an AASHTO guide.

Anticipated Outcomes and Benchmarks

The primary outcome of research in this area would be an a set of algorithms and/or one or more software programs that provide equipment management organizations with a tool to forecast and compare the long-term fiscal and economic impacts of financing projected equipment replacement costs under a variety of suitable approaches. It is possible that separate methodologies would be needed to explore the merits of guaranteed buy-back programs (which are essentially close-end leases) which typically are available only for selected types of equipment assets, and for exploring more generic capital financing approaches such as loans, leases, and sinking funds. The endorsement and dissemination of the methodologies/software by AASHTO would hasten their adoption by DOTs.

Metrics that could be used to determine the effectiveness of the recommended research include the following:

- The number of state DOT's who have used the methodologies or software programs to conduct investigations of fleet replacement costs and funding requirements under alternative financing approaches.
- The number of DOT's that have changed financing approaches as a result of such investigations.
- Increases in equipment replacement funding and/or spending levels.
- Reductions in average asset age by asset class.
- Improvements in asset age-related fleet performance metrics such as equipment availability and breakdown rates, average return-to-service times, and asset residual values.

Importance and Readiness

As noted above, an organization's choice of capital financing approach is the single most important factor influencing the effectiveness of its fleet replacement program. Consequently, having a toolkit that helps equipment managers quantify and compare side by side the long-term economic costs and budgetary requirements associated with

financing projected fleet replacement purchases under several potential financing approaches is critical for justifying the replacement of an existing, suboptimal approach.

While the economic and, in particular, the fiscal impacts of alternative financing approaches usually are the most important considerations for management and elected officials, it should be realized that a variety of non-quantitative factors often come into play when an organization considers changing the way it finances equipment capital costs. These range from statutory impediments to the use of particular types of financing programs; to constraints imposed by financing programs already in use (e.g., a sinking fund, a line of credit, a master lease-purchase program, etc.) on an organization's willingness to explore new approaches; to managerial and/or political antipathy to any approach other than paying "cash on the barrelhead." At some point, equipment managers undoubtedly would benefit from a research synthesis on state and local government best practice in this area to assist them in responding to objections to exploring new approaches. TRB already has published a basic primer on alternative capital financing approaches, but it is for the most part silent on such matters.[3] Having said this, developing the ability to quantify cost savings associated with switching to a financing approach that improves the timeliness with which equipment assets are replaced is clearly the most important priority in this area.

USED EQUIPMENT REMARKETING

Challenge

Promote the optimization of equipment capital costs by employing used asset remarketing methods that facilitate the maximization of used asset residual values.

Description

The proper disposal of used equipment can have a significant impact on the capital cost of fleet assets. This is especially true if DOTs have effective fleet replacement programs and do not run their equipment "into the ground." Thus, determining the most cost-effective methods for decommissioning and remarketing used equipment is an important component of an overall strategy for managing fleet total cost of ownership. Fleet management organizations need to determine the appropriate level of reconditioning (if any) of the different types of assets in their fleets; the best methods of remarketing their assets (e.g., via local or regional public auctions, sealed bids, private-party transactions, on-line auctions, etc.); and the best timing of sales.

Area(s) of Research

Survey fleet owner organizations, including state DOTs, other large public-sector organizations, appropriate private companies (e.g., in the utility and waste management

[3] *Financial Aspects of Equipment Acquisition, Transportation Research Circular Number E-C052* (2003-7) A.T. Swenson, TRB Committee on Maintenance Equipment Synopsis available at **http://pubsindex.trb.org/view.aspx?id=661869**

industries), and national equipment remarketing companies, to catalog and develop information on the relative cost effectiveness of the specific equipment decommissioning and disposal methods they employ.

Use the results of this research to develop guidelines and tools that will assist equipment managers determine the level of investment that will result in the highest yield at sale.

Anticipated Outcomes and Benchmarks

The primary outcomes of research in this area would be a comprehensive survey of used equipment remarketing practices and guidelines for use by state DOT fleet management organizations in disposing of their used fleet assets. The endorsement and dissemination of the guidelines by AASHTO would hasten their adoption by DOTs.

