Transit State of Good Repair

BEGINNING THE DIALOGUE

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U.S. Department of Transportation

Federal Transit Administration

Maintaining the condition of our transit infrastructure is an issue of national importance—and one that poses pressing challenges—for most of the Nation's transit systems. In a country where public transportation is increasingly looked to as a necessary and critical mode of travel, ensuring that local transit systems are maintained in a "state of good repair" to provide efficient, reliable, and safe service is more important than ever.

The Federal Transit Administration (FTA) has been, and will continue to be, proactive on this issue by raising awareness throughout the industry, bringing diverse stakeholders together to assess and measure the scope of the problem, and by exploring creative approaches to financing necessary repairs and upgrades for aging transportation assets.

In the summer of 2008, the Federal Transit Administration (FTA) brought together representatives from 14 public transportation providers and State Departments of Transportation to discuss the state of repair of our Nation's transit inventory. We discussed, among other things, transit recapitalization and maintenance issues, asset management practices, and innovative financing strategies. We explored issues related to measuring the condition of transit capital assets, prioritizing local transit re-investment decisions, and preventive maintenance practices. And we discussed research needs and potential tools for helping agencies cope with this growing problem.

Subsequently, FTA met with equipment manufacturers, construction and engineering firms, and private equity firms to explore potential public-private partnership opportunities within public transportation—including the potential for private-sector involvement in long-term capital asset management, to help ensure that legacy assets are maintained or replaced as needed.

We will continue to focus on this issue, in part by including a discussion about ways to include state-of-good-repair needs in the next authorization for federal surface transportation programs.

In addition, FTA plans to convene a State of Good Repair Roundtable in 2009 to further discuss the challenge of transit recapitalization, lessons learned, and best practices. We will report to Congress as well on the level of investment needed to bring the Nation's largest rail transit agencies to a state of good repair, and will continue to explore other opportunities to discuss this issue and potential solutions.

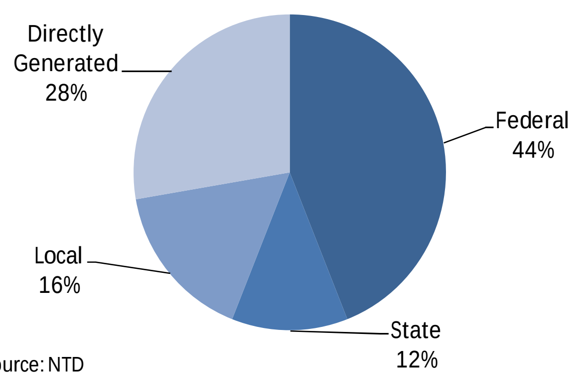
Bringing our Nation's transit systems to a state of good repair—while at the same time planning for and implementing needed service expansions—is a steep challenge. But we at FTA are confident that working together we can develop the solutions to continue to provide public transportation to the millions of Americans that depend on it.

Beginning the Dialogue

State of Good Repair Initiative

Maintaining the nation's bus and rail systems in a state of good repair (SGR) is essential if public transportation systems are to provide safe and reliable service to millions of daily riders. Data, discussed later in this paper, indicates that investments to date have not been adequate. This report is the first step in a collaborative initiative to comprehensively articulate the problem, to define a commonly adopted definition of "state of good repair", and to identify strategies, technical assistance briefs, peer to peer exchanges, and best practices aimed at achieveing such a state industrywide.

Capital Funding Shares: 1997 to 2006



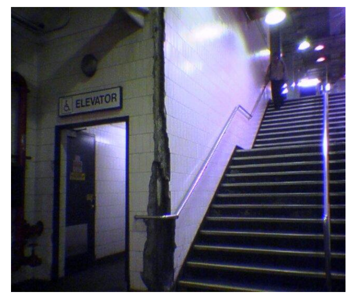
Source: NTD

Since 1991, Federal, state and local funding resources have invested $165 billion in the preservation and expansion of the nation's rolling stock and infrastructure. Despite this ongoing investment, much of the nation's rolling stock and infrastructure is deteriorating and the current capital reinvestment rates appear insufficient to halt or reverse this decline. For transit riders, this deterioration manifests itself in the form of declining service reliability. For transit operators, aging capital assets drive increasing maintenance costs and limits the ability to expand system capacity at a time of high demand prompted by high fuel costs. All share a mutual concern over the potential impacts on safety.

Current capital reinvestment rates are only 60% to 80% of that required to address existing backlog and normal replacement needs

These concerns have prompted FTA to take a closer look at the nation's transit recapitalization and maintenance needs. As we do so, FTA is partnering with the industry to help assess the magnitude of the problem and to identify meaningful solutions. Working together, we hope to ensure adequate commitment and resources to protect and preserve investments.

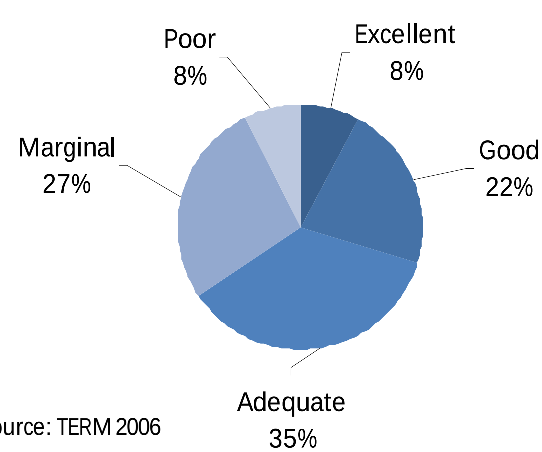
Recent Trends



The ongoing decline of the nation's bus and rail assets and the increasing pressure on existing funding sources to address the resulting reinvestment needs has been captured by a broad range of industry analyses. Consider the following:

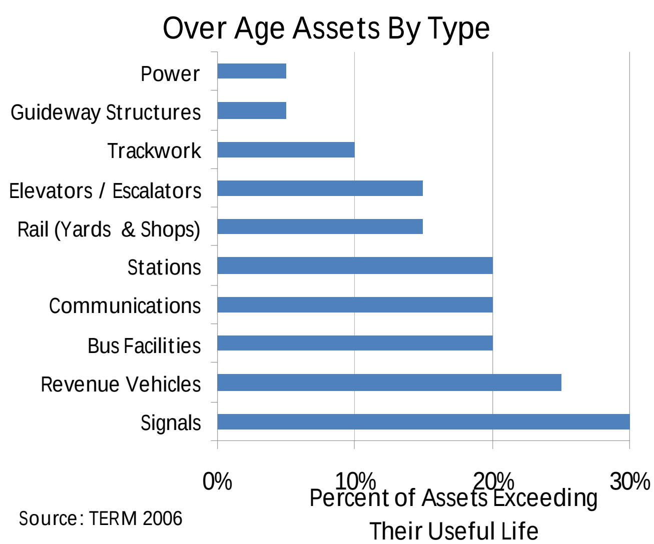
- Current Conditions: FTA analysis of national transit data suggests that roughly one-quarter of the nation's bus and rail assets are in marginal or poor condition (implying these assets are near or past their useful life or have one or more defective or deteriorated components). The proportion of assets in marginal or poor condition jumps to one-third when the analysis is limited to the nation's nine largest rail agencies (including these agencies' non-rail assets).

Asset Conditions: Largest Rail Agencies



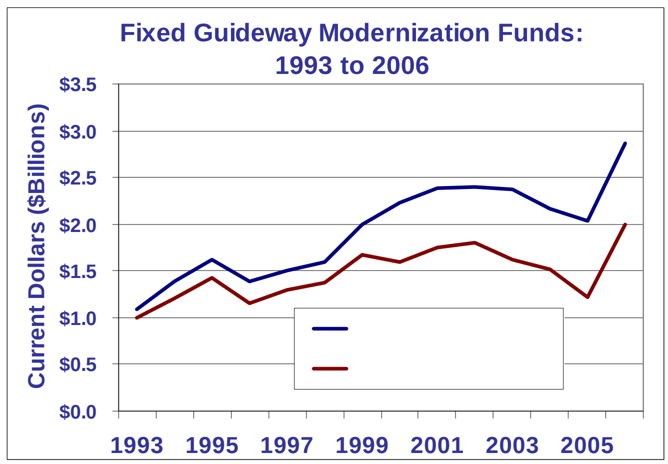
Source: TERM 2006

Asset conditions are generally poorest for the heavy rail and bus modes (both with roughly one-third of assets in marginal or poor condition). A lesser proportion (7%) of light rail assets are in marginal or poor condition, reflecting the significant level of investment in new light rail systems over the past twenty years (resulting in a greater proportion of younger assets compared to other modes). FTA expects these percentages to grow if recapitalization needs are not addressed.



n SGR Backlog: Based on FTA analysis, the total level of investment required to bring the nation's bus and rail assets to a state of good repair is currently estimated at $25 billion ($2004). This investment would effectively replace all assets that currently exceed their expected useful life and address delayed rehabilitation activities. After eliminating the backlog, an additional $9 to $11 billion from all sources is required annually to maintain this state of good repair into the future. At present, annual capital reinvestment rates are only 60% to 80% of that required to address both the existing backlog and normal replacement needs.

n Declining Share of Federal Resources: The nation's oldest and largest rail transit agencies carry nearly 60% of ridership and receive 40% of all Federal transit funding. And while the increase in the number of rail systems throughout the country brings access to improved transit service to more Americans, the Fixed Guideway Modernization Program – FTA's primary source of rail capital replacement funds – is spread more thinly as new systems are added. As a consequence, the proportion of Fixed Guideway Modernization funds distributed to the oldest rail systems (with the highest proportions of poor and marginal asset conditions) has declined from over 90% in 1993 to less than 70% by 2006. The demand for Fixed Guideway Modernization funds will only accelerate as rail systems constructed in the 1980s and 1990s begin to experience their first major recapitalization needs.



n Safety: In recent hearings and reports, the National Transportation Safety Board (NTSB) stated its concern that the rail transit industry is not investing enough to protect its workers, passengers and capital assets. An example here is a July 2006 CTA Blue Line derailment where the NTSB concluded that: "The tie plates and fastener systems failed to maintain the track gauge because of the effects of corrosion and wear of the rail and fastener systems, and degraded ties." NTSB Member Higgins called the incident a "wake up call…to all transit agencies…with equipment and infrastructure that ages with each passing day."

n Local Examples: Local agency analyses also highlight the need for significant capital reinvestment, to address needs that remain unmet due to insufficient funding.

§ New York City Transit (NYCT): NYCT has been working steadily since 1982 to bring the nation's largest and second oldest rail transit system to a state of good repair, this following a period of underinvestment and decline. After making significant progress, this long-term major reinvestment program recently encountered a setback following the defeat of New York's proposed congestion pricing plan, a measure that would have yielded a significant portion of funding to meet NYCT's reinvestment and expansion needs. Over the next twenty years, NYCT capital needs include roughly $20 billion in state of good repair (SGR) investments and an additional $2 billion in annual normal replacement (NR) investments.

§ Massachusetts Bay Transportation Authority (MBTA): Boston MBTA estimates that it needs $620 million in annual capital investment to attain its assets in a state of good repair over the next twenty years. With only $470 million in anticipated annual funding, this leaves roughly $150 million in annual unfunded capital needs. The resulting investment backlog includes parking, maintenance shops, and fare equipment, as well as assets that serve fewer passengers (and hence a lower investment priority). Eliminating the existing backlog would help improve operating speeds and reliability, reduce operating costs and encourage new ridership.

§ Washington Metropolitan Area Transit Authority (WMATA): WMATA, along with San Francisco's Bay Area Rapid Transit (BART) and the Metropolitan Atlanta Rapid Transit Authority (MARTA), is representative of a group of larger operators with rail systems entering their first major rounds of capital reinvestment needs. Built over the past thirty years, many of WMATA's rail assets are now entering "middle age," leading to increasing recapitalization needs. At the same time, the Washington Metropolitan region continues to grow, leading to tough choices between expansion and reinvestment.

Beginning the Dialogue

Over the past several months, FTA has taken some initial steps to focus attention on transit capital asset preservation and renewal. Moving the industry towards an overall "state of good repair" is a key agency objective. Consider the following:

- What is a "state of good repair" (SGR) and how can we measure it?
- What is the magnitude of the SGR investment backlog?
- What is the gap between reinvestment needs and available resources?
- What strategies are agencies using to address SGR needs?
- How can FTA help?

The answers to these questions will impact how we think about and address state of good repair issues. Recent FTA initiatives have begun to address these challenges.

- SGR Workshop: In August 2008, FTA convened a two-day workshop with senior engineers and capital planning staff from 14 bus and rail agencies. The SGR Workshop provided local agency staff with an opportunity to discuss the magnitude of their SGR needs, potential strategies to address this problem, and the problem of limited resources. The discussion topics and findings from this workshop are provided at the end of this report. The SGR workshop represents only a first step in FTA's plan to partner with the industry to jointly assess and address the nation's transit recapitalization needs.

- Rail Modernization Study: In response to a December 7, 2007 letter from twelve U.S. Senators[1], and related language in the FY 2008 Transportation-HUD Appropriations bill, FTA is conducting a Rail Modernization Study. This study will assess the level of investment required to bring the nation's largest rail transit systems to a state of good repair. The study will also consider the gap between reinvestment needs and historic funding levels, and potential changes to the existing Fixed Guideway Modernization funding formulas. The study will be submitted to Congress in early 2009. Prior FTA rail modernization studies were completed in 1979 and in 1987.

- FTA SGR Working Group: FTA has established an internal working group that meets regularly to consider SGR related issues and to establish new initiatives.

Future Focus

Beyond these first steps, FTA is considering additional strategies to promote an understanding and awareness of national transit recapitalization and maintenance needs and potential solutions to address those needs.

[1] Senators signing the letter include: Richard Durbin, Barack Obama, Evan Bayh, Robert Casey, Hillary Clinton, Christopher Dodd, John Kerry, Edward Kennedy, Joe Lieberman, Robert Menendez, Charles Schumer, and Arlen Specter.

- SGR Roundtables and Advisory Groups: FTA currently conducts biannual "roundtables" with industry engineering professionals to address common issues impacting the design and construction of New Starts projects. FTA is considering a similar roundtable program to address state of good repair issues. As with the existing Construction Roundtables, these "SGR Roundtables" would include industry engineering and capital planning experts, with the objective of sharing approaches and solutions to common state of good repair problems. These roundtables would also help ensure that FTA's strategies for attaining state of good repair accurately reflect real world reinvestment realities. The possibility of an SGR Roundtable received strong support from the transit agency staff attending FTA's recent SGR workshop.

- Definition and Measurement of State of Good Repair: At present, there is no industry accepted definition of "state of good repair." In the absence of a clear definition and reliable measures, Federal, state and local decision-makers cannot easily establish an operational policy of attaining a state of good repair, determine what it will take to reach that objective or determine when (or if) that goal has been attained. FTA will work with the industry to help define what is meant by "state of good repair" and how best to measure it. The goal would not be to impose a common definition or measures on the industry but rather to find a common language to discuss the problem.

Asset management is a strategic capital planning process that supports well informed investment decisions based on good quality data and clear organizational objectives.

- Transit Asset Management: In the early 1990s, the nation's highway industry initiated development of the country's first transportation asset management systems. Today, virtually all state DOTs possess well developed asset management processes designed to actively monitor current asset conditions and evaluate reinvestment needs and tradeoffs. In contrast, few U.S. transit operators possess asset management processes comparable to those in the highway sector. FTA looks forward to working together with the transit industry to jointly develop asset management approaches that serve our specific needs. Asset management can help agencies:

- Establish clear organizational SGR definitions and objectives;
- Assess the magnitude of the issue;
- Better coordinate agency planning, engineering and decision-making functions;
- Prioritize the use of scarce reinvestment funds.

- “TERM Light”: FTA’s Transit Economic Requirements Model (TERM) is an analysis tool designed to help evaluate long-term transit recapitalization needs. In development for more than a decade, TERM can estimate the level of capital investment required to attain a state of good repair (or other investment objective) and can also assess how variations in capital funding availability will likely impact the future condition and performance of transit assets. FTA is exploring the development of a simplified version of TERM (or “TERM Light”) for use by local agency capital planning staff. In return, FTA will seek local agency asset data and participation in the ongoing improvement of this useful tool.

- National Transit Asset Inventory: A prerequisite to effective, long-term transit capital reinvestment analysis – at either the national or local levels – is the availability of good quality asset inventory and condition data. At present, only a handful of U.S. transit operators actively maintain transit asset inventories for capital planning purposes and there is no Federal reporting on transit assets except vehicles. FTA is considering expanding the current National Transit Database (NTD) reporting requirements to include data on local agency asset inventory holdings and conditions. This data will support TERM’s assessments of national reinvestment needs and will be valuable to those agencies not currently collecting this data for their own needs assessment purposes.

- Research and Technical Assistance: The SGR Workshop identified several areas where FTA might provide research and technical assistance relating to state of good repair and asset management. Examples include:

  - Asset Inventory Development: What are the best practices in the development of asset inventories and how are other agencies applying their inventories?
  - Linear Asset Management Tools: How are rail transit agencies utilizing “linear asset management tools” for the maintenance management and capital planning needs of their linear rail asset types (e.g., right of way, signals, track, tower, structures, etc.)?
  - Maintenance Management Systems: How can agencies make better use of their existing maintenance management systems to address state of good repair issues?
  - Innovative Financing: How can FTA support the industry in developing and promoting the use of innovative financing methods specifically designed to support capital reinvestment?

§ Lessons Learned and Best Practices: What are the best practices in asset management and state of good repair planning?

r Next Steps

In the coming months, FTA will complete the Rail Modernization Study and other SGR related efforts designed to help inform the upcoming Surface Transportation Reauthorization. Moving forward, FTA will continue to promote attainment of industry-wide state of good repair as a key long-term objective. As we do so, we will work closely with the industry to better understand the problem and to develop effective strategies that preserve the nation's transit capital assets and ensure safe and reliable transit service to the nation's riding public.

FTA State of Good Repair Workshop

Topics and Proceedings

Introduction to FTA State of Good Repair Workshop

OVERVIEW

On August 13, 2008, the Federal Transit Administration (FTA) convened a two-day workshop to consider the state of good repair (SGR) needs of the nation's rail and bus transit rolling stock and infrastructure. Specific issues considered by the workshop included:

- How should state of good repair be defined and measured?
- What is the current condition of the nation's transit capital assets?
- What level of investment is required to attain SGR, and how does this compare with existing funding?
- How are local agencies addressing their SGR needs?
- How can preventive maintenance, asset management and alternative financing approaches help agencies attain SGR?
- What should the federal role in SGR be?

The seven papers in this volume address each of these questions, provide background on the current understanding of the underlying issues, and then encourage the reader to consider alternate approaches or solutions to these issues. Preliminary versions of each paper were provided to each workshop participant before the meeting date as preparation for the workshop. The workshop then included one session related to each of the seven topics.

This report updates each of the seven papers and presents key observations from the SGR workshop.

BACKGROUND

The SGR workshop and related FTA state of good repair initiatives (e.g., the Rail Modernization Study) are motivated by a number of related events and concerns:

- Several highly visible infrastructure failures have called into question the adequacy of the maintenance of the nation's transportation infrastructure.
- FTA seeks more accurate information concerning the scope and cost of maintaining the nation's transit capital assets in a state of good repair.
- By law, FTA must examine its grantees' ability to maintain their existing transit systems when making decisions to support new fixed guideway projects. FTA is concerned that some guideway modernization funds have been diverted to its New Starts program.
- At the request of twelve U.S. Senators and the FY2008 Transportation-HUD Appropriations Bill, FTA is currently conducting a "Rail Modernization Study" to assess the level of investment required to bring the assets of the nation's largest rail transit agencies to a state of good repair.

Given these events and concerns, key objectives of the SGR workshop were to (1) help assess the extent of the issue (e.g., what is SGR, how should SGR needs be assessed, how are agencies currently addressing these needs, etc.) and (2) obtain local agency input to FTA's State of Good Repair initiative.

SGR WORKSHOP

The objective of this workshop was to obtain local agency perspectives on a range of SGR-related issues currently of interest to FTA.

Workshop Participants: The workshop participants included each of the agencies included in FTA's Rail Modernization Study as well as representatives of smaller rail and bus agencies. Participants also included senior FTA staff – including Deputy

Administrator Sherry Little – and consultant staff supporting the workshop. A complete listing of the transit agency workshop participants is found at the end of this introduction.

Workshop Sessions: The SGR Workshop consisted of a series of moderated sessions, and opening and closing remarks by workshop participants. Each session covered a different SGR-related issue and each of the papers in this volume corresponds to one of those sessions. Each session consisted of a brief overview of the topic area to be discussed (e.g., the application of asset management to address SGR needs) followed by a question and answer period between the session moderator and the session participants. This process produced an improved understanding of how local agency staff are currently addressing each of the topic areas discussed.

TOPICS

The seven papers presented here consider the topic areas for each of the seven primary session areas of the SGR Workshop. These papers are not intended to provide final answers or policy directives, but rather to elicit thought and local agency perspectives on the part of workshop participants and provide useful background and understanding of the major state of good repair issues. Local agency and other transit industry participants should find these papers helpful in identifying approaches and policies for addressing their own state of good repair needs.

KEY OBSERVATIONS

The SGR Workshop yielded a number of observations and valuable perspectives with respect to state of good repair issues.

- Funding Gap: Most agencies clearly indicated that existing funding was less than that required to meet current capital reinvestment needs.
- Investment Prioritization: Agencies tend to favor reinvestment in some asset types versus others. For example, "mission critical" asset types like vehicle fleets tend to receive the highest priority, whereas "less critical" assets such as maintenance facilities and station amenities tend to receive lower prioritization.
- Betterments and Standards Requirements: Few assets are replaced "in-kind." Rather, most replacement activities include some form of quality, technology, or safety improvement or mandated improvements such as those related to ADA requirements. For this reason, replacement costs are not "comparable" to, and generally higher than, the replaced asset's initial purchase cost.
- Preventive Maintenance (PM) Practices: Good quality PM programs can contribute to increasing asset longevity and service reliability as well as overall state of good repair.
- Measurement of SGR: Physical asset condition assessment is the best way to measure SGR for individual assets and on an agency-wide basis. Asset age is a second-best proxy, since it is highly variable based on asset utilization, environment, quality of manufacture and other factors.
- Data: Agencies that have collected and maintained detailed inventories of their transit assets have benefited from a clearer understanding of their long-term capital reinvestment needs. FTA would also benefit from a reporting process on the age and condition of the nation's inventory of transit assets.
- SGR Research: The transit industry would benefit from national-level research on SGR-related issues such as new materials, preventive maintenance practices and best practices in asset management.

QUESTIONS

At the opening and closing of the workshop, FTA Deputy Administrator Sherry Little posed the following key questions for the industry to consider with respect to state of good repair:

- What should the Federal role in SGR be? Setting standards or sharing best practices?
- If FTA combined all grant programs into one flexible block grant, how would your agency use this money, assuming there are no set rules for its expenditure?
- How would you bring your system to a SGR if you have limited additional resources?
- How can we generate political support for SGR activities? Can FTA help make fix-it-first as politically appealing as ribbon-cutting for a new service?

Moving forward, FTA will continue to pursue answers to these questions through future workshops with industry representatives and related initiatives.

APPENDIX: SGR WORKSHOP PARTICIPANTS

As noted above, the workshop participants included each of the agencies in FTA's Rail Modernization Study as well as representatives of smaller rail and bus agencies. Participants also included FTA staff and consultant staff supporting the workshop. Transit agency participants included:

Transit Agency Attendees (alphabetical order)

Name	Title	Agency
Vicki Barron	Director, Project Delivery	Portland Tri-Met
Michael Chubak	Executive Vice President	New York NYCT
Michael Connelly	Manager, Capital Improvement Program Development	Chicago CTA
David Couch	Director, Infrastructure Renewal Projects	Washington WMATA
Michael Davis	Director, Metro Operations	Maryland MTA
Peter Garino	Director, Strategic Policy Initiatives	New Jersey NJT
Richard Jarrold	Director, System Development & Engineering	Kansas City KCATA
Jeffrey Knueppel	Assistant GM, Engineering, Maintenance & Construction	Philadelphia SEPTA
John Lewis	Deputy Chief Operating Officer	Boston MBTA
Denise Longley	DEO, Strategic Development, Facilities & Operations	Los Angeles MTA
Gregg Marrama	Department Manager, Capital Programs	San Francisco BART
Charlie Passanisi	Deputy Director, Capital Budget	Boston MBTA
Barbara Reese	Deputy Secretary of Transportation	Virginia DOT
Carter R. Rohan	Senior Director, Transportation Planning & Development	San Francisco MTA
James Zingale	Deputy Director	Charlotte CATS

Current Conditions of the Nation's Transit Infrastructure
FTA State of Good Repair Workshop

OVERVIEW

Despite ongoing reinvestment, much of the nation's capital assets continue to deteriorate, and current capital reinvestment rates appear insufficient to reverse the decline. Decaying transit capital assets raise concerns for service reliability and rider safety. FTA and its state and local funding partners have a mutual interest in understanding the extent of the problem and the ability of existing funding resources to address the issue. This paper considers the current condition and capital reinvestment needs of the nation's bus and rail transit capital assets:

- What is the current physical and service condition of the nation's transit assets and how do these conditions compare to an "ideal state of good repair"?
- What is the current investment backlog and what level of investment would be required to attain a state of good repair?
- How are unmet reinvestment needs affecting service quality and maintenance needs?

To explore these questions, this paper reviews industry sources including local agency capital plans, industry studies, and FTA's own analyses. The issues considered here are central to the workshop objectives of defining, measuring and addressing the nation's transit state of good repair needs.

BACKGROUND

Developing a clear understanding of the overall condition of the nation's transit assets – and the impact of those conditions on service performance and investment needs – is complicated by the scarcity of reliable and consistent information sources. As a means of describing overall needs, this paper will rely on the following two sources:

- Federal Analyses – including FTA analyses as published in the biennial Condition and Performance Report to Congress
- Local Agency Reports – including Capital Improvement Programs (CIPs) and 10- and 20-year plans

This discussion makes it clear that a significant proportion of the nation's transit assets are past their useful life. In addition, current expenditures on capital reinvestment are insufficient to address this backlog, and may not be sufficient to maintain current conditions.

Moreover, this review observes that a complete understanding of national transit asset conditions is hampered by the scarcity of reliable data sources and the broad range of assumptions used by local agencies in assessing their own needs (including differences in useful lives, and rehabilitation and preventive maintenance practices). Together, these factors suggest the need to develop better, more reliable national-level information sources and, where appropriate, to better define industry standards for useful life and preventive maintenance.

ASSESSMENT OF NATIONAL CONDITIONS

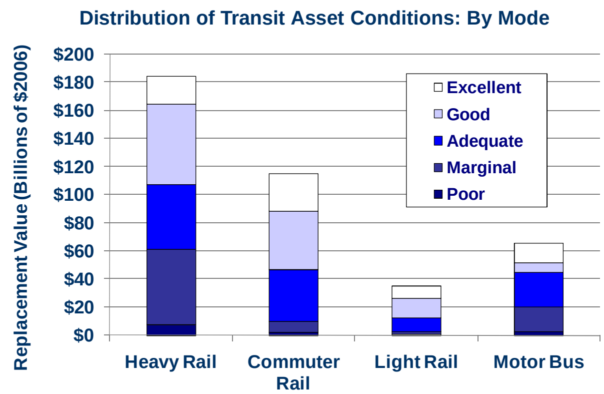
Every two years, the FTA and Federal Highway Administration (FHWA) jointly issue a report to the U.S. Congress on the Condition and Performance of the nation's surface transportation capital assets (known as the "C&P Report"). The C&P Report provides a comprehensive assessment of the physical condition and reinvestment needs for all public transportation capital assets nationwide. For transit assets, this assessment is developed based on output from FTA's Transit Economic Requirements Model (TERM), a federal-level needs assessment decision support tool. In turn, TERM relies on data reported to FTA through the National Transit Database (NTD) and also through special asset inventory data requests to large rail and bus operators.

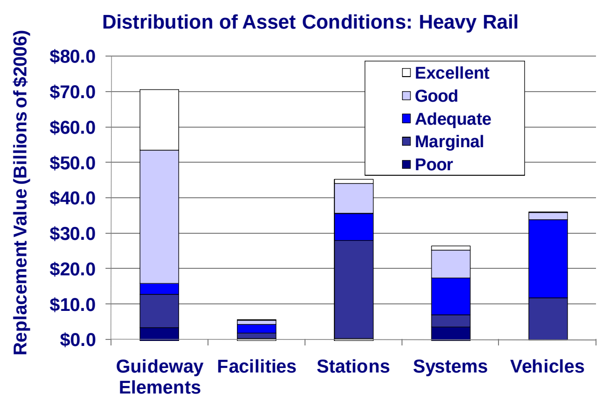
Asset Conditions: FTA's TERM model uses a detailed asset inventory along with a set of empirically derived asset decay curves and a detailed listing of the nation's transit assets to estimate the current physical condition of the nation's bus and rail transit capital assets[2]. The charts below provide TERM's current assessment (as of 2006) of the distribution of transit asset conditions nationwide: the first based on mode and the second by asset type (for heavy rail and bus only). The table below outlines the asset condition ratings used by TERM.

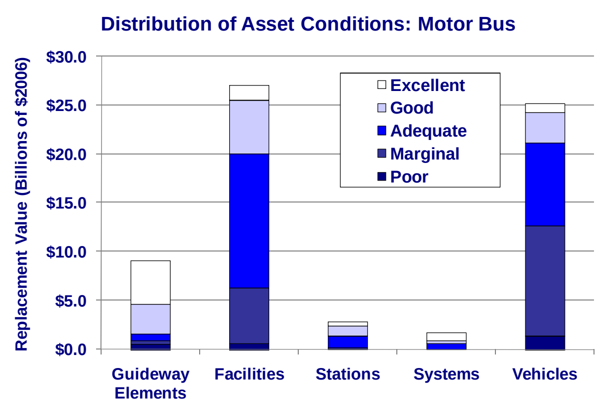
TERM Condition Ratings

Condition	Description
Excellent	New or like new asset; no visible defects
Good	Asset showing minimal signs of wear; some (slightly) defective or deteriorated component(s)
Adequate	Asset has reached its mid-life; some moderately defective or deteriorated component(s)
Marginal	Asset reaching or just past its useful life; increasing number of deteriorated components
Poor	Asset past its useful life; in need of replacement; may have critically damaged component(s)

Based on TERM's assessment, a significant proportion (up to one-third) of heavy rail and motor bus assets have either exceeded or are close to the end of their useful lives. The proportion of assets in these condition groupings is lower for light and commuter rail, but this should not be too surprising given the level of new investment in light rail and the expansion of commuter rail systems over the past two decades.



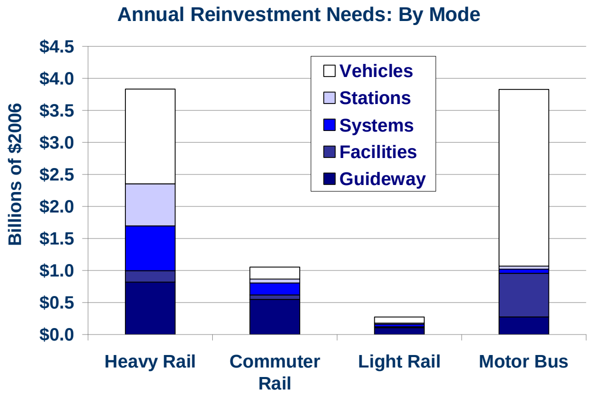




Within heavy rail, TERM has identified stations (primarily subway stations) and vehicles as the asset types with the greatest proportion of assets near or past their expected useful life. Similarly, for bus the

[2] The data used to develop TERM's asset decay curves were obtained from on-site inspections of hundreds of bus and rail transit vehicles, maintenance facilities, stations, and train control, traction power and communications systems at over fifty different rail and bus agencies. Data for the trackwork and structures decay curves were obtained from select local agency condition assessments.

maintenance facilities and revenue vehicles have the greatest proportion of assets in the lowest condition.



Reinvestment Needs: In addition to assessing current conditions, TERM also generates estimates of average annual investment needs for the next twenty year period as required to attain a "state of good repair".[3] These needs estimates (by mode and asset type) are presented in the chart above. As should be expected from the preceding condition assessment discussion, the estimated needs are greatest for heavy rail and motor bus and within these two modes, needs are highest for vehicles. After vehicles, annual reinvestment needs are highest, and roughly equal for heavy rail stations, systems and guideway components (track and structures) and for bus maintenance facilities. Estimated total needs to attain a state of good repair for these three modes (but excluding paratransit, ferry, van pool and other modes) is roughly $9.0 billion annually from all sources for the next twenty years.[4] When all transit modes are included, the average annual needs estimate increases to $10.7 billion from all sources. Both amounts exceed the roughly $8.6 billion in annual capital reinvestment expenditures from all sources observed in 2006.

[3] For this TERM analysis, a "state of good repair" is defined as having replaced all assets exceeding their useful life over the twenty-year period covered by the model analysis.