Metrics that could be used to determine the effectiveness of the recommended research include the following:

- The number of state DOTs that have used the guidelines to develop and implement new remarketing programs.
- The number of equipment managers who have found these guidelines to be useful.
- Reductions in used equipment remarketing costs and in days to sale (the amount of time that elapses between the decommissioning of an asset and its final sale).
- Increases in used equipment residual values (while controlling for the effects of inflation and changes in equipment specifications).

Importance and Readiness

As suggested above, there is a clear interrelationship between equipment replacement and equipment remarketing activities. Simply put, effective replacement practices increase the importance of having effective remarking practices because they result in the replacement of assets when they are newer and have considerably higher fair market values. Conversely, if an organization does not replace its fleet assets in a timely manner, it should not invest a significant amount of effort in optimizing its remarketing practices. A beat up, 15 year-old truck is only worth so much money, regardless of how well or how poorly it is sold.

It also should be remembered that there is an interrelationship between capital financing and equipment remarketing practices. As pointed out earlier, organizations that pay cash up front for their equipment acquisitions generally tend to view the capital costs of fleet assets as sunk costs once the assets have been acquired, and thus have limited motivation to think about how to reduce these costs through improvements in remarketing techniques. In short, the results of research in this area would likely be of the most interest and benefit to DOTs that do not have the opportunity to achieve much

larger cost savings (than those available in this area) through improvements in equipment replacement, utilization, and cost management.

CONCLUSION

The group that assembled at the Beckman Center in June 2011 identified and prioritized several key research challenges of importance to state departments of transportation and their equipment fleet managers. The prioritization of the challenges discussed in this report necessarily reflects the views and preferences of the particular individuals who participated in this meeting, including the authors of this report. Given a different group of participants and taking into consideration the dynamic macroeconomic, fiscal, and political forces buffeting so many governmental entities and departments of transportation today, a somewhat different set of priorities might emerge. However, the implementation of the research recommendations presented herein will unquestionably advance the capabilities of the equipment management profession whose effective performance is, in turn, so vital to the mission of building and maintaining the nation's roads, bridges, and other transportation infrastructure.

APPENDIX A

SPECIAL MEETING PARTICIPANTS

The individuals who participated in the meeting at the Beckman Center June 28-29, 2011 were the following:

- Amir N. Hanna, NCHRP (project manager)
- Paul Lauria, Mercury Associates, Inc. (facilitator)
- Len Bammer, Mercury Associates, Inc. (facilitator)
- Rick Bradbury, FHWA
- John Brewington, Brewington & Company
- Tim Cunningham, Kansas Department of Transportation
- John Dolce, Consultant
- Bruce Erickson Oregon Department of Transportation
- Dennis Halachoff, Arizona Department of Transportation
- Drew Harbinson, North Carolina Department of Transportation
- Frank Lisle, Transportation Research Board
- Erle Potter, Virginia Department of Transportation
- Sonja Scheurer, Michigan Department of Transportation
- Jim Smith, Pennsylvania Department of Transportation
- Janie Vrtiska, Nebraska Department of Roads
- John Wiegmann, Booz Allen Hamilton

APPENDIX B

BACKGROUND PAPER FOR JUNE 28-29, 2011 SPECIAL MEETING

NCHRP Project 20-07/Task 309

Challenges and Opportunities: A Strategic Plan for Equipment Management Research

Background Information for June 28-29, 2011 Special Meeting

Prepared by Paul T. Lauria, Mercury Associates, Inc.

Introduction

At the request of the AASHTO Standing Committee on Highways (and the recommendation of the AASHTO Highways Subcommittee on Maintenance), NCHRP initiated Project 20-07/Task 309 to develop a strategic plan for maintenance equipment research. This plan will be developed through input from fleet managers, consultants, and others involved in maintenance equipment operations and management. NCHRP organized a meeting of such individuals to achieve this objective. This paper presents information aimed at helping meeting participants develop an understanding of the current state of research on equipment management practices and improvement opportunities associated therewith. In order for the meeting to facilitate the development of sound recommendations for future research, it is important that the participants have an understanding of what research has already been conducted in this area and its suitability relative to the array of activities that collectively comprise the realm of equipment management for helping professionals working in this area effectively meet future challenges and opportunities.