[4] All investment needs identified by TERM are required to pass TERM's benefit-cost test before being included in the model's tally of national investment needs (as required by OMB). Hence, the numbers reported here only include the needs for those investments that pass this benefit-cost test.

r AGENCY ASSESSMENTS

While most transit operators regularly develop Capital Improvement Plans (CIPs) to determine how existing capital funding will be spent, relatively few publish estimates of unconstrained needs and fewer still conduct comprehensive assessments of current conditions. Nevertheless, most agency practices are consistent in their emphasis on facilities, signals, and stations, and their conclusion that infrastructure needs exceed available funds.

Asset Conditions: The table on the following page presents agency estimates of the proportion of assets exceeding their useful life based on analyses at New York City Transit (NYCT) and the Massachusetts Bay Transportation Authority (MBTA).[5] The table also presents TERM's estimates of overage vehicles for comparison purposes for the entire country. With a few minor exceptions, the proportions of assets estimated to exceed their useful lives is roughly comparable for these two mature rail agencies and for the industry as a whole (based on TERM's estimates). Based on this limited sample analysis, the data suggest that stations and rail signal systems have the largest proportion of assets exceeding their useful life (the latter driven in part by technological obsolescence). Rail yards and shops also appear to have a relatively high proportion of overage assets. The significant difference between the TERM estimates of the share of overage revenue vehicles and the agency shares likely represents differences in assumed useful life – TERM assumes the FTA *minimum* while agencies generally assume a longer *expected* life (e.g., the FTA minimums are 12 years for 40-foot buses and 25 years for rail vehicles; MBTA assumes 15 years for buses and 35 years for rail vehicles).

[5] The data presented here were derived from NYCT's *Twenty Year Needs Assessment 2005-2024* and MBTA's *State of Good Repair Report: 2006 Edition*.

Percent of Assets Exceeding Their Useful Life

Asset Type	NYCT (2005)	MBTA (2006)	TERM (2006)
Guideway Elements			
Structures	10%	15%	5%
Trackwork	0%	0%	5%-10%
Facilities			
Bus	10%	10%	20%
Rail (Yards & Shops)	20%	20%	15%
Systems			
Signals	25%	30%	30%
Power	10%	10%	5%
Communications	0%	40%	20%
Elevators/ Escalators	0%	25%	15%
Stations	55%	30%	20%
Revenue Vehicles	> 5%	> 5%	25%

Reinvestment Needs: The table at right presents agency estimates of the level of annual capital investment as required to address outstanding capital reinvestment needs for a sample of rail transit operators, including the Bay Area Rapid Transit (BART), the Chicago Transit Authority (CTA), NYCT and MBTA.[6] The table also shows the assumed time period to address the outstanding needs, which varies significantly across operators, as well as each agency's expected (or recent) funding levels and the gap between expected funding and unconstrained needs. Finally, the table also presents TERM's national level estimates.

It is clear that unconstrained needs (i.e., the level of expenditures required to address both deferred investments and normal replacements) over various time periods is *less* than expected funding levels. This finding implies that the condition of the nation's transit assets is likely to decline in the absence of new funding capacity.

[6] The data presented here were derived from BART's *FY08 Short Range Transit Plan and Capital Improvement Program*, CTA's *2007 Unfunded Capital Needs*, NYCT's *Twenty Year Needs Assessment 2005-2024* and MBTA's *State of Good Repair Report: 2006 Edition*.

Annual Unconstrained Needs* vs. Expected Funding* ($Millions)

Agency	Average Annual Needs	Time Period (yrs)	Expected Annual Funding	Gap
BART	$386	25	$151	$235
CTA	$1,536	5	$376	$1,160
MBTA	$620	20	$470	$150
NYCT	$2,406	20	$2,162	$244

* Excludes expansion investments

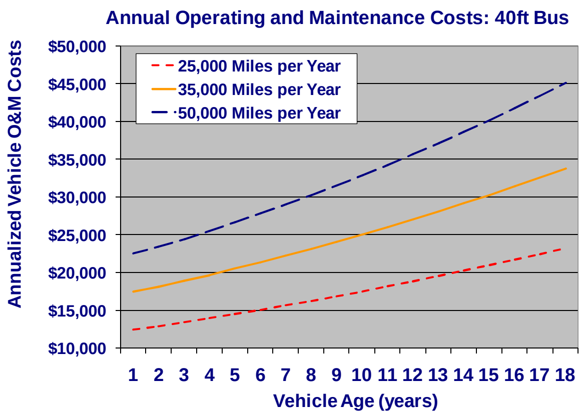
IMPACT ON PERFORMANCE

The analysis referenced has considered the current condition of the nation's transit assets and estimates of the level of investment required to address both outstanding and normal replacement needs. The question remains, then, as to how current transit conditions are impacting service performance (e.g., service reliability, mean time/distance between failures, track operating speeds)? Similarly, how would attaining a state of good repair improve service performance and/or reduce operating and maintenance costs? This section considers the known relationships between transit conditions and each of the following:

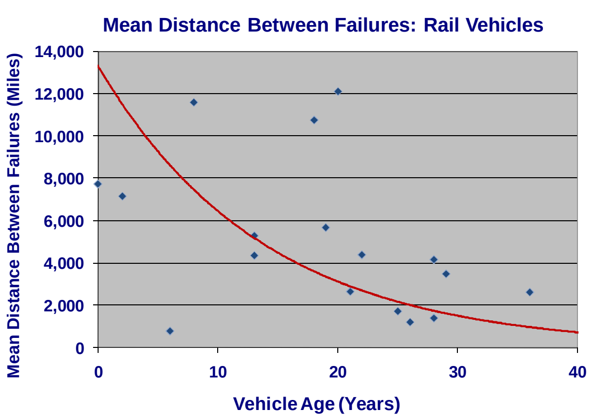
- Maintenance costs
- Service disruptions
- Slow speed zones
- Other service quality measures

Given limitations in data and the existing research, this discussion focuses primarily (but not exclusively) on vehicle conditions and performance, with the understanding that similar issues are encountered with most other asset types. Moreover, the discussion below only serves to help emphasize the relationships between condition and performance; it does not assess current performance or quantify the expected improvement to performance from a significant reinvestment program.

Operating and Maintenance Costs: Older assets – including vehicles, roadbeds and facilities – tend to experience increasing maintenance needs and hence increasing costs as compared to newer assets. It should be expected then that aging transit fleets and other infrastructure implies increasing maintenance and repair costs, and both agency reports and cost research supports this position. As an example, consider the chart below showing the expected increase in bus operating and maintenance (O&M) costs as total life-to-date miles on the vehicle increases.



Service Disruptions: Similarly, older assets are less reliable, with the probability of failure increasing with asset age and asset wear. While this is again most easily demonstrated with fleet vehicles (see chart on in-service failures vs. rail vehicle age below), this observation also applies to other asset types as well, including train control systems, trackwork, and electrification systems.



Slow Speed Zones: Slow zones occur where trains are required to reduce their speed due to poor structural, power, signal, or track conditions. To the extent that poor conditions can become more prevalent as assets age (more so for track and structures), slow zones are likely to be both more numerous and require greater speed reductions with an aging asset base.

Service Quality Measures: Finally, the impact of asset physical conditions on performance can also be assessed using a variety of service quality measures including the percent of assets in proper working order (e.g., fleet vehicles, fare gates, escalators, etc.), on time performance, and the number of customer complaints relating to asset conditions/ deterioration.

ASSESSMENT LIMITATIONS

The ability of local agencies and FTA to assess the current asset conditions and reinvestment needs of the transit industry is hampered by a variety of factors. These include the following:

At the Local Level:

- Few agencies perform detailed condition assessments on a regular basis;
- Most agencies do not maintain comprehensive asset inventories (for the purpose of asset condition monitoring and replacement needs assessments);
- Most agencies do not conduct unconstrained long-term state of good repair needs estimates on a regular basis.

At the Federal Level:

- Absence of a national asset condition or inventory reporting requirement;
- Absence of a standardized condition reporting system;
- Assumptions regarding asset useful lives and the time period to address the investment backlog vary widely across agencies.

OBSERVATIONS FROM SGR WORKSHOP

The SGR Workshop yielded a number of observations and valuable perspectives with respect to the current condition of the nation's transit assets and the level of investment required to address unmet needs. Following are several key study observations:

Current National Estimates: Some workshop participants expressed the concern that the current estimates produced by FTA's TERM model may be low, and discussed at length the importance of a consistent definition of SGR needs. In particular, participants were concerned that the tool may not fully account for "betterments," "improvements" or mandated requirements (e.g., ADA) that occur whenever assets are replaced, or additional costs to replace assets supporting active operations (note: many TERM replacements are made "in-kind"). FTA has already initiated work programs to better capture these betterment and improvement cost increments in future versions of the model.

Needs versus Funding: Representatives of two of the older rail agencies participating in the workshop cited internal estimates that their SGR needs outpace expenditures by a ratio of 2:1. Participants also noted that some operating expenses (e.g., lease payments) are actually SGR related investments. Hence, strict comparisons of available reinvestment needs and funding available for reinvestment activities may not account for these types of expenditures.

Deferred Investments: Most participants agreed that maintenance facilities, bridges, signals, and station amenities tended to be the asset types with the largest deferred investment needs (these are generally considered lower priority assets, assuming there are no safety issues resulting from their deferral).

Rehabilitation/Replacement Costs: Participants noted that rehabilitation and replacement costs used for needs estimation must fully capture all cost factors including:

- Installation under no, partial or full service;
- Agency force account and/or contracted labor;
- Soft costs, including design and project management;
- Inflation rates appropriate to the types of materials and labor being utilized;
- Required materials or technology improvements.

Technological Obsolescence: Reinvestment activities are sometimes driven by the need for technological improvements as much as by replacement of worn assets.

ISSUES REMAINING

Following are additional questions for the industry to address with respect to the current conditions of the nation's transit assets and overall state of good repair:

- Is the assessment of needs and conditions presented above reasonably accurate? For example, are asset conditions poorest and investment needs most significant for bus and heavy rail? Within these two modes, are the highest reinvestment needs for stations and vehicles (heavy rail) and vehicles and maintenance facilities (bus)?
- What are the biggest investment needs in terms of investment dollars (i.e., where are the largest deferred needs) by mode and asset type?
- How are local agencies addressing their reinvestment needs given the gap between needs and available funding?
- Where are the most significant sources of potential risk to local agencies if current outstanding needs are not addressed (e.g., in terms of safety, potential for extended service disruptions, or other risks)? Is there a specific asset type most associated with risk?

- How would attaining full SGR impact national transit performance in terms of: throughput, reliability, operating speed, maintenance costs and overall quality of service?
- How significant is the gap between available resources and local agency state of good repair needs? Do local agencies have reliable estimates of the size of that gap?

Defining and Measuring State of Good Repair
FTA State of Good Repair Workshop

OVERVIEW

What exactly is meant by a "state of good repair"? In the absence of a clear and widely-shared definition and reliable measures of SGR, pursuing a state of good repair can be challenging. Without such a definition, local agency decision-makers will struggle to 1) establish an operational policy of attaining SGR, 2) determine what it will take to reach that objective, and 3) determine when (or if) that goal has been attained. Therefore, this paper considers (but does not fully answer) the following questions:

- How should the transit industry define SGR?
- How can SGR (or movement towards or away from SGR) best be measured?
- Should the concept of SGR be based entirely on asset physical condition or should issues of technological obsolescence or desired service performance be embedded in the concept?

DEFINING STATE OF GOOD REPAIR

Before being able to *measure* SGR it is first necessary to *define* what SGR means. The table at right presents several definitions of "state of good repair" as applied by a sample of U.S. transit operators. These definitions include a mix of concepts – including specific reinvestment guidelines (when should specific asset types be replaced?), asset performance standards investment (ensuring assets are functioning at their "ideal capacity") and investments that address deferred needs. Despite their differences, these definitions are essentially a variation on the basic theme that assets are in a "state of good repair" when all life cycle investment needs have been addressed – including preventive maintenance, rehabilitations and scheduled replacement needs – resulting in the general absence of deferred investment needs. While this characterization of SGR represents a notional ideal (it is impossible to maintain this ideal state as scheduled rehabilitation and replacement activities arise continuously), it does provide an objective (if unattainable) investment target and a standard against which current conditions can be measured.

Transit Agency Definitions of State of Good Repair (SGR)

Agency	*Definition*
CTA	CTA defines SGR primarily in terms of standards: • Rail lines should be free of slow zones and have reliable signals. • Buses should be rehabbed at 6 years and replaced at 12 years. • Rail cars should be rehabbed at quarter- and half-life intervals and replaced at 25 years. • Maintenance facilities should be replaced at 40 years (70 years if rehabbed).
Cleveland RTA	State of good repair projects are those needed to bring the system to a consistent, high quality condition system-wide.
MBTA	A state of good repair standard [is where] all capital assets are functioning at their ideal capacity within their design life.
NJT	"State of Good Repair" is achieved when the infrastructure components are replaced on a schedule consistent with their life expectancy.
NYCT	Investments that address deteriorated conditions and make up for past disinvestment
SEPTA	An asset or system is in a state of good repair when no backlog of needs exists and no component is beyond its useful life. State of good repair projects correct past deferred maintenance, or replace capital assets that have exceeded their useful life.

For the purposes of discussion, this paper suggests the following *operational* definition of SGR based on the definitions considered above as a starting point for the dialogue:

> *An asset or system is in a state of good repair when no backlog of capital needs*

exists – hence all asset life cycle investment needs (e.g., preventive maintenance and rehabilitation) have been addressed and no capital asset exceeds its useful life.

This definition is "operational" since it is possible to continuously evaluate the size of the investment backlog – the total value of all deferred life cycle investments – an amount that reflects the difference between an ideal state of good repair and the current condition of an agency's existing assets.

Making SGR "Operational": To make this definition operational, agencies must first define the timing of asset life cycle events (i.e., at what ages are assets rehabbed and replaced). These decisions are important as the selected rehab and replacement policies will directly impact both total investment needs (shorter replacement cycles are generally more costly) as well as what physical conditions are

Sample Useful Life Assumptions

Asset Category	CTA	MBTA	NYCT
Structures	100-year life	Subway: 100 yrs Bridges: 50-70 yrs	Subway: 100 yrs Elevated: 50 yrs
Trackwork	As needed	25-year life	Ballasted: 35 yrs Subway DF: 65 yrs Elevated: 25 yrs
Facilities	40-year life; 70 with renovation	75-year life; Mid-life rehab /minor renovations	75-year life; Mid-life rehab/ minor renovations
Signals	50 yrs	25 yrs	50 yrs
Substations	40 yrs	30 yrs	40 yrs
Cable		15 years	50 years
Stations (buildings)	40-year rehab cycle	50-year life; mid-life overhaul	35-year rehab cycle
Rail Vehicles	25-year life; Mid/quarter-life overhauls	35-year life; Mid-life overhaul	40-year life; Mid-life overhaul
Bus Vehicles	12-year life; Mid-life overhaul	15-year life; Mid-life overhaul	12-year life; Mid-life overhaul

considered "acceptable". As the table demonstrates, there are no common industry standards for asset useful lives.

Related Investment Concepts: Before moving on to the topic of SGR measurement, it may be helpful to contrast the concept of SGR with other investment concepts as a means of better defining what SGR is and is not. Consider the following:

- Normal Replacement (NR) - Projects that replace assets at the end of their normal useful life based on the age and according to a scheduled program of replacement *as needed to maintain a state of good repair*. (In contrast to SGR investments, which move an agency *towards* a state of good repair, normal replacements help *maintain* a state of good repair).

- System Improvement (SI) - Projects to improve existing assets or operations (e.g., technology or materials upgrades, capacity improvements). SGR and NR investments frequently include an SI component as assets are rarely replaced entirely "in kind".

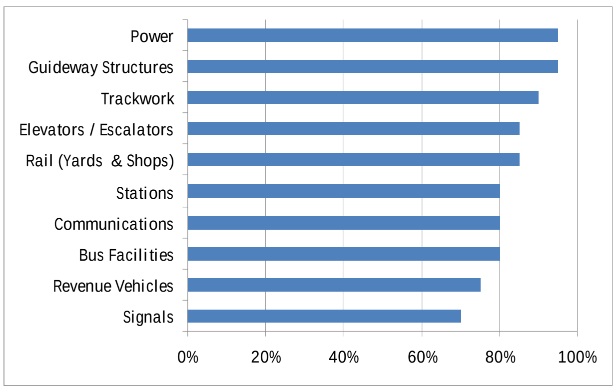
MEASURING STATE OF GOOD REPAIR

This section considers four different measures of state of good repair based on the definition of SGR developed above. Each of the following is considered:

- Percent of assets in SGR
- Percent of service life remaining
- Asset condition ratings
- Asset specific condition measures

Percent of Assets in SGR: Percent of assets in a state of good repair is the simplest and easiest to understand measure of state of good repair. In practice this percentage measure can be based either on (i) the proportion of assets (by count or value) that do not exceed their expected useful life or (ii) based on engineering assessments of the proportion of assets that are in "good working order". The chart below presents an example of this measure, showing the proportion of U.S. transit assets, by type, that are less than their expected useful life. The chart is based on asset data from the Federal Transit Administrations' (FTA) Transit Economic Requirements Model (TERM).