Equipment Management Defined

In order to develop a strategic plan for equipment management research, it is first necessary to define what activities are encompassed by the term “equipment management.” Broadly speaking, the management of equipment fleets consists of two distinct types of activities: *asset management* activities and fleet services *program management* activities. Activities in the first area focus on the acquisition, operation, utilization, upkeep, disposal, and replacement of the physical assets that make up a vehicle and equipment fleet (few fleets are comprised solely of equipment). Activities in the second area focus on the acquisition and use of the responsibilities, authority, resources, expertise, cooperation, and decisions required to efficiently and effectively operate a fleet services program whose mission it is to furnish assets and asset management services to fleet users.

It goes without saying that the nature of any organization’s asset management activities is closely tied to the characteristics of the assets it uses. For instance, the asset management activities associated with operating a fleet of passenger cars, while based on certain universal principles of effective fleet management such as the importance of preventive maintenance or the timely replacement of vehicles, are quite a bit simpler

than those required for operating a fleet of plow tucks, mowing equipment, street sweepers, or paving equipment – or all of the above. This is because cars are neither as technologically complex nor, in most organizations, as mission critical as, say, an asphalt paver or a road roller on which the productivity of an entire paving crew depends. For these reasons, many of the asset management functions associated with operating a passenger vehicle fleet are more readily outsourced to contractors and/or vendors than are those associated with operating a work truck and equipment fleet. The "outsourceability" of an organization's fleet asset management functions, in turn, significantly influences the importance of its program management activities.

Program management activities include things like financial management, human resources management, procurement management, facility management, and information technology (IT) management. They are an important facet of equipment management for two reasons. First, an organization's program management activities can have a direct and profound impact on its asset management activities, especially since their conduct frequently is governed by enterprise-wide policies and procedures that were not promulgated with the particular needs of a fleet services program in mind. For instance, an internal IT organization that refuses to permit the implementation of a stand-alone fleet management information system in the belief that an enterprise resource planning (ERP) system such as *SAP*® offers ample functionality to manage a fleet can effectively prevent a fleet services program from optimizing both the efficiency and effectiveness of its data processing and management analysis and reporting efforts.

Second, asset management activities are far more likely to be performed in house for an equipment fleet than for a passenger car fleet due to the aforementioned mission criticality and technological complexity of the assets involved. Consequently, asset management effectiveness is more susceptible to constraints imposed by genericized, enterprise-wide management policies and processes – such as the use of a "one-size-fits-all" ERP or enterprise asset management (EAM) system – in organizations with equipment fleets. This implies that equipment management professionals should devote at least as much attention to program management activities as to the "care and feeding" of the equipment assets in their organizations.

In identifying research needs that will help advance the capabilities of equipment management professionals, consideration should be given to the asset management and fleet services program management functions shown in Exhibit 1. This is not a comprehensive list of equipment management activities. Rather, it focuses on the most important such activities which also might be good candidates for research. It excludes many activities which, while important if not critical to the effective management of a vehicle and equipment fleet, do not seem to lend themselves to *research,* which is defined as "studious inquiry or examination; *especially***:** investigation or experimentation aimed at the discovery and interpretation of facts, revision of accepted theories or laws in the light of new facts, or practical application of such new or revised theories or laws."[4] Defining functional/operational requirements for equipment and the most cost-effective means of meeting them is an equipment management activity that lends itself

[4] http://www.merriam-webster.com/dictionary/research

to inquiry into the methodologies and analytical tools used by different departments of transportation; performing post-trip inspections and maintaining records that comply with FMCSA regulations are activities that do not.

Table 1
Equipment Management Functions and Available Research Studies

	Asset Management Function	Objective	Any Research Studies Available?
	Equipment Acquisition		
1	Requirements definition	Define equipment needs in a consistent manner based on established work methods, business practices, allocation methods, and/or formally defined standards.	**U**[5]
2	Alternative provision methods analysis	Identify the most cost-effective means of meeting the need for an asset (e.g., own versus rent versus reimburse; assigned versus pool).	**U**
3	Specifications development	Ensure that assets meet business requirements, take advantage of technological advances, promote government sustainability initiatives, comply with applicable procurement rules, and facilitate standardization of fleet composition.	**Y**
4	Equipment selection	Select from among competing make/models of assets that meet functional/technical specifications so as to optimize equipment cost effectiveness, leverage volume buying power, and facilitate standardization of the fleet.	**U**
5	Upfitting	Ensure that post-purchase upfitting activities are performed only when cost effective for meeting equipment functional requirements and are carried out in a timely manner.	**U**
6	Commercial equipment rental	Utilize commercial equipment rental sources when cost effective to meet periodic temporary/seasonal equipment needs.	**U**

[5] U = unknown; Y = yes

	Asset Management Function	Objective	Any Research Studies Available?
	Equipment Operation Management		
7	Driver/operator training	Ensure that operators receive training in the proper (safe, economical, and environmentally responsible) *operation* of equipment.	**Y**
8	Equipment misuse/abuse/collision management	Identify and rectify/minimize instances/patterns of improper equipment operation so as to minimize equipment-related safety hazards and unnecessary repair costs.	**Y**
	Equipment Utilization Management		
9	Establishment of utilization guidelines and benchmarks	Determine levels of ongoing equipment utilization that warrant the ownership and dedicated assignment of specific types of assets.	**U**
10	Utilization data capture	Obtain accurate and timely information on equipment usage that can be used to identify opportunities to assess and improve the suitability, allocation, deployment, and use of assets.	**U**
11	Identification and investigation of utilization exceptions	Use exception reporting and follow-up investigation methods to identify opportunities to improve fleet size, composition, and/or utilization.	**U**
12	Driver/operator training	Ensure that user organizations and equipment operators receive guidance and training in the cost-effective *utilization* of assets.	**U**
13	Equipment pool establishment, sizing, and composition	Operate in-house motor pools when cost effective to meet periodic equipment needs that do not warrant the dedicated assignment of assets to specific user organization/locations.	**U**
	In-House Equipment Maintenance and Repair Management		
14	PM program development	Minimize unexpected and costly mechanical failures through the performance of pre-defined, pre-scheduled equipment and component inspection, adjustment, replenishment/refurbishment, and replacement services.	**U**

	Asset Management Function	Objective	Any Research Studies Available?
15	Maintenance technician supervision	Ensure the safe, efficient, and effective performance of equipment maintenance and repair services by providing technical guidance and quality assurance inspection, as needed, in the performance of assigned tasks.	**U**
16	Warranty management	Avoid paying for the repair/replacement of equipment and equipment components and parts that are covered by supplier warranties.	**U**
17	Parts procurement and supply	Ensure that maintenance technicians are provided with quality parts at a reasonable cost through the establishment and effective execution of integrated parts requisitioning, procurement, inventorying, and disbursement policies and procedures	**U**
	Outsourced Maintenance and Repair Services Management		
18	Outsourcing feasibility determination	Determine the relative merits of performing non-routine equipment maintenance, repair, and refurbishment activities in house versus outsourcing them to vendors/contractors.	**U**
19	Service authorization and quality control	Ensure the appropriateness (e.g., relative to vehicle repair history, replacement plans, manufacturer TSBs/recalls, and flat rate time standards) of all services proposed to be performed by vendors, and compliance with all contract terms and conditions where applicable, in an efficient and effective manner.	**U**
	Equipment Fueling Management		
20	Bulk fuel purchasing and inventory management	Acquire and manage supplies of bulk fuel in the most cost-effective manner possible, while ensuring compliance with applicable safety and environmental protection regulations.	**U**
21	Bulk fuel facility transaction management	Obtain accurate and timely fuel transaction data in the most cost-effective manner possible in order to understand equipment fueling needs, consumption levels, and fuel efficiency rates.	**U**

	Asset Management Function	Objective	Any Research Studies Available?
22	Commercial fuel transaction management	Optimize fleet fueling service levels and costs by utilizing commercial service providers where appropriate, subject to the use of appropriate transaction management and control procedures.	**U**
	Equipment Replacement Management		
23	Replacement cycle guideline development	Facilitate the development and justification of fleet replacement plans and the identification and consideration of specific assets for possible replacement through the development and use empirically validated optimal replacement cycle guidelines by asset type.	**Y**
24	Fleet replacement planning	Facilitate the analysis and communication of ongoing fleet replacement costs, funding needs, and alternative capital financing approaches through the development of forecasts of long-term fleet replacement costs.	**Y**
25	Replacement earmarking and budgeting	Identify specific assets to be replaced in the next fiscal year systematically and equitably.	**Y**
	Equipment Disposal Management		
26	Equipment decommissioning	Ensure that assets determined to no longer be needed are physically removed from service so as to control fleet size and composition (fleet creep); ensure the accuracy of fleet inventory records and customer billings; and prevent unauthorized expenditures on old assets.	**U**
27	Used equipment remarketing	Recondition (as appropriate) and dispose of used assets in the most efficient and cost-effective manner possible.	**U**