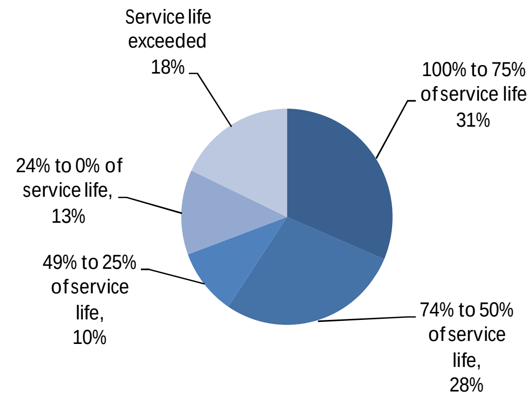
Percent of U.S. Transit Assets in SGR (Estimate)



While easy to develop and easy to explain to decision-makers, percent of assets in SGR provides no information on the condition of assets currently in SGR. For example, are most assets in excellent shape or will a significant proportion of assets currently in SGR require rehabilitation or replacement in the near future? Percent of assets in SGR cannot shed light on these questions.

Percent of Service Life Remaining: Distributions of percent of service life remaining show the proportions of transit assets at different stages during their service life cycle based on their expected useful life. In the example below, track work assets from a sample of U.S. rail operators are segmented into quarter life groupings (for trackwork within its useful life) and an additional grouping for trackwork that has exceeded its expected service life. This presentation provides more information on the overall condition of an asset grouping, as compared to the percent of assets in SGR example presented above. This measure can be applied to any grouping of agency assets, ranging from the age distribution for a specific subsystem (e.g., rail switches) to age distribution of all agency assets system-wide.

Percent of Trackwork by Service Life Remaining (1/4 Lives)



Note that infrastructure managers in other industries often report only the proportion of assets that currently exceed their useful life. This is sometimes called a "facilities condition index" and equal to the following:

$$\text{Facilities Condition Index} = \frac{\text{Value of Assets Exceeding Useful Life}}{\text{Value of all Assets}}$$

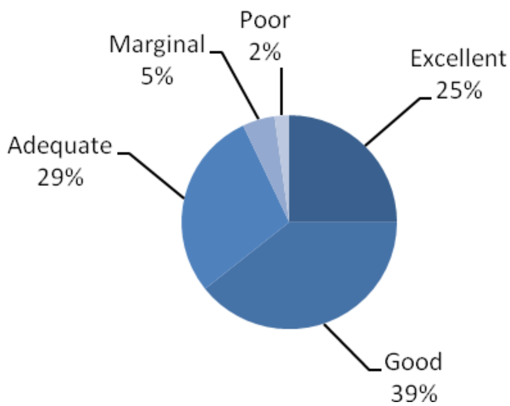
This measure has also been used to establish a desired SGR *target* within some industries (e.g., no more than 2% of assets exceed their useful life). Note that the percent of assets that currently exceed their useful life is the exact opposite of the proportion of assets in SGR measure.

Asset Condition Ratings: While the percent of service life age distributions presented above provides a good understanding of the proportions of assets in varying conditions, the practice of using quarter-life age groupings is arbitrary. Specifically, these age groupings may not provide a good representation of the differing phases of asset conditions an asset will experience throughout the full life cycle. To address this issue, many transit agencies, state DOTs and engineering firms utilize four- or five-point condition rating scales to assess the condition of capital assets. An example of this approach is the five-level condition scale used by FTA's Transit Economic Requirements Model (TERM), which was adapted from a detailed engineering condition assessment performed by the Chicago Transit Authority in the early 1990s. This condition scale and a condition distribution chart for U.S. light rail operators based on this scale follow.

TERM Condition Ratings

Condition	Description
Excellent	New or like new asset; no visible defects
Good	Asset showing minimal signs of wear; some (slightly) defective or deteriorated components
Adequate	Asset has reached its mid-life; some moderately defective or deteriorated components
Marginal	Asset reaching or just past its useful life; increasing number of deteriorated components
Poor	Asset past its useful life; in need of replacement; may have critically damaged components

Condition Distribution of U.S. Light Rail Assets (TERM)



A key value of condition rating systems is that all assets, regardless of type, can be rated using the same condition ratings. This facilitates both comparisons of conditions across asset types (e.g., between vehicles and trackwork) and also allows the agency to represent asset conditions for any grouping of assets – including the agency as a whole (or a whole mode, as provided in the pie chart above).

Asset-Specific Condition Measures: Finally, agencies can also develop and utilize SGR measures that are specific to individual asset types. For example, most rail agencies maintain records of rail conditions as obtained from track geometry car readings. Other examples include pavement roughness indexes (for busway lanes), mean time between failure rates for vehicles, and vehicle ride quality indices. While these measures are extremely valuable in monitoring the needs of the specific asset types they address, they are of less value than the measures considered above when assessing an agency's overall state of good repair.

Summary: SGR Measure Strengths and Weaknesses

Measure	*Strengths*	*Weaknesses*
Percent of assets in SGR	• Easy to implement • Easy to understand	• Poor understanding of full distribution of asset conditions
Percent of service life remaining	• Easy to implement • Easy to understand	• ¼-life age groupings may not reflect meaningful differences in conditions or needs
Asset condition ratings	• Can be applied across any grouping of assets	• User must understand the rating system
Asset specific condition measures	• Good understanding of the condition/ needs of specific assets	• Measures not comparable across multiple types

r STATE OF GOOD PERFORMANCE

Finally, this paper has discussed the issue of state of good repair almost entirely in terms of re-investment in existing assets with deferred needs. There has been little discussion of whether these investments involve improvements or betterments to these existing assets beyond their original capabilities (i.e., the discussion has focused on replacement "in-kind" and not "betterments"). This raises the question of whether the concept of state of good repair should be based entirely on asset physical condition considerations (for existing assets) or the extent to which the concept should also include consideration of overall system performance. Phrased differently, is the objective of SGR to ensure effective rehabilitation and replacement of existing assets, or is it to maintain a “state of good performance”?

OBSERVATIONS FROM SGR WORKSHOP

Most of the participating agencies have already established an internal definition of SGR. With minor variations, these agencies typically defined SGR as a state where all assets are functioning normally (reliably) and within their useful life. The group discussed the advantages and disadvantages to measuring SGR using *condition*, *age*, or *performance*, and generally agreed that condition was best, age was second-best, and performance should probably not be used. The measurement may depend on the financial context or intended audience:

Condition is the ideal measure of SGR, as it incorporates the on-site evaluations of trained engineering experts. On-site condition assessments also take into account the current performance and expected future remaining life based on the specific environment within which an individual asset is operating (i.e., the characteristics of which can significantly impact asset life expectancy).

Age (Useful Life) is a “second-best” measure of condition as it does not incorporate other (non-age) factors that can drive asset deterioration (e.g., utilization, maintenance history and operating environment). The use of age as a measure of condition makes the implied assumption that a (single) industry standard useful life is correct and appropriate for all situations. On the other hand, age data are more easily collected than condition data and hence age makes an easy proxy for use in long-term planning exercises.

Performance-Based measures of SGR – such as mean times between failures – provide valuable information but in reality are only indirect measures of the underlying state of repair or asset conditions.

Although the group did not reach consensus on whether *obsolescence* should be included in the definition of SGR, participants agreed that the cost of upgrading assets to modern standards should be included in their replacement cost.

ISSUES REMAINING

Following are additional questions for the industry to address with respect to the definition and measurement of the state of good repair:

- Should the industry develop a common definition of “state of good repair”?
- Are agencies developing clear life expectancy targets for all major transit asset types (e.g., trackwork, structures, stations, bus and rail vehicles, systems and facilities)?
- Are there specific measures of SGR the industry should adopt?
- What specific measures are in use by U.S. agencies? Are they age, value or condition based?
- Are agencies conducting asset condition assessments? When conducted, are these assessments periodic or regularly scheduled events?
- Would the transit industry benefit from development of a standardized set of useful life values for major transit asset types?

Transit Asset Management
FTA State of Good Repair Workshop

OVERVIEW

The term "asset management" has become widespread in discussions of how best to address the needs of aging transportation rolling stock and infrastructure. Unfortunately, the term has also taken on broadly different meanings for different user groups. This paper aims to help establish a working definition of "asset management" for transit – based primarily on the experience of other industries and transportation modes – and then to consider asset management's potential role and limitations in addressing the issue of state of good repair:

- What is asset management?
- What are the benefits of asset management?
- How do other transportation modes, industries or countries define and practice asset management?
- How is the transit industry applying asset management?
- How can asset management help address state of good repair needs?

This paper shows how asset management practices can help agencies make better-informed investment decisions – primarily in the areas of reinvestment planning and prioritization – and can help justify requests for increased funding. The U.S. transit industry is beginning to make positive advances in the application of asset management principles, but it generally lags the domestic highways industry and much of the international transportation community, where the application of asset management concepts is more advanced and the "state of the art" more mature.

BACKGROUND: WHAT IS ASSET MANAGEMENT?

The concept of "asset management" has different meanings to different users. For many in the U.S. transit community, it is synonymous with maintenance management or preventive maintenance activities (e.g., day-to-day "shop floor" activities), while for others it may imply outsourcing of operating and maintenance functions, potentially through a public private partnership. This paper suggests the following, much broader definition of Transportation Asset Management (TAM):

> *"Transportation Asset Management is a strategic and systematic process of operating, maintaining, improving and expanding physical assets effectively throughout their life cycle. It focuses on business and engineering practices for resource allocation and utilization, with the objective of better decision-making based upon quality information and well defined objectives."*

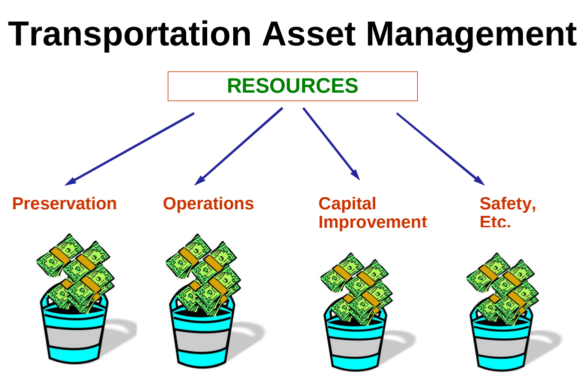
This is the definition of asset management currently applied by the U.S. highways industry, including most State DOTs, the American Association of State Highway Transportation Officials (AASHTO) and the Federal Highway Administration (FHWA). This definition is also consistent with how asset management is being defined and applied by transportation agencies in the UK, Canada, Australia, and New Zealand. Based on this definition, asset management is:

- *Strategic* and not *tactical* (i.e., has a long-term focus)
- Seeks to *balance the competing needs* of operations, maintenance, reinvestment and

system expansion; it is not focused on maintenance or reinvestment alone

- An *organization-wide endeavor*: It seeks to integrate planning, engineering, funding, and IT perspectives
- Seeks to make *informed* and *prioritized* decisions regarding the use of *scarce resources* based on *reliable data* in support of *clear organizational objectives*

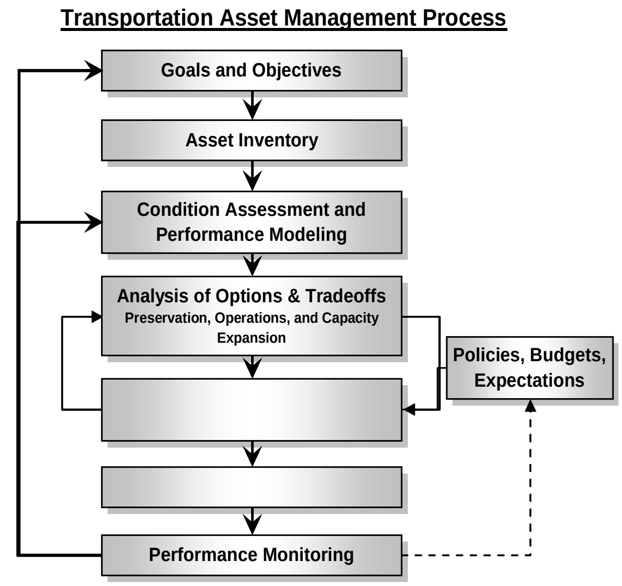
As a means of contrasting this definition with more "traditional" practices, practitioners note that asset management seeks to allocate resources based on merit (i.e., highest investment return) and not based on a simple, "worst first" prioritization. While many agencies have implicitly invested based on merit, asset management is designed to make these processes explicit and well-defined.



Finally, this definition, and the practices it represents, has important implications for attaining and maintaining a state of good repair. Specifically, attaining a state of good repair necessarily involves tradeoffs with other agency investment objectives, including operations, capital expansion and safety. Moreover, the state of good repair objective must also consider tradeoffs between individual asset types (e.g., when to invest in trackwork vs. maintenance facilities). Again, a key goal of asset management is to make informed investment decisions when allocating resources between these investment options.

COMPONENTS OF ASSET MANAGEMENT

A comprehensive asset management program consists of a mix of agency objectives, data sources, measurement and evaluation processes and decision support tools. A typical representation of these components and their interaction is provided in the flow chart below.



Of these components, the following are most relevant to the objective of attaining and maintaining a state of good repair:

- Goals and Objectives: Is attainment of a state of good repair an organizational objective? If so, has "state of good repair" been clearly defined?
- Asset Inventory: Does your agency possess a comprehensive and current listing of all major fixed assets, documenting asset types, condition, remaining useful life and value? This is not a fixed asset ledger for accounting purposes, but an asset-based inventory for needs assessment purposes.
- Condition Assessment Process: Does your agency regularly (or periodically) assess the

physical condition/remaining useful life of all inventory assets?

- Decision Support Tools (model): Does your agency have a decision support tool with which to analyze state of good repair needs or investment scenarios over an extended time horizon (e.g., 20 years)? These tools process the asset inventory and physical condition data to assess unconstrained needs and to help prioritize investments.
- Options and Tradeoff Analysis: Does your agency have a process to evaluate the investment tradeoffs and investment returns of alternate investment options? One that considers the competing needs between different asset types (within preservation) and between preservation and other needs (e.g., expansion, safety)?
- Decision Making: What information sources and analyses do decision-makers rely on to allocate resources between competing uses? Asset management driven organizations utilize information garnered from the preceding steps.
- Measurement: How do you measure "state of good repair" and your progress in attaining that goal? Does this measurement provide a clear target that can be defined as a "state of good repair"? Do you have incremental targets (toward that goal) for consecutive three-to-five-year periods?[7]

Importantly, each of these components is linked together in a comprehensive asset management program, and relies on the joint participation of various agency functions including engineering, budget, planning, IT and senior decision-makers. Moreover, many state DOTs are investing heavily in Enterprise Resource Planning (ERP) systems and data warehouses to combine data from multiple agency sources into a centralized repository to facilitate both analysis and decision-making.

CURRENT TRANSIT INDUSTRY PRACTICES

While most U.S. transit agencies have adopted some of the asset management components identified above, relatively few have initiated more comprehensive programs. The following is a very rough assessment of asset management as practiced by U.S. transit operators:

Maintenance Management Systems: Most U.S. transit agencies utilize a maintenance management system (e.g., MAXIMO) to track and schedule maintenance activities for transit assets. While they are designed for all asset types, most agencies only enter asset inventory data for their revenue vehicle fleets, repair equipment and maintenance facility components. Few agencies use these systems for other asset types such as stations, traction power and train control systems, or trackwork.

Traditional Capital Reinvestment Planning: Transit agencies' engineering staff typically estimate capital reinvestment needs. Specifically, the engineering staff representing various categories of assets (e.g., track, structures, facilities, vehicles) develop their own, independent assessments of the reinvestment needs for the assets they represent. These needs are then consolidated across asset types and prioritized (subject to funding constraints) based on further input received from the engineers, the goals of the organization (which may be implicit or explicit) and the judgment of decision-makers. This process is consistent with the asset management process described above as any comprehensive assessment of investment needs is impossible without input from agency engineers. At the same time, this process represents only a component of the full asset management process as it may lack an objective process for prioritizing needs (e.g., based on generalized condition measures) and may only reflect

[7] Note: Transportation agencies taking advantage of the "modified" accounting approach under GASB-34 are required to have an asset inventory, a condition measurement system and clear condition attainment targets. As of 2002, nearly half of all state DOTs were using the modified GASB-34 method.