	Program Management Function	Objective	Any Research Studies Available?
	Information Management		
28	Data capture	Identify, codify, and collect data needed to support the development of information on all aspects of fleet utilization, condition, costs, and performance; on all aspects of fleet management efficiency and effectiveness; and on fleet user needs through direct data input or electronic data interchange, as appropriate.	**U**
29	Software acquisition and use	Acquire, implement, integrate, maintain, and optimize the design, deployment, performance, and use of automated information systems and analytical tools to support management analysis and reporting in all areas of fleet management and operation.	**Y**
30	Performance measurement and reporting	Establish, monitor, and report on adherence to quantitative measures of condition and performance that reflect the degree of accomplishment of specific fleet management and operation-related goals and objectives.	**U**
31	Ad hoc management analysis	Support specific fleet-related forecasting, planning, budgeting, evaluation, decision making, and reporting activities through the development of ad hoc data query, analysis, and report development capabilities and tools.	**U**
	Fleet Financial Management		
32	Budgeting	Secure funds to provide fleet resources and fleet management services that meet fleet user needs at an appropriate cost through long and short-range forecasting of resource requirements and associated costs.	**U**

	Program Management Function	Objective	Any Research Studies Available?
33	Cost of service analysis	Control fleet costs and cost-effectiveness/competitiveness through activity-based analysis of the costs of providing specific fleet management services and comparison of those costs against suitable internal and/or external benchmarks.	**U**
34	Cost charge-back rate development	Ensure complete recovery of product and service delivery costs; promote the efficient provision and consumption of fleet resources and services by using a *rate structure* that produces pricing signals and cost transparency that create accountability and encourage value management.	**U**
35	Cost distribution (billing)	Promote the efficient provision and consumption of fleet resources and services by using a *billing process* that creates cost transparency and encourages cost control.	**U**
36	Cash/fund management	Ensure that cash flows and financial reserves are managed so as to meet working capital requirements and that funds obtained to support one service delivery activity or line of business are not used to inappropriately subsidize the costs of other activities.	**U**
37	Asset acquisition financing	Ensure the availability of funds to replace equipment in a timely manner by employing capital financing mechanisms that minimize year-to-year volatility in funding requirements and permit the capital costs of assets to be paid for over their expected service lives.	**Y**
	Human Resources Management		
38	Organization structure definition	Optimize staff size, composition, and performance through the formal delineation of employee roles, responsibilities, authority, and lines of communication.	**U**
39	Employee recruitment	Optimize the suitability of employees hired to fill open positions through the use of a well-structured recruitment process and effective working relationship with the public service commission.	**U**

	Program Management Function	Objective	Any Research Studies Available?
40	Employee classification and compensation	Define job responsibilities and career tracks clearly; ensure that compensation levels are competitive, commensurate with the skill, experience, and educational prerequisites of each position, and that they treat employees equitably.	**U**
41	Employee training and professional development	Improve the skills and capabilities of employees through the development, delivery, and/or purchase of suitable technical, managerial, and human relations training programs; apprenticeship programs, and mentorship programs.	**Y**
42	Employee performance management	Promote continuous improvement in employee performance by providing regular, structured feedback on the quality of fulfillment of job responsibilities and rate of progress toward attainment of specific performance improvement goals and objectives.	**U**
	Fleet Management Infrastructure Management		
43	Facility location management	Establish and maintain locations of fleet (i.e., maintenance and fueling) facilities that strike an appropriate balance between equipment user access and facility ownership and operating costs.	**U**
44	Facility design and construction	Maximize the efficiency, effectiveness, and safety of facilities and capital equipment through the development and application of design prototypes, guidelines, and standards that reflect advances in technology and industry best practices, as well as the unique operating environments/locales in which specific facilities are located.	**U**
45	Facility safety management	Provide safe working conditions and promote safe work practices through the proper equipping, operation, education, and/or supervision of fleet facilities, employees, customers, and other visitors.	**U**

	Program Management Function	Objective	Any Research Studies Available?
	Customer Service Management		
46	Transaction-based communication	Promote clear, constructive communication between fleet management service providers and customers (equipment operators and users) regarding the objectives and results of specific asset provision methods and/or acquisition, rental, maintenance and repair, fueling, replacement, and decommissioning transactions.	**U**
47	Customer satisfaction measurement	Promote high levels of satisfaction with equipment management service quality and costs (overall and in specific areas) by conducting regular customer surveys, focus group sessions, etc. and incorporating lessons learned in appropriate business process modifications.	**U**
48	Ongoing customer relationship management	Establish and maintain relationships and communication channels (e.g., web site, newsletters, annual reports, on-line policy and procedure statements) with customers aimed at fostering mutual understanding of one another's missions and promoting collaboration and overall cost effectiveness in the provision and use of fleet resources.	**U**
	Fleet Management Program Business Planning		
49	Plan development and dissemination	Facilitate continuous improvement and leadership in the delivery of fleet resources and services and in fleet management efficiency and effectiveness through the development, annual updating, and dissemination of a formal strategic business plan.	**U**
50	Annual report development	Ensure awareness and understanding of the goals, methods, challenges, opportunities, and accomplishments of the fleet services program through the preparation and publication of an annual fleet management report.	**U**

Publications

According to TRB, very little research has been conducted in the area of equipment fleet management. To wit, a search of the literature that was prepared in support of this project yielded the following results:

- Douglas D. Gransberg (2006) *Construction Equipment Management for Engineers, Estimators, And Owners*[6]
- John E. Dolce (2009) *Analytical Fleet Maintenance Management, 3rd Edition*[7]
- John E. Dolce (2003) *Fleet Manager's Guide to Vehicle Specification and Procurement, Second Edition*[8]
- Mike Vorster (2009) *Construction Equipment Economics*[9]
- Thanapun Prasertrungruang and B.H.W. Hadikusumo (2008) *System dynamics modeling of machine downtime for small to medium highway contractors*[10]
- Thanapun Prasertrungruang and B.H.W. Hadikusumo (2009) *Heavy equipment management practices and problems in Thai highway contractors*[11]

It is worth noting that only two of the publications cited above, by Prasertrungruang and Hadikusumo, present actual research study results. The others are all text book-type publications that present technical guidance based primarily on the experience of the authors rather than on the results of research studies.

Additional text book-type publications in the same vein, identified by Mercury Associates in preparing this paper, include the following:

- John D. Campbell et al. (2010) *Asset Management Excellence: Optimizing Equipment Life-Cycle Decisions, Second Edition*[12]
- David A. Day and Neil B.H. Benjamin (1991) *Construction Equipment Guide*[13]
- David J. Edwards et al. (2003) *Management of Off-Highway Plant and Equipment*[14]

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[6] Available at **http://books.google.com/books?id=__KfMapExTgC&lpg=PP1&ots=dBieqbYBF&**
[7] Available at **http://books.sae.org/book-r-371**
[8] Available at **http://books.sae.org/book-r-332**
[9] Available at **http://www.cempcentral.com/CEE**
[10] Available at **http://www.emeraldinsight.com/journals.htm?issn=0969-9988&volume=15&issue=6&articleid=1752252&show=abstract**
[11] Available at **http://professionalprojectmanagement.blogspot.com/2009/11/heavy-equipment-management-practices.html**
[12] Available at **http://www.amazon.com/Asset-Management-Excellence-Optimizing-Engineering/dp/0849303001/ref=dp_ob_title_bk/179-1131079-2927150**
[13] Available at **http://books.google.com/books?id=4GsBphPn1EYC&printsec=frontcover&dq=inauthor:%22David+A.+Day%22&hl=en&ei=oLDvTfSkBOT50gHXxNX1DA&sa=X&oi=book_result&ct=result&resnum=1&ved=0CDAQ6AEwAA#v=onepage&q&f=false**
[14] Available at **http://books.google.com/books?id=lUOcd-vbEuUC&printsec=frontcover&dq=**

- S.W. Nunnally (2000) *Managing Construction Equipment*[15]
- John Schaufelberger (1998) *Construction Equipment Management*[16]

Most of the above publications contain bibliographies that can be consulted to identify additional books and research papers and reports on specific facets of vehicle and equipment fleet management.