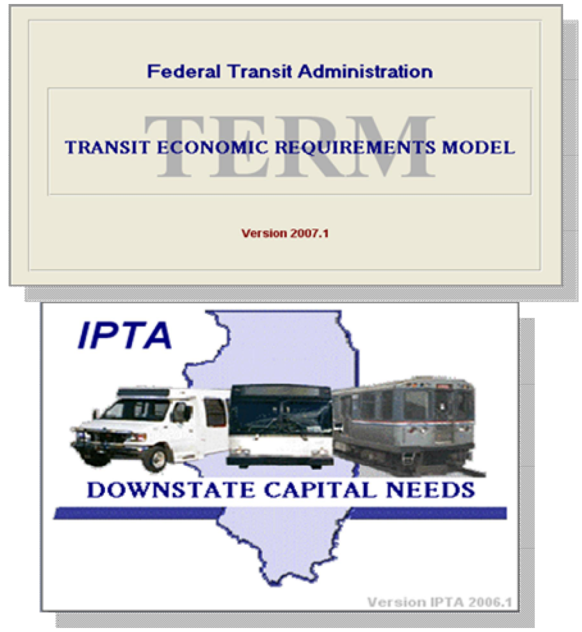
short- to medium-term "tactical" needs (asset management is intended to have a long-term, strategic focus).

Condition Assessments (periodic): Some major rail agencies have begun to conduct periodic (e.g., every five-to-ten years) system-wide condition assessments of all fixed assets. Such assessments can be thought of as independent "studies," typically performed by outside contractors, and are used more as "snapshots" of current conditions than an ongoing planning process. These assessments are a valuable input to the "traditional" capital reinvestment planning process described above.

Condition Assessments (continuous): In contrast, other agencies assess their asset conditions on a regular schedule, and to use this information within the context of an ongoing, long-term capital planning process. Agency engineering staff, not contractors, usually perform these ongoing assessments. Given their continuous nature, the condition data provide a basis for assessing changes in asset conditions over time and allow the agency to measure progress against their SGR goals.

Decision Support Tools: Decision support tools are analytical processes and/or models used to estimate capital needs and model alternative investment scenarios over an extended time horizon. These tools can be used to help prioritize specific investments, or to assess the impact of alternate funding level scenarios (e.g., how long will it take to attain a state of good repair under different funding levels?). A key value of these tools is their ability to generate an objective analysis of agency needs across an extended time horizon. Decision support tools are complements, not substitutes, for needs assessments by engineering staff; engineering needs analyses should be a key input to the decision support tool.

Examples of Transit Decision Support Tools



While decision support tools are not widely used by transit operators, several agencies have developed such tools with successful results and some have used these tools to justify increased funding requests from local and state funding agencies. Examples include MBTA's State of Good Repair Model, Chicago RTA's Capital Asset Model, Illinois DOT's Downstate Transit Capital Needs Model, and FTA's Transit Economic Requirements Model (TERM).

Asset Inventory: Most components of transit asset management described here depend on the availability of a current and comprehensive inventory of an agency's major transit assets. This asset inventory should be organized around the assets' engineering and capital characteristics, separate and distinct from a fixed asset ledger used for accounting purposes. Inventory data can be collected as part of ongoing or periodic condition assessments and can also be useful in analyzing that data on a systematic basis (e.g., for coordinated project planning). At this point, relatively few U.S. transit agencies actively maintain a comprehensive asset inventory for the purpose of asset management.

Tradeoff Analysis: While most U.S. transit operators actively consider the expected impacts of differing investment scenarios, few have developed either a clear set of prioritization objectives or a well-defined prioritization process. From an asset management perspective, a well-defined and *objective* prioritization process is required to ensure that scarce capital dollars are directed towards those investments that do the most to support the agency's overall goals and objectives (e.g., maximize service reliability, safety and/or quality of service). In practice, these can consist of point-based ranking systems, well-defined internal review processes (with representation from engineering, planning, capital budgeting staff and senior management), or combinations of similar approaches. This is in contrast to more traditional agency approaches where engineering staff representing different asset classes (e.g., facilities, maintenance-of-way, vehicles, or structures) develop independent needs assessments for the asset groups they represent and then effectively compete for access to a limited pot of funding. Once again, the objective of asset management is to replace the implicit and potentially subjective investment prioritization of this more traditional process with a well-defined and objective prioritization process designed to directly support overall organizational objectives. Within the transit industry, these processes can be and have been supported by decision support tools that facilitate the analysis of the service and state of good repair implications of alternative prioritization ranking schemes.

Linking IT Systems: Many state DOTs are currently working to link various asset inventory, condition assessment, maintenance management, accounting system and related databases to create information warehouses to support asset management, sometimes called Enterprise Resource Planning (ERP) systems. The objective is to co-locate all data relevant to the asset management processes to facilitate analysis of current conditions and future needs. Few if any transit agencies have attempted to link multiple data sources for the purpose of asset management. A natural starting point to do so would be to combine data from asset inventories, condition assessments, maintenance management systems, track geometry readings, slow track zones, and perhaps the fixed asset ledger.

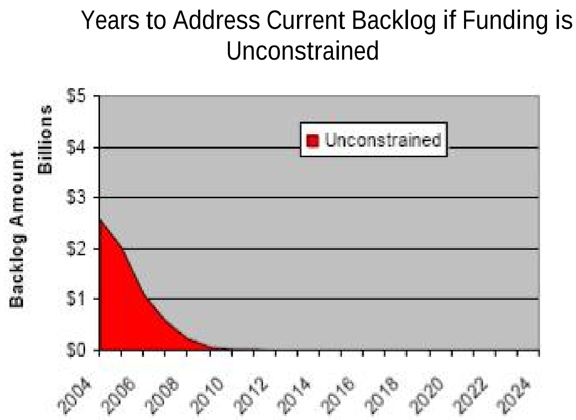
WHAT CAN AGENCIES LEARN FROM ASSET MANAGEMENT?

Effective asset management provides decision-makers with reliable information on:

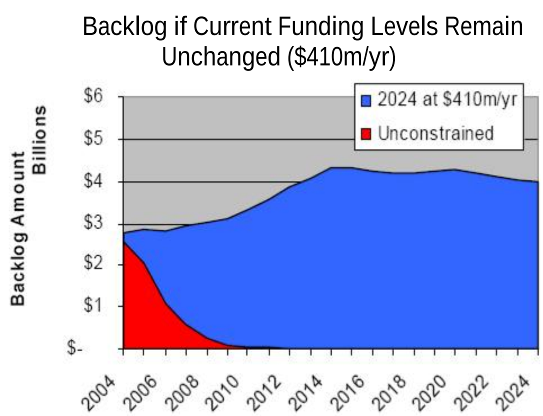
- Current asset conditions;
- The investment required to maintain or improve those conditions (e.g., to a state of good repair); and
- How variations in funding will impact an agency's ability to address investment needs over various time horizons.

Asset management also helps decision-makers prioritize investment needs such that the highest return investments are addressed first (e.g., those with the highest benefits to the largest number of transit riders). The following is a good example of how asset management systems provide valuable information to decision-makers. Below are four charts displaying output from a transit agency asset management decision support tool. Specifically, these four charts demonstrate how variations in funding availability will impact that agency's total investment backlog. Following are descriptions of each chart:

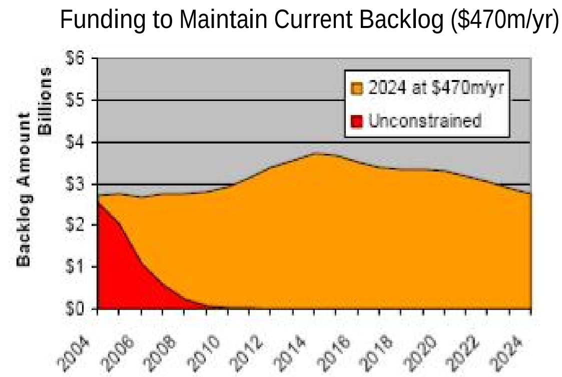
- Years to Address Current Backlog (Unconstrained): this chart presents the magnitude of the current backlog, and the years to address the backlog assuming funding is unconstrained.



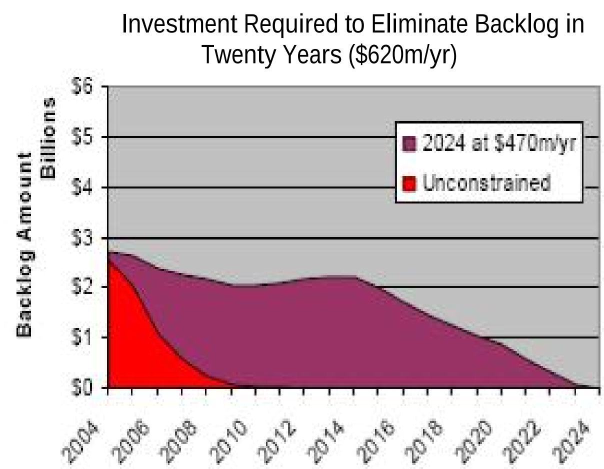
- Maintain Current Funding Levels – what happens to the size of the backlog if funding remains at current levels? For this agency, the backlog is expected to grow if funding remains unchanged. Note that the rate of growth in the backlog is *predictable* as is its expected impact on conditions and performance – all valuable information to agency decision-makers.



- Maintain Current Conditions – what level of investment is required to *maintain* current asset conditions? This assumes that the status quo is a desirable investment target (which is not the case if the agency is at less than a state of good repair). This chart presents variations in the backlog over time assuming sufficient funding such that the backlog in twenty years is the same as it is today.



- Eliminate Backlog in Twenty Years – what annual investment is required to fully address the current backlog and attain a complete state of good repair in twenty years? Armed with this type of information, decision-makers can approach funding partners with specific details on investment targets and the time and resources required to attain each target.



LIMITATIONS OF ASSET MANAGEMENT

While effective asset management provides a powerful tool for improving the quality of capital investment decisions, it is not intended (nor is it capable of) addressing all agency needs. Specifically, total asset management is most effective in ensuring that limited funds (for rehabilitation/replacement, expansion, operations, safety and other uses) are channeled towards their most effective uses – with funding allocation decisions based on sound information and well-defined and objective decision-making processes. Hence, asset management can very much help agencies make more effective use of existing agency resources.

It is not, however, designed to expand the amount of available resources (e.g., operating and investment funds). With that in mind, it should be noted that good quality asset management practices arm the agency with superior information to help justify the reasoning behind their funding requests as well as the ability to demonstrate how additional funds can lead directly to improvements in service quality, reliability and safety. Given this information, funding agencies are more likely to consider reallocating existing funds or developing new funding capacity in response to this improved understanding (this has been the case for several state DOTs).

r OBSERVATIONS FROM SGR WORKSHOP

The SGR Workshop yielded a number of observations and valuable perspectives with respect to both the application and the effectiveness of asset management processes. Following are several key observations.

Data – Asset Inventories: Many of the nation's larger transit agencies now possess asset inventories developed specifically for the purpose of capital planning and other asset management activities. Those agencies that have collected and maintained such asset inventories have benefited from a clearer understanding of both their current asset conditions and their *long-term* capital reinvestment needs. At the same time, most agencies rarely used direct analysis of their asset inventories to make precise, financially-constrained funding decisions for their *short-term* capital programs.

It was also recognized that FTA would benefit from a reporting process on the age and condition of the nation's inventory of transit assets, again for the purpose of more accurate needs assessments and funding analysis at the national level.

Investment Prioritization: The participants observed that most agencies tend to favor reinvestment in some asset types versus others. For example, "mission critical" asset types like vehicle fleets tend to receive the highest priority whereas "less critical" assets such as maintenance facilities and station amenities tend to receive lower prioritization. Note, however, that few agencies employed ordinal ranking processes or other methods to prioritize their capital reinvestment needs. Rather, most reinvestment activities continue to be prioritized based on a meeting and negotiation process between agency departments. Many agencies do not prioritize their investments between expansion, rehabilitation and other uses. Rather, they continue to utilize the same historical funding allocations between these uses from one year to the next. Participants also noted that *short-term* investment prioritization depends on the logical phasing and scoping of related capital projects (e.g., reinvestment activities within a given rail segment), since this is how an asset management plan becomes actionable projects.

Decision Support Tools: Relatively few participants noted the use of decision support tools as a means of assessing and prioritizing long-term SGR needs, but all expressed interest in learning more about the development, use, benefits and limitations of such tools. Those that do use such tools found them effective in answering "what-if" questions regarding the impact of varying funding levels on current and future asset conditions and service quality. These participants also reported using their needs assessments and decision support tools to justify and advocate for a shift in available funds from expansion to SGR uses, or to reprioritize funds to assets with the highest reinvestment benefits.

ISSUES REMAINING

Following are some additional questions for the industry to address with respect to asset management techniques and the attainment of a state of good repair:

- How are transit agencies currently defining the term “asset management”? Are their working definitions based on short- or long-term objectives? Are they focused on strategic or just tactical issues?
- How many U.S. agencies have implemented asset management programs? What do these programs consist of?
- How many agencies conduct either periodic or continuous condition assessments (if so, which and how often)?
- How many agencies actively maintain an asset inventory in support of asset management practices (i.e., distinct from their fixed asset ledger)?
- How many agencies use decision support tools to support their capital planning processes and decision-making?
- How are agencies determining how capital reinvestment funds will be allocated between various asset types/uses? Who participates in making these decisions and what processes do they use?
- How many agencies have specific capital investment objectives (e.g., to attain a state of good repair by 2015)?

Standards for Preventive Maintenance

FTA State of Good Repair Workshop

OVERVIEW

The current economic climate has had a significant impact on many companies and organizations in both the public and private sectors throughout the country. Transit systems are not immune to these impacts. The increases in the cost of petroleum-based fuels have contributed to unprecedented ridership increases on many of our nation's transit systems over the course of the past year. However, these unexpected increases in fuel costs have also strained the budgets of the transit systems. In addition, the downturn in consumer spending has reduced the sales tax revenues that many transit systems rely on as an essential component of their budgets. Our nation's transit systems are faced with attempting to satisfy this increased demand with fewer resources.

This economic climate is prompting everyone, including public transit agencies, to rethink current practices and business methods, and it is prompting public transit agencies to strive for productivity improvements and efficiency gains to be better, faster, and cheaper.

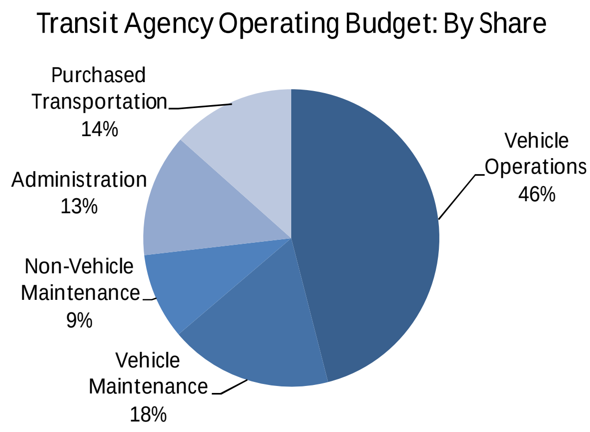
The paper will review maintenance and preventive maintenance (PM) practices from the following perspectives:

- What proportion of agency resources are devoted to maintenance activities?
- What options do agencies have to make more productive use of these resources?
- How can better preventive maintenance practices reduce other maintenance needs as well as other agency costs?
- Should the industry adopt standardized requirements for preventive maintenance?
- How do PM practices impact asset conditions and state of good repair needs?

BACKGROUND

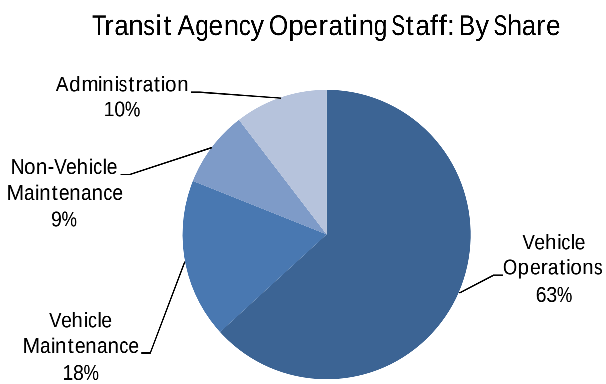
Transit agencies typically devote a large proportion of their resources to preventive maintenance, which also makes PM activities a frequent target for cost reduction exercises. This paper argues that rather than increasing or decreasing PM expenditures, a better approach is to find ways to improve the productivity of these resources, most notably by applying better planned preventive maintenance activities.

Maintenance department budgets are typically the second largest component of the total operating costs of a transit system (see chart below based on National Transit Database data over the period 1995 through 2006). Over the past decade, roughly 18 percent of agencies' operating budget resources have been devoted to vehicle maintenance and an additional 9 percent to non-vehicle maintenance activities – for a total of 27 percent, or more than one-quarter of the operating budget devoted to maintenance costs (excluding maintenance costs for purchased transportation).



Number of maintenance department employees is also typically second only to vehicle operations (see chart below, again derived from NTD data over the period 1995 to 2006). Here again, the same proportions of agency operations (as distinct from capital) resources have been devoted to the maintenance of both vehicle and non-vehicle assets over the decade.

Finally, not including fuel, materials and supply costs represent 11.3%[8] of a transit agency's budget. Note that all of these statistics have remained relatively consistent for the past decade.



The nature of public transit agency operations requires that transit agencies continually strive to do more with less. Tight operating budgets force transit agencies to continually look closely at productivity improvements without compromising safety and quality. In order to have a meaningful impact on reducing expenses, without cutting service, transit agencies frequently look to realizing greater efficiencies in maintenance. The maintenance budget, therefore, is a frequent target for cost reductions.

The question remains then as to how increases or decreases to maintenance budgets and resources can be expected to impact the reliability, safety and overall quality of transit services. Moreover, as discussed below, reduced resource availability for maintenance activities – in particular those relating to preventive maintenance – can result in cost increases for other agency activities, including unscheduled maintenance, operating costs (e.g., fuel consumption) and even capital costs (e.g., in the form of reduced asset life expectancy).

APPROACHES

There are important similarities among infrastructure intensive industries. The airlines, trucking, utilities, etc., industries all share something in common: critical extensive assets that must be maintained in a state of good repair. Maintenance productivity concepts, in varying forms, have always been around. Early on, to realize savings and greater efficiencies these industries were compelled to set time standards for repetitive maintenance tasks, preventive maintenance programs, and repair functions. Repair times and written procedures for maintenance tasks were established and provided as productivity improvement tools.

Maintenance activities can be classified in two general categories: scheduled or unscheduled.

- Scheduled maintenance consists of planned activities including Preventive Maintenance inspections, planned component repair or replacement, driver defect cards, and other planned inspections.
- Unscheduled maintenance activities result from breakdowns caused by component failures and from defects found during scheduled inspections. Although unscheduled maintenance can never be eliminated, its frequency and duration can be controlled.

Moving maintenance into the scheduled category gives managers greater control and improves the structure of their operations. The key to reducing unscheduled maintenance activities is having good data and using it to make decisions. Reducing unscheduled maintenance can save money. Replacing components *before* they fail reduces the incidences of unscheduled maintenance; however,

[8] 2006 National Transit Database

component life must be optimized to reduce costs. Replacing components at failure increases the frequency of unplanned maintenance.

Maintenance Management Systems: The advent of computerized maintenance record-keeping facilitated data collection, analysis, and information dissemination, and supported faster problem solving. More reliable data provided the tools to better balance costs and performance. Computerized maintenance and materials management systems were first developed and deployed in the private sector. Gradually these programs were modified and adapted to the transit industry. Some were adapted or developed specifically for transit agencies. Early adaptors were the Chicago Transit Authority, and Southern California Regional Transit District. Typically the early software systems were work order systems, limited and designed primarily to collect data. They were generally not used to manage maintenance activities.

Since the 1980s and 1990s, when these systems were first installed, a second generation of computerized maintenance and materials management systems have been installed at many transit agencies around the country. These systems have extensive functionality and have been employed to realize efficiencies and reduce costs without a corresponding increase in unscheduled maintenance. Successful examples of where data is being used to better plan maintenance activities, include: UPS and Ryder, where they are using information to schedule all aspects of the maintenance operation. During a recent FTA-funded educational tour of Europe, it was found that Berlin Transit (BVG) has relied on a computerized maintenance and materials management system for 9 years to meet its maintenance tracking needs. The system enables BVG to capture the life cycle cost, reliability, availability, and safety information about vehicles and related transit equipment. Its capabilities for failure analysis help BVG identify potential problems before they arise. The system provides BVG personnel mean time and distance-between-failures data that support this effort. Metropolitan Transit Authority (MTA) New York City Transit has successfully utilized a computerized maintenance and materials management system to increase mean distance between failures of its subway cars to approximately 150,000 miles.

PREVENTIVE MAINTENANCE STANDARDS

Should the transit industry adopt common PM standards and, if so, who should develop these standards, on what basis, and should there be incentives for agencies to adopt these common standards?

At present, all U.S. transit providers have basic or core PM programs for revenue vehicle fleets as well as for most other major asset types[9]. Examples of the parameters for these basic programs include:

- Vehicles: Periodic inspections and maintenance activities based on mileage.
- Building Components and Systems: Periodic maintenance based on either manufacturer recommended or agency developed PM programs.

It is important to note, however, that these activities are far from standardized. Hence both the (1) length between (or frequency of) these inspection periods and (2) the types of scheduled PM inspection and maintenance activities performed during each PM cycle can and do vary widely between transit agencies. For example, it is certainly the case that some agencies perform their PM activities with relatively low frequency but conduct a relatively high number of maintenance activities for each cycle, while others conduct their PM activities more frequently but include lower maintenance activities within each cycle.

A good example here is PM inspection programs for forty-foot buses (with forty-foot buses being by far the

[9] Note that FTA requires grantees to have established PM programs for assets purchased using Federal funds. However, this requirement says little about the specifics of the PM program, only that the program must be in place.

most common and, perhaps, best understood type of transit asset and hence best positioned for PM standardization). Over the period 1999 to 2002, the Federal Transit Administration (FTA) collected data on the vehicle inspection and PM programs of a sample of forty-three U.S. transit bus operators as part of a bus condition assessment program. This analysis documented a wide range of vehicle PM inspection frequencies for standard forty-foot transit buses – ranging from every 2,000 to 8,000 miles (with every 6,000 miles being the most common). As expected, the thoroughness of the inspections and related preventive maintenance activities also varied widely (with the thoroughness of these activities not well correlated to the frequency of the inspections). Interestingly, there was no observed relationship between the physical condition of the vehicles and the frequency of vehicle inspections. A similar study of rail transit vehicles yielded similar results.

Based on this research, it is clear that PM frequencies and activities are far from standardized across the nation's transit operators (at least for vehicle fleets). The question remains then as to whether PM practices *should* be standardized. Here again, FTA's condition research for bus and rail assets provides a helpful perspective. These condition assessments documented how differences in the service and environmental characteristics of individual transit operators impacted their assets' physical conditions, life expectancy and maintenance needs. Specifically, these maintenance needs and asset conditions were related to each of the following factors:

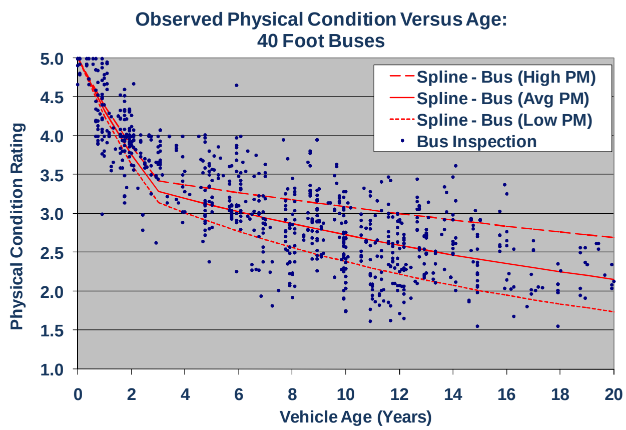
- Ridership levels
- Annual hours and miles of service (e.g., per vehicle)
- Climate/environment (e.g., presence of salt)
- Make and Model

The analysis suggested that operators with higher ridership, higher asset utilization (e.g., annual miles per vehicle) or more severe climates should expect that more frequent or more comprehensive preventive maintenance activities may be required to ensure their assets are maintained in good working order. Similarly, there are also variations in the reliability of differing pieces of transit equipment of the same type – yielding yet another variable to identification of an optimal PM program. Together, these considerations suggest that it may not be possible or sensible to apply standardized, "one size fits all" PM programs to assets of the same type but of differing quality and applied in widely different operating environments.

PREVENTIVE MAINTENANCE AND STATE OF GOOD REPAIR

What, then, are the relationships between preventive maintenance and state of good repair (SGR)? A primary consideration here is whether the concept of preventive maintenance should be included within the definition of "state of good repair." Specifically, can an asset or transit system be in a state of good repair if its preventive maintenance requirements are not met? The position taken here is that a comprehensive PM program is a necessary condition to ensure that SGR is maintained but that occasional or temporary postponement of some PM activities does not imply that a system (or asset) is not in a state of good repair.

A second consideration here is the impact of differences in the comprehensiveness of preventive maintenance programs on asset conditions, asset life expectancy and, by extension, state of good repair. In other words, do more comprehensive programs effectively yield better asset conditions and longer asset life? Here again, FTA's asset condition research provides a valuable perspective. Specifically, this research considered how differences in preventive maintenance practices impacted asset physical condition (see chart below for 40-foot transit buses). This analysis demonstrated fairly effectively that transit assets (again primarily vehicles) subject to higher levels of preventive maintenance tend to be of higher physical condition at all asset ages (implying longer asset life) as compared to similar assets subject to less comprehensive PM programs. These results suggest that more comprehensive research, covering a broader variety of asset types, would be of value in developing more effective PM programs across all transit asset types.



OBSERVATIONS FROM SGR WORKSHOP

Participants at the SGR Workshop largely agreed that a comprehensive PM program can increase assets' reliability and condition, and extend assets' useful lives, which helps contribute generally to a state of good repair. However, the group did not reach a consensus on whether SGR needs assessments should include the costs of PM.

Workshop participants also felt the industry should not set national standards for PM, given that PM practices (and PM needs) vary widely from agency to agency. Specifically, both PM and SGR replacement activities can and do depend on the following factors:

- Operating environment/asset utilization
- Prior asset maintenance history
- Quality of manufacture

Proper use of a maintenance management system can be a crucial step to enable PM to help SGR. However, some participants reported difficulty getting maintenance staff to incorporate such systems into daily practices. On the management side, some agencies have not yet managed to utilize the data collected by these systems to conduct analyses of the effectiveness of PM practices in minimizing corrective maintenance needs and in improving overall quality of service.

Most agencies at the workshop felt they could achieve economies of scale in vehicle maintenance if FTA rules permitted them to extend fleet procurement contracts over multiple years (allowing larger purchase orders with options). A single vehicle fleet would generally reduce parts inventories and lower design, procurement, and maintenance costs.

ISSUES REMAINING

Following are additional questions for the industry to address with respect to preventive maintenance practices and the attainment of state of good repair:

- Are transit agencies managing to conduct the right (or optimal?) levels of preventive maintenance?
- Is it realistic to expect transit agencies to significantly increase planned maintenance activities and reduce unplanned maintenance?
  - How can it be accomplished?
  - What are some of the potential obstacles?
- In addition to more effective use of available tools, what else can be done to reduce the incidents of unplanned maintenance?
- How close are the ties between preventive maintenance and SGR?
  - Should PM be included in the definition of SGR?
  - How do PM expenditures/practices impact asset conditions and SGR needs?
- How can FTA help the transit operators improve maintenance and reduce costs?

Core Capacity of a Transit System
FTA State of Good Repair Workshop

OVERVIEW

Rising public transportation ridership coupled with expanding transit networks across the country are putting pressure on the core capacity of many mass transit systems. As new fixed guideway transit systems are constructed and existing systems lengthened, many U.S. transit agencies are reaching the upper limits of their infrastructure to accommodate more passengers at chokepoints and core areas.

The core capacity of a transit system represents the maximum number of passengers or trips that can be accommodated without having to widen or build additional guideway or route infrastructure. Since most transit systems tend to have concentrated areas of destinations (such as central business districts or transfer points), the core capacity of the system may be constrained at a level below the maximum capacity of individual components or segments (such as outlying branches). Similarly, since transit trips are not evenly distributed throughout the day, the core capacity will be reached during periods of peak usage. Because of the difficulty of funding the very high cost of new guideway or route infrastructure, and the time required to implement such expansion, it is necessary to first explore all options for maximizing the core capacity of the system.

DETERMINING CORE CAPACITY

The following presents the issues and elements that should be considered to maximize the core capacity of a transit system without widening or building new guideway. For convenience these elements can be grouped under the following categories:

- Network Strategies
- Line Capacity
- Vehicle Capacity
- Station Capacity
- Support Capacity
- Other Strategies

It should be noted that these categories, and the individual elements included in each, are not necessarily independent variables but may be closely related and have complementary or counteracting impacts on capacity.

NETWORK STRATEGIES

On systems with multiple routes and feeder services, network strategies consider changes in the configuration or operation of the system to make use of available capacity. These strategies are discussed here.

- Feeder Bus Modifications: Restructuring of feeder bus routes to direct flows to alternative lines or stations which have additional capacity to absorb demand.
- Service Improvements on Alternate Lines: Where another line has excess capacity and the potential to serve as an alternative route for persons who are using a line experiencing congestion and approaching core capacity, increased frequency or other service improvements on the alternative route could induce some riders to switch to the less congested line.
- Line Connections: On multiple-line systems that intersect, consider building guideway connections to reroute some services over less congested parts of the system and to provide greater flexibility in working around disruptions.
- Vehicle Consolidation: On multiple-line systems that converge on a trunk, consider merging and coupling single vehicles such as light rail cars into trains, or lengthening trains to

the maximum that can be accommodated, to reduce the number of movements on the trunk where capacity is constrained and the service is at minimum headways. This may require some investment in infrastructure, such as sidings, at the convergence location to accommodate the coupling procedure without interfering with main line movements and capacity.

- System Schedule Coordination: On multiple-line systems that converge as ultimate train capacity on the trunk is approached, timing of arrivals becomes critical to using every schedule slot without delays to other trains. A missed schedule slot wastes capacity and causes cascading delays. Consider upgrades to the network control system to coordinate and adjust train movements to optimize arrivals on the trunk portion of the system.

LINE CAPACITY

Line capacity refers to the maximum number of vehicles or trains per hour, or other unit of time, but not necessarily the number of passengers that a line can accommodate. The capacity in terms of passengers per hour is also impacted by vehicle seating and standing capacity and station platform length available to access vehicle doors, which are discussed separately below.

- Train Control: The minimum spacing of trains for safe operation is governed by the signal/train control system. In less sophisticated systems it is governed primarily by maximum line speeds and train braking distances, which in turn govern signal locations and block lengths. Automatic train control can eliminate variables in driver response and performance, allowing schedules to be built with less contingency for driver reaction. Communications-based train control, based on the actual distance between trains taking into account their actual speeds and distances with fixed blocks, can further increase capacity.
- Line Speeds: A line may have physical characteristics such as degree of curvature that require trains to slow or run at less than optimum route speed at particular locations. Reducing curvature, increasing banking (superelevation), or reconfiguring turnouts, can allow trains to run at higher speeds

STATION DWELL

Station dwell times are often the controlling element in limiting the number of trains that a line can accommodate per hour and are affected by numerous factors. Minimizing station dwell should be a key goal in maximizing line capacity. There are several factors to be considered.

- Configuration of Routes at a Junction: Systems with lines that converge at flat junctions can improve capacity by constructing flyovers to eliminate conflicts between opposing movements.
- Train Acceleration and Braking: Acceleration and braking are important to capacity, particularly as they help to reduce the impacts of station dwell times by allowing trains to move into and out of stations quickly.
- Terminal Reversing Procedures: At locations where trains must reverse at a terminal station, there are potential improvements to reduce or eliminate capacity constraints.

VEHICLE CAPACITY

Several options may be considered to increase the passenger carrying capacity of trains. Each of these may have an impact on station capacity, which will need to be taken into consideration as discussed under stations below.

- Longer Trains: Increasing the length of trains can add to core passenger carrying capacity.

- Higher Capacity Cars: Several strategies exist to increase the capacity of vehicles. Some of these, such as favoring more standee room over seats, need to be carefully considered against the grantee's standards of comfort and the service quality goals of the system.

STATION CAPACITY

Station capacity will impact, or be impacted by, many of the other core capacity elements discussed above. Any changes that increase the density of passengers using the station, particularly platform volumes, will have to take into consideration the basic design parameters for the station, including passenger flow, ingress and egress, emergency evacuation requirements, fare collection, and HVAC loadings. Aside from basic life safety and code requirements, the primary core capacity issue with stations is dwell time to offload arriving passengers and board departing passengers, which quite often is the controlling limitation on core line capacity.

- Vehicle Design Impacts on Capacity: Systems using a step-up platform can reduce dwell time by converting to level boarding platforms, which may require new vehicles. Systems that must accommodate boarding and alighting at street level can adopt low-flow designs that match curb height platforms for level boarding. Additional or double-width doors and revised seating/standing interior arrangements can improve the flow of boarding and alighting and reduce dwell time.
- Platform Crowding and Circulation: Any strategies that increase the frequency of trains or passenger capacity of trains can increase the density of passengers on the platforms, with potential crowding and restrictions on flow, thus increasing dwell times.
- Modification of Station Tracks and Platforms: Major modification of tracks or platforms at stations can be costly and disruptive, but where feasible they can reduce or eliminate dwell time constraints on core capacity at critical stations.
- Station Access: To effectively make use of the maximum core passenger carrying capacity of the system an equivalent number of passengers must be able to access the system. Depending on the nature of the immediate station area as well as its catchment area, access capacity enhancements to consider include feeder bus schedules, parking, pedestrian/bicycle access, and traffic controls.

SUPPORT CAPACITY

Some capacity enhancements may require improvements or modifications to support infrastructure.

- Traction Power Systems: The capacity of the traction power system to accommodate longer trains and shorter headways either alone or in combination must be considered.
- Shops and Yards: Longer or more frequent trains will increase fleet demands on shops and storage yards.

OTHER STRATEGIES

Because the usage of a transit system is not evenly distributed throughout the day or by location across the system, core capacity is typically reached during peak periods of demand or at choke points and locations of maximum loading on the system. Techniques to redistribute the demand, or the growth in demand, by time of day or by location of excess capacity, while not directly under the control of the transit operator, should be explored as a matter of public policy to maximize the capacity of the system for moving people.

- Staggered Work Hours: Policies of staggering the start and finish times of workplaces can reduce peak demand and make more use of excess capacity on the shoulders of the peak hours.

- Congestion Pricing: Charging higher fares during periods of peak congestion can shift demand, particularly non-time-critical trips, to periods of excess capacity. The ability to do this will depend on the method of fare collection, and on some systems this may require a major investment in upgrading or replacing the fare collection system.
- Redirected Development: Land use and zoning policies could encourage additional development at locations where the increased transit demand should occur. This would require origin and destination demand modeling of the network to determine the impact of the redirected growth in demand on other parts of the system that may be at or near core capacity.

OBSERVATIONS FROM SGR WORKSHOP

The SGR Workshop yielded a number of observations and valuable perspectives with respect to core capacity needs and the issue of state of good repair.

Core Capacity Needs: Workshop participants generally acknowledged that their rail and bus systems have significant unmet core capacity needs, with the level of need depending on local/regional circumstances. The size of the vehicle fleet, the capacity of the traction power system, and the condition and capacity of signal systems were frequently cited as the primary infrastructure constraints to expanding system throughput. All observers expressed the need to balance their SGR reinvestment needs with the need to accommodate ongoing ridership growth (with the later need exacerbated by the recent increase in fuel prices and consequent increase in transit ridership).

Core Capacity and SGR: At the same time, because capacity-constrained systems also have SGR reinvestment needs, many agencies reported that their existing SGR reinvestment plans also include some (often minor) core capacity improvement elements. For example, the aging signal and traction power systems are typically replaced with new technology equipment capable of supporting higher passenger throughput. As noted in other sessions, few asset replacements are made on an "in-kind" basis. Rather, asset replacement typically involves replacement with assets of larger size, newer technologies and better materials that support higher throughput, improved service quality, and sometimes greater core capacity.

Increased Funding Flexibility: The participants' reactions to the question of whether agencies would benefit from more flexible Federal funding (e.g., more flexible between SGR and capacity improvement uses) was mixed. Some participants felt that increased flexibility would permit better resource allocation towards the highest priority needs. However, others expressed concern that this change may result in a loss of SGR funding for agencies that receive their Federal funding through a regional reallocation process (i.e., where federal funds do not flow directly to the final recipient agencies).

Limited Funding Availability: As with SGR needs, workshop participants cited a lack of sufficient funding as the largest obstacle to meeting core capacity investment needs. Once again, this limited funding and significant needs for both core capacity and SGR investments have resulted in the need for agencies to prioritize between these two investment types. However, few agencies cited make use of a clear, objective process (e.g., benefit-cost comparisons) to prioritize between these differing investment types.

ISSUES REMAINING

Following are additional questions for the industry to consider with respect to core capacity needs and their relation to the attainment of state of good repair:

- Is it useful to determine the difference between meeting increased demand and state of good repair? What are the ramifications of treating them differently?

- How should Federal funding be provided to maximize existing infrastructure capacity?
- How do systems balance/prioritize these core capacity issues with other recapitalization issues?
- How can capital investment in core capacity enhancements be balanced with maintenance of the system?

Alternative Approaches to Financing
FTA State of Good Repair Workshop

r OVERVIEW

Recent estimates place the amount of capital investment needed to overcome deferred maintenance and replacement backlogs at the Nation's largest transit rail systems at more than $35 billion. With the recent decline in highway vehicle miles traveled (VMT) due to higher gas prices, gas tax revenues have decreased, as has the balance in the Nation's Highway Trust Fund. This will make it difficult for the Federal government to continue to provide a significant share of the needed funds. The same problem exists at State and local government levels. Alternative financing sources will be needed to fill the gap where there are shortfalls in funding. Continuing to defer maintenance and replacement of substandard assets is not an option as the cost to our economy and standard of living of not maintaining transit services is unacceptable. Our urban quality of life depends on reliable transit.

In 2006 total public transit agency expenditures for capital investment were $13 billion, of which 44% were funded by the Federal government. The remaining funds came from State and local sources, including operating revenues. These are substantial resources, but finding funds to address capital investment backlogs, much less provide for new capacity, is increasingly difficult. This paper explores some alternative approaches to leveraging public funding with resources from private sector investors.

r PUBLIC PRIVATE PARTNERSHIPS

The Federal Transit Administration is following the lead of other infrastructure agencies in promoting the use of public-private partnership (PPP) arrangements. These partnerships can be set up in many ways. There seems to be no standard model, as each partnership must be tailor-made to suit local conditions and requirements. PPPs are already fairly common for highway projects, and we are starting to see PPPs in the transit industry as well. FTA has initiated a program to teach transit managers, investors, and its staff about the advantages of this type of financing. FTA has also initiated a pilot program to gain experience with incorporating this type of financing into its New Starts Program procedures.

There is an industry-wide need for developing expertise in this type of contracting. FTA seeks input from transit providers and investors on best practices to emulate and on barriers that still need to be overcome.

Although PPPs are not widely used in the U.S. for transit projects, the industry can learn from the experience of transit operators in Europe and Australia, where PPPs have been common for some time. This experience has identified two potential advantages for PPPs: reduced direct public costs due to the use of private capital, and reduced public indirect costs due to expedited project delivery.

Just like public sector debt financing, private financing may be more expensive than the traditional "pay as you go" method of funding. For example, the BART Oakland Airport Connector project will include costs related to private sector financing of the project. This will add an estimated $30-to-$40 million to the cost of the concession over a 30-to-40-year term versus an approach in which the project's capital costs were entirely funded with public sector monies. However, given the scarcity of State funds, the project would not be possible without private financing, and BART has estimated that the cost for the agency to borrow directly would be similar to the cost of private financing.

Although it can take longer to negotiate PPP contracts, the contractor's financial interest in the project often expedites project delivery and quality.

The overhead costs of Minnesota Department of Transportation and Metro Transit associated with the Hiawatha Corridor light rail project were trimmed by an estimated $25-to-$38 million due to the project's completion one year earlier than expected with a design-bid-build project delivery approach.

Indirect cost savings also result from the transfer of risk of operating and maintenance cost increases to a private consortium. New Jersey Transit will pay the Hudson-Bergen Light Rail project's consortium a guaranteed price in 1996 dollars for operation and maintenance of the line, subject to increases in the consumer price index (CPI) and other inflation indices for selected operating costs, including electricity. This insulates the agency from growth in operating costs for reasons other than inflation, and provides the operating consortium incentive to keep a lid on operations and maintenance cost escalation.

One of the primary reasons the public sector is interested in using PPPs is to save time in the total development process by concurrently performing certain activities whose results are not mutually dependent, and by using resources more efficiently. PPPs can also expedite the application of advanced technology. Thus, private developers seek to "fast-track" design and construction, proceeding with certain elements of the construction work while design is still ongoing on others. They also involve the construction firm in design reviews to avoid delays associated with design defects affecting project construction. Time savings can also lower the cost of the project by avoiding large increases in material costs due to price inflation.

Delivery of many of the projects identified in FTA's December, 2007 *Report to Congress on the Costs, Benefits, and Efficiencies of Public-Private Partnerships for Fixed Guideway Capital Projects* was advanced by a year or more, in part as a result of the PPP delivery approach.

PPP CASE STUDY: LONDON UNDERGROUND

Although there are several U.S. design-build-operate-finance agreements between private investors and public transit agencies for system expansion, there have not been any similar agreements designed to bring a transit system to a state of good repair. We must look overseas for examples of how this could be implemented. A particularly relevant example is found in Great Britain, where operation of London's famous subway system was jeopardized by a decades-old maintenance backlog.

In 1998 London announced its proposal for modernizing the Underground network by means of PPP agreements to reduce the Government's financial burden in bringing the system to a state of good repair. The objective of the PPP was to optimize cost and performance over the whole lifecycle of the assets from design, construction, maintenance, and refurbishment to replacement.

The PPPs split the responsibility for delivering the Underground's services as follows:

- Public Sector - ownership of the assets remains in the public sector. The London Underground (LU) is responsible for operating trains, stations and signals, and for managing the customer interface. Ultimate responsibility for system safety lies with LU.
- Private Sector - responsible for putting the assets into service each day. Infrastructure companies (Infracos) maintain, renew and upgrade the Underground's infrastructure under 30-year contracts.

LU entered into three agreements with the following infrastructure companies for the following rail lines between December 2002 and April 2003:

- Tube Lines – Jubilee, Northern and Piccadilly
- Metronet BCV – Bakerloo, Central, Victoria, Waterloo and City
- Metronet SSL – District, Circle, Metropolitan, Hammersmith and City, East London

The contracts included the following conditions and terms:

- Performance-related incentives and penalties to remunerate the Infracos for the improvements they make to the network.
- Infracos decide what maintenance and investment projects they carry out to deliver the required performance.
- LU specifies target dates for a number of projects, such as station refurbishments, track replacement and fleet replacement.
- Infracos are paid a fee-for-service every four weeks with performance-related bonuses and abatements.
- Review of the contractual obligations and remuneration every 7.5 years carried out by the PPP Arbiter, an independent office-holder appointed by the Greater London Authority.
- Contains provisions for an Extraordinary Review where an Infraco considers that it is incurring additional costs above the level allowed for in its bid.
- Additional costs are calculated by reference to a notional Infraco operating in accordance with Good Industry practice.
- If net adverse effects in a 7.5-year review period exceed a contractual threshold, the Arbiter can direct that the payment by LU is increased.

The PPP is funded by a combination of farebox revenues, private sector capital and government grants. The Infracos each borrowed around $600 million to pay for refurbishment of the Underground. It is intended that over the first 15 years of PPP contracts, the partnership will provide infrastructure improvements of $16 billion, and up to $10 billion worth of maintenance work.

The PPP is predominantly a performance-based contract, and the Infracos are paid to deliver a required level of service and to maintain the assets in a state of good repair as follows:

Availability (reliability)

- Day-to-day service reliability, measured by recording any disruption >=2 minutes;
- Lost customer hours, measured by the length of incidents multiplied by a location and time of day factor; and
- Bonus payments at $6 an hour if better than benchmark. Abatements at $6 an hour if worse than benchmark and above unacceptable, and $9 an hour if worse than unacceptable.

Capability (capacity)

- Practical capacity of each line measured by a journey time capability score;
- Infracos can improve the score by adding capacity (more trains for service); and
- Infracos are paid for additional capability based on a capability score for each period compared to the pre-defined benchmark and unacceptable scores.

Ambience (quality)

- The quality of the traveling environment (e.g., cleanliness, ride quality, PA audibility, and levels of litter) is measured through a quarterly Mystery Shopping Survey (MSS); and
- Payment is based on the MSS score for each period compared to the pre-defined benchmark and unacceptable scores.

Condition (state of good repair)

- Infracos must maintain, renew and manage the assets so as to ensure reasonable life expectancy (defined as assets in condition A-C) no later than the third review period;
- Infracos must also achieve specified condition or residual life benchmarks by the end of the contract; and
- During the first review period (7.5 years), all grey assets (condition unknown) must be assessed.

Fault Reporting (repairs)

- Infraco must rectify all asset related faults reported by LU staff.
- Service points are allocated to certain failures if Infracos do not meet contractual obligations.

Major Projects (line upgrades)

- Major projects involving replacement of trains and signals which increase the capability to deliver improvements in trip times.

Station Refurbishment and Modernization

- Infracos must implement a program of station modernization and refurbishment as specified in the contract.
- Any project not delivered by the latest completion date will incur abatements. Abatement is levied until the project is completed and varies according to the scale of the project.

After five years of operating with the PPP, the London Transport Assembly, in its January 2007 Review, stated: “There have been some very worthwhile gains from the PPP. When we have seen the private sector at its best, the results have been impressive. They have had much better relationships with their workforce, and have been inventive and resourceful in using innovative engineering solutions to overcome challenges on the Tube network that should have been tackled decades ago.”

However, on July 18, 2007, the Metronet Infracos collapsed after a $4-billion cost overrun on their PPP contracts. The Transport Committee's report on the failure laid much of the blame for the problems surrounding the consortium of private sector companies with the UK Department for Transport, which it said should have been seen that the proposed management structure of the contracts would be incapable of efficient delivery. Thus, this PPP cannot be considered an unmitigated success. If we are willing to learn from their successes and mistakes then there is much positive knowledge we can take from this example.

The London Underground experience is intriguing in that it provides experience on how private sector investors can, or cannot, make a profit operating a public enterprise while protecting the public interest. It shows how a guaranteed public funding stream can be leveraged to provide very substantial up-front investment in infrastructure renewal and also realize the benefits of private sector management. This can be done at a cost comparable to the cost of issuing public bonds. Private sector management has the advantage of not being tied to the annual budgeting constraints that make strategic asset management difficult for public agencies.

CAPITAL LEASING

Capital leasing is a routine way of financing capital equipment in the U.S. In 1987 the Surface Transportation and Uniform Relocation Assistance Act (STURAA) started Federal support for capital leasing. This was codified into law by TEA-21 and remained unchanged in SAFETEA-LU.

Grantees may use Federal funds for capital assistance for up to 80 percent of the cost of acquiring transit assets by lease. A capital lease can be used to purchase capital equipment such as vehicles, or it can be used to purchase a combination of capital and maintenance services such as chassis rebuilding and engine/drive train replacement.

Capital leases can not be longer than the useful life of the asset, nor less than 75% of the useful life of the leased asset. They may include financing charges and ancillary costs such as delivery and installation. Transit agencies should use cost-benefit analysis to decide whether to lease or to buy.

Capital leases can help agencies with insufficient revenues meet project requirements; it increases their cash flow to match outlays. They are usually used to facilitate fleet replacement or to accelerate capital rehabilitation and replacement programs, which can lead to reductions in operating and maintenance costs. This helps reduce capital acquisition costs by moving forward purchases of expensive capital assets when capital costs are rising faster than the general level of inflation.

Capital leasing is not without risks. Troubles may arise if an agency is unable to secure future appropriations to pay off their leases. An agency may also run into problems if it overextends its lease commitments, leaving it with insufficient future funding to meet its contractual obligations.

r REVENUE BONDS

Revenue bonds are another source of funds for transit systems. Revenue bonds may be issued directly by a transit agency or by a state or local government and secured by repayment from the transit agency. A public referendum may be required before a revenue bond can be issued.

In most jurisdictions, public transit systems are authorized by statute or ordinance to issue debt secured with a variety of revenue sources, such as motor vehicle registrations, sales taxes, and property taxes. TEA-21 authorized the use of farebox revenues and anticipated grant receipts as additional sources of collateral for revenue bonds.

Revenue bonds can only be backed by farebox revenues if the level of State and local funding committed to transit for the 3 years following the bond issue are higher than the funds that were committed in the 3 years prior to the bond issue. Agencies must identify another source of funds for their operating expenses before issuing a revenue bond.

NY MTA has been the only agency to issue bonds backed by farebox revenues, although these bonds were also backed by other revenues and are much closer to the traditional concept of a revenue bond.

r GRANT ANTICIPATION NOTES

Revenue bonds that are backed by anticipated grant receipts are called grant anticipation notes (GANs). GANs were made possible by funding firewalls in TEA-21, which allow principal and interest on GANs to be repaid with FTA capital funding. Prior to TEA-21, future Federal funding had been used as one, but not as a sole, source of funds for repayment of revenue bonds.

The proceeds raised by a GAN can be used for the local match for a transit project. In 1997 New Jersey Transit was the first agency to issue bonds backed solely or primarily by anticipated Federal formula funding. Since then over $3.2 billion in GANs have been issued. Terms have ranged from 3-to-15 years for principal ranging from $18-to-$450 million.

GANs secured by Section 5307 and 5309 program funds are considered to have lower levels of risk than GANs that are backed by a New Starts full-funding grant agreement.

The most recent GAN was made in July 2006. It authorized the Alaska Railroad to issue up to $165 million in tax exempt bonds backed by FTA Section urbanized area formula funds and fixed guideway modernization funds. Proceeds will be used to accelerate the railroad's mainline track and bridge rehabilitation program by as much as ten years.

The Chicago Transit Authority (CTA) used a GAN in October 2004 to issue $250 million in notes backed by FTA urbanized area formula funds. This now supports renovation of the Dan Ryan branch of the Red Line, expansion of the Brown Line, station and bus garage reconstruction, new rail car procurement, and bus farebox replacement.

DEBT SERVICE RESERVE

Debt service reserves are cash reserves set aside by a borrower to ensure full and timely payments to bond holders. They have been used for many years by private business and public entities to support debt issues. SAFETEA-LU authorized transit grantees to be reimbursed for up to 80 percent of the deposits in a debt service reserve established for the purpose of financing transit capital projects from 5307 and 5309 funds.

It is hoped that transit agencies will benefit from cost savings from a higher initial bond rating resulting from the establishment of a reserve fund. To create a debt service fund an agency must first issue bonds, equal to about one year's worth of debt service payments, to support an eligible transit capital project. The agency can then apply for 80% reimbursement.

To date, no transit agency has applied for reimbursement of a debt service reserve.

TIFIA

The Transportation Infrastructure Finance and Innovation Act (TIFIA) was created under TEA-21 and reauthorized under SAFETEA-LU. It is administered by the U.S. Department of Transportation and offers eligible applicants, with eligible projects, the opportunity to compete for secured loans, loan guarantees and standby lines of credit. Credit assistance is based on a variety of factors, including the repayment potential of the project; recent applications have included concession fees for this purpose.

Three transit projects have used TIFIA assistance; two have been public-private partnerships. One of these was the Washington Metropolitan Area Transit Authority (WMATA) Infrastructure Renewal Program which received a $600 million guarantee.

OBSERVATIONS FROM SGR WORKSHOP

At the FTA SGR Workshop, agency participants shared their experiences using a variety of alternative financing mechanisms – including Grant Anticipation Notes, lease-leaseback arrangements, public-private partnerships, and TIFIA as a means of financing their capital needs (primarily for expansion needs). A number of agencies reported using bond mechanisms to help meet their SGR investment needs, but cautioned that their current debt service expenses were now an obstacle to further use of this mechanism.

All participants agreed that alternative financing mechanisms can help agencies achieve SGR in the short-term, with some long-term costs such as debt service. Participants also agreed that agencies should weigh the higher operating costs of not being at SGR against any financing costs before utilizing the debt financing option for asset replacement.

ISSUES REMAINING

Following are additional questions for the industry to address with respect to the use of alternative funding mechanisms to help attain an overall state of good repair:

- Transit agencies have a responsibility to serve the public interest in many ways. Private partners are necessarily motivated primarily by profit. How can an agency retain enough control to meet a diverse set of objectives while contracting out large portions of its activities?
- One of the London Underground Infracos went into receivership and cost the government a

reported \$4 billion. How can PPP contracts be written to protect the public interest?

- PPP contracts are complex and can take a long time to negotiate. Most transit agencies have little experience with this kind of contracting, whereas private investors often have a great deal. How can we protect our interests when dealing with a far more sophisticated private partner?
- Which of these funding models can be used to address maintenance and replacement backlogs while minimizing the need for up-front funding?
- Should the Federal Government act as an investor to provide incentive-based funding that could be paid back as it is in PPPs, or in infrastructure bonds?

Research Needs
FTA State of Good Repair Workshop

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r OVERVIEW

What kinds of research would help the transit industry pursue a state of good repair for the nation's bus and rail transit rolling stock and infrastructure? This paper formed the basis of a discussion on research needs at the workshop. The key questions we hope the industry will help to answer during that discussion are:

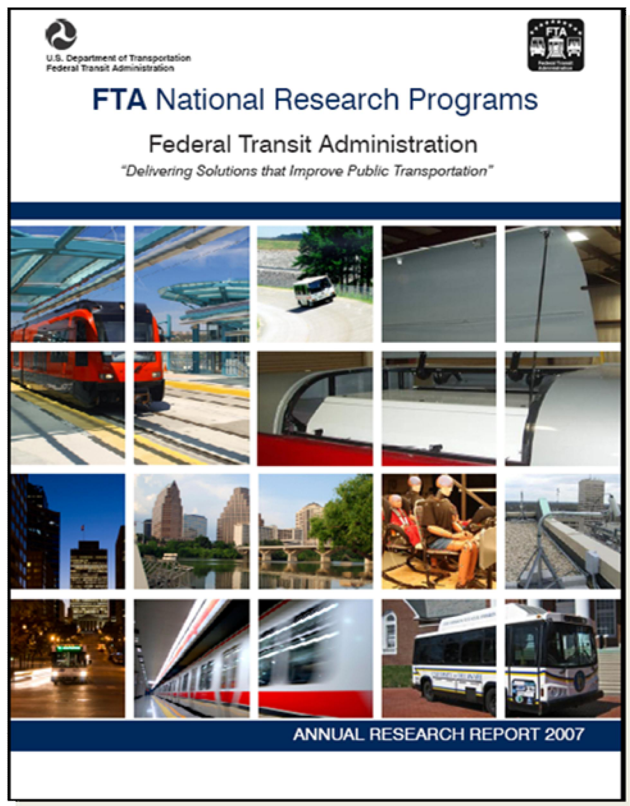
- What are some of the resources for funding federal research?
- What have we learned from previous research on maintaining the transit capital assets?
- What are some specific safety research topics that may help a transit agency achieve SGR?
- What are some of the technology advances that might help better maintain the nation's transit capital assets?
- What are some of the SGR research gaps that should be addressed by transit research?

About half of all passenger miles traveled and 37% of passenger trips are taken on rail systems, yet a small percentage of FTA's Research and Technology funding is allocated to rail. So, while this SGR industry workshop will focus on rail and bus systems, a large gap exists with regard to rail transit infrastructure research.

r BACKGROUND

FTA uses industry input to prioritize and shape our research programs. Most suggestions come from dialogue with the industry. The Transit Research Analysis Committee (TRAC) meets twice each year and advises FTA on research strategy. While Congressional earmarks make up the majority of research expenditures, FTA works closely with grantees to ensure these earmarks address goals and objectives found in the agency's Strategic Research Plan.

Besides the National Research and Technology Program, FTA's two other transit research programs are the University Transportation Centers (UTC) Program (funded by FHWA) and the Transit Cooperative Research Program (TCRP). There are opportunities to utilize the talents at UTCs, and those in the transit industry, as TCRP panelists to shape our research program. Their assistance in identifying and prioritizing research objectives, questions and projects will help FTA provide research leadership to improve the industry.



r LITERATURE REVIEW

Some literature related to the state of good repair exists already. Listed below are some online resources for researching topics related to the state of good repair.

Reports developed by the University Transportation Centers (UTC) program can be found at: http://utc.dot.gov/utc_results.html

The Transit Cooperative Research Program (TCRP) has developed reports that include resource materials on maintenance. TCRP "Research Field E: Maintenance" contains information on:

- Bus maintenance practices
- Transit railcar diagnostics
- Inventory management
- Maintenance training standards

No single TCRP report appears to be a comprehensive examination of the issues on how to maintain the nation's aging transit capital assets. More information can be found at: http://www.tcrponline.org/

The National Technical Information Service is administered by the U.S. Department of Commerce and serves as the largest central resource for government-funded scientific, technical, engineering, and business related information available today. More information can be found at: www.ntis.gov

The Transportation Research Information Services (TRIS) contains over 640,000 records of published research and almost 25,000 new records are added to TRIS each year. It is produced and maintained by the Transportation Research Board. To review research, go to: http://ntlsearch.bts.gov/tris/index.do

The following reports address the state of repair for the nation's transportation capital assets.

GAO: Physical Infrastructure: Challenges and Investment Options for the Nation's Infrastructure (May 8, 2008). The report identifies the challenges associated with the nation's surface transportation capital assets and the principles GAO identified to address those challenges. It also examines existing and proposed options to fund investments in the nation's capital assets. The report can be found at: http://www.gao.gov/new.items/d08763t.pdf

The Infrastructure Crisis – American Society of Civil Engineer's (ASCE) (January 2008). This special report examines the state of the nation's infrastructure in 15 major categories, as outlined in ASCE's three "report cards," as well as the various causes and costs associated with the problem, and explores some possible solutions. The report can be found at:
http://pubs.asce.org/magazines/CEMag/2008/Issue_01-08/article1.htm

2006 Status of the Nation's Highways, Bridges and Transit: Conditions and Performance Report to Congress. This report is completed every two years.
The latest report can be found at:
https://www.fhwa.dot.gov/policy/2006cpr/index.htm

FUTURE RESEARCH INITIATIVES NEEDS/QUESTIONS

What are some of the most pressing issues facing the transit industry with regard to SGR? What "low hanging fruit" research needs can be addressed immediately? This paper identifies five major areas of research needs:

Technologies:

- There are technologies and maintenance strategies that could help support more reliable equipment and safer infrastructure. The Transportation Technology Center, Inc., in Pueblo, CO, is just one example of an organization that develops such tools. What technologies will best support better transit equipment conditions? (e.g, condition-based maintenance, infrastructure health monitoring systems, etc.)
- Assuming the industry can identify and develop these new technologies, what should be the return on investment (ROI) or payback time of such technologies?

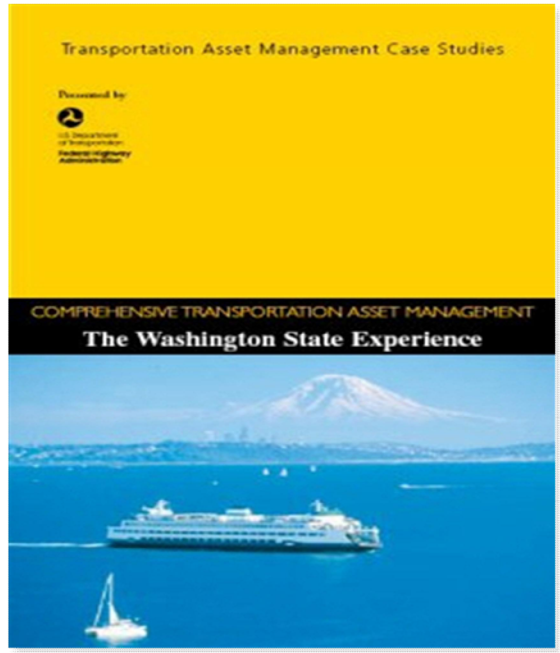
Measurement Tools:

- The Conditions and Performance report defines how to measure the condition of rail and bus maintenance facilities, operational performance, safety performance, and other transit elements. How do we define and measure state of good repair for various transit assets so that it is consistent with the Conditions and Performance Report?

- Transit agencies are often forced to make funding decisions that impact upkeep and maintenance of their assets. How does deferred maintenance impact modeling state of good repair?
- APTA and other standards development organizations have grown and vetted maintenance standards within the transit industry. What are some potential standards that, if developed, will improve SGR?
- The data for the Conditions and Performance Report and other reports comes from transit agencies. Can FTA's Transportation Economic Requirements Model (TERM) be adapted for use by transit agencies and will that lead to better predictions about future conditions and funding needs?
- FTA collects a variety of information for the National Transit Database (NTD) which is published annually. Does this accident and service delay data correlate with state of good repair ratings?
- Many transit agencies base their maintenance schedule on the miles a transit vehicle has traveled or how long an asset has been utilized. Can a service to maintenance budget ratio be devised that correlates to state of good repair ratings?

Case Studies:

- TERM is the source for determining the current state of transit conditions and performance. Should an evaluation of TERM and other existing models used to predict and define SGR be conducted?
- Other transportation modes are facing the same challenge of keeping an aging capital asset safe and viable for the traveling public. What are SGR lessons learned and best practices from other DOT modes and industries – highway, airports and railroads?
- The challenges faced by transit agencies to maintain the aging transit capital assets didn't appear suddenly. What has been attempted thus far to address the issue? Should case studies be developed on what works/doesn't work to support SGR?



- European countries have maintained extensive transit systems longer than the U.S. What can we learn from European and Asian countries with regard to transit SGR and asset management?
- Earlier this year FTA heard a presentation from representatives from the London Underground regarding its maintenance and operation. What case studies can be pulled from systems like the London Underground?

Private Sector:

- A few U.S. transit agencies are considering leaseback arrangements. For example, a major transit authority is nearing agreement to sell and lease back one of its rapid transit lines. There should be a life cycle cost examination or research conducted on leaseback arrangements such as the leasing of transit vehicles or entire lines. Is this a good model to follow? What are the long-term benefits and downsides?
- Public Private Partnerships (PPPs) appear to be the wave of the future with regard to funding transit needs. What are the various ways that PPPs can help in maintaining the transit infrastructure?

- The Design Build Operate Maintain (DBOM) concept has proven to be a reliable, cost and time savings project delivery strategy. In most cases the DBOM contractor is responsible for maintaining the rail system assets under contract. How have DBOM arrangements worked with regard to maintenance? An examination of the San Juan Metro and the NJT Hudson-Bergen and River Line transit systems should occur.

Other Research Needs:

- It is important that the industry is made aware of any previous or current examinations regarding the SGR so as not to duplicate research. A more rigorous literature review of SGR-related research and an annotated bibliography should be considered.
- With the increasing growth of transit ridership, the media is spotlighting the successes and failures of a once overlooked commodity. How does public perception play into infrastructure funding and how can infrastructure needs be better marketed to voters and decision-makers?
- Are Federal policies and guidelines hindering transit agencies' ability to sustain safe and reliable transit service? Should Federal rules be amended to allow more flexibility with regard to funding the maintenance of transit capital assets?
- Fare increases are necessary to maintain a level of service demanded by the public. Service cutbacks and the loss of experienced maintenance personnel all impact transit agencies' ability to provide reliable operations. How does deferred maintenance affect service cutbacks? What's the impact on ridership and public perception?

OBSERVATIONS FROM SGR WORKSHOP

Participants at the SGR Workshop highlighted research needs on asset management systems and potential improvements to FTA's TERM model during the working session, and also indicated research priorities on a written handout. Specific areas of greatest interest to the workshop participants included:

"TERM Light": Agencies supported the concept of developing a simplified agency-level version of TERM. In return for supporting FTA in improving TERM's capabilities and modeling accuracy, local agencies would receive a customizable version of TERM for use by local agency staff. Many agencies also expressed interest in participating on a Technical Panel to help review the assumptions and methodologies employed by TERM and to discuss the development and use of asset management decision support tools in general.

Asset Inventory Development: Similarly, nearly all respondents expressed interest in establishing working groups to share best practices in asset management techniques. A clear starting point was for agencies to share their approaches and rationale in (1) the development of their asset inventories (what data fields to include?), in (2) the collection and maintenance of this asset inventory data, and finally (3) the use of this data in conducting needs assessments and long-term capital planning.

Linear Asset Management Tools: Participants were particularly interested in learning what others had learned about comprehensive, linear asset management systems. In particular, a maintenance management system that could combine all rail asset types (right-of-way, signals, track, tower, structures, etc.) and that could be used for both daily practices and long-term capital programming was considered to be needed.

Maintenance Management Systems: Finally, some participants stated that there would be some benefit in developing technical assistance and workshops to help agencies make better use of their existing maintenance management systems. While the current systems are considered to provide sufficient functionality, many agencies felt they could be deriving more benefits from these systems by adjusting their internal management practices.

In each of these areas, most respondents agreed there is a clear role for FTA to offer technical assistance and to help facilitate dissemination of best practices in asset management practices and other approaches