Several trade associations have produced publications such as best practices compilations and how-to guides pertaining to certain facets of vehicle and equipment fleet management. Among these, the most notable are:

- American Public Works Association (www.apwa.net)[17]
- American Trucking Associations Technology & Maintenance Council (www.truckline.com/Federation/Councils/TMC)[18]
- NAFA, Fleet Management Association (www.nafa.org)[19]
- National Truck Equipment Association (www.ntea.com)[20]
- SAE International (www.sae.org)[21]

Some of these associations also publish their own periodicals containing articles touching on a wide array of vehicle equipment management topics. Additional periodicals of particular relevance to the fields of vehicle and equipment fleet management include:

- Bobit Publishing's *Automotive Fleet, Fleet Financials, Government Fleet*, *Work Truck Magazine*, and several other publications (www.fleet-central.com)
- *BucketTrucks.org* (www.buckettrucks.org)
- *Commercial Carrier Journal (www.ccjdigital.com)*
- *Construction Business Owner (www.constructionbusinesowner.com)*
- *Construction Equipment* (www.constructionequipment.com)

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inauthor:%22David+J.+Edwards%22&hl=en&ei=ja7vTdyoMKqz0AGTofH3DA&sa=X&oi=book_result&ct=result&resnum=1&ved=0CDEQ6AEwAA#v=onepage&q&f=false

[15] Available at **http://books.google.com/books?id=vuseAQAAIAAJ&q=inauthor:%22S.+W.+Nunnally%22&dq=inauthor:%22S.+W.+Nunnally%22&hl=en&ei=va3vTbrDCIrMgQfgvfjxAQ&sa=X&oi=book_result&ct=result&resnum=2&ved=0CC4Q6AEwAQ**

[16] Available at **http://www.amazon.com/Construction-Equipment-Management-John-Schaufelberger/dp/0137162677/ref=sr_1_1?ie=UTF8&s=books&qid=1307560177&sr=1-1**

[17] On-line publications catalog available at **http://apwa.net/Topics/Fleet-Services**

[18] TMC's *Recommended Practices Manual* can be accessed on-line at **http://www.truckline.com/Federation/Councils/TMC/Documents/Misc/RPS_2010_LIST.pdf**

[19] On-line publications catalog available at **http://www.nafa.org/Template.cfm?section=Product_Listing &Template=/CustomSource/NAFAProductDisplay.cfm**

[20] On-line publications catalog available at **http://www.ntea.com/vango/core/orders/**

[21] SAE's on-line automotive publications catalog is available at **http://www.sae.org/pubs/automotive/**

- *Equipment World* (www.equipmentworld.com)
- *Fleet Equipment* (www.fleetequipmentmag.com)
- *Fleet Management Weekly* (www.automotivedigest.com)
- *Fleet Owner* (www.fleetowner.com)
- *Grounds Maintenance* (www.grounds-mag.com)
- *Light & Medium Truck* (www.lmtruck.com)
- *Transport Topics* (www.ttnews.com)

Past Research

In addition to the two research studies cited previously, Mercury's search of the **Transportation Research Board** Web site for equipment management-related publications yielded the following results:

- *Computerized Equipment Replacement Methodology, Transportation Research Record No. 1824* (2003) J. Weissmann et al.[22]
- *Construction and Maintenance Equipment: A Compilation of Data on Time Utilization, Performance, and Costs* (contents, author(s), publisher, and date of publication unknown; synopsis not available)
- *Economic and Environmental Optimization of Vehicle Fleets: A Case Study of Impacts of the Impacts of Policy, Market, Utilization, and Technological Factors, Transportation Research Board Annual Meeting 2011 Paper #11-4265* (2011) Miguel Figliozzi, Transportation Research Board[23]
- *Equipment Quality Improvement Measures: Large Truck Fleet, Maintenance Management 2006: Presentations from the 11th AASHTO-TRB Maintenance Management Conference, Transportation Research E-Circular E-C098* (2006) Jared Beard and Richard Clarke[24]
- *Equipment Replacement at Departments of Transportation: Prioritization Measures, Software Tools, and Supplementary Data, Transportation Research Record No. 2150* (2010) Phillip O. Kriett et al. [25]
- *Evaluation of Systems to Monitor Blind Areas Behind Trucks Used in Road Construction and Maintenance: Phase 1, RI 9660* (2003) Todd M. Ruff, National Institute for Occupational Safety and Health[26]

[22] Synopsis available at **http://pubsindex.trb.org/view.aspx?id=663400**
[23] Synopsis available at **http://pubsindex.trb.org/view.aspx?id=1093498**
[24] Synopsis available at **http://pubsindex.trb.org/view.aspx?id=786939**
[25] This appears to be a distillation of research results presented in Kim et al. Synopsis available at **http://trb.metapress.com/content/u123u96102285340/**
[26] Available at **http://www.cdc.gov/niosh/mining/pubs/pdfs/ri9660.pdf**

- *Financial Aspects of Equipment Acquisition, Transportation Research Circular Number E-C052* (2003-7) A.T. Swenson, TRB Committee on Maintenance Equipment[27]
- *Fleet Management and Selection Systems for Highway Maintenance Equipment, NCHRP Synthesis of Highway Practice Report 283* (2000)[28]
- *Fleet Replacement Modeling: Final Report, SPR 670* (2009) David S. Kim et al., Oregon Department of Transportation and Federal Highway Administration[29]
- *Improved Visibility for Snowplowing Operations, NCHRP Project 6-12 Final Report* (2000) Mark S. Rea and Brian E. Thompson[30]
- *Winter Maintenance Technology and Practices - Learning from Abroad, An NCHRP Research Results Digest* (c. 1995)[31]

In addition to the specific research studies cited above, the TRB Web site contains references to a large number of publications (not necessarily research reports) pertaining to alternative fuel technology that have been produced over the last 15 years or so. Given the dynamic nature of this facet of fleet management, we did not attempt to catalog all of these publications in this paper.

Clear Roads (www.clearroads.org) is a pooled fund research project that develops and disseminates testing and research results related to winter road maintenance operations, including results specifically related to equipment selection, operation, and performance. Examples of research projects that have been sponsored by Clear Roads include:

- *Collision Avoidance Systems for Snowplows: An Overview of Strategies and Research* (2008)
- *Material Spreader Use in Winter Maintenance Operations: A Survey of State Practice* (2010)
- *Virtual Snowplow Training: State of the Practice and Recent Research* (2008)

[27] Synopsis available at **http://pubsindex.trb.org/view.aspx?id=661869**
[28] Contents and authors unknown. A synopsis is available at **http://books.trbbookstore.org/syh 283.aspx**
[29] Available at **http://www.oregon.gov/ODOT/TD/TP_RES/docs/Reports/2009/Fleet_Model.pdf?ga=t**
[30] Synopsis available at **http://144.171.11.40/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=879**
[31] Contents and authors unknown. A synopsis is available at **http://www.trb.org/Main/Blurbs/ 154183.aspx**

Research Needs Statements

There are three current TRB research needs statements related to equipment management:

- *Comparison of Fleet Funding, Management, and Charge Back Systems to Develop Optimum Fleet Efficiency* (2010)[32]
- *Standardized Equipment Classifications for Improved Asset Management and Data Sharing* (2010) [33]
- *Use of Performance Measures and Benchmarking in DOT Fleet Operations* (2010)[34]

Conclusions

There is a considerable body of published information on equipment fleet management in the form of text books, trade association how-to guides and compendia of annual conference papers and educational presentations, and magazine articles from both trade/professional associations and independent publishers. However, our brief review of the literature suggests that very little research on equipment fleet management has been conducted, and the preponderance of that has been in the areas of the safe operation of equipment and equipment replacement management. Interestingly, almost none of the research appears to touch on those fleet service program management activities which we have found to be so critical to the performance of transportation and public works-type fleets.

Table 1 identifies 50 facets of equipment fleet management that are both important to the operation of an effective, safe, reliable, economical, and sustainable fleet and that would seem to lend themselves to research on industry-wide practices, innovations, and information sharing, and learning opportunities. This should provide for a wide-ranging discussion of research needs at our upcoming meeting.

[32] Synopsis available at **http://rns.trb.org/dproject.asp?n=13841**
[33] Synopsis available at **http://rns.trb.org/dproject.asp?n=12974**
[34] Synopsis available at **http://rns.trb.org/dproject.asp?n=12763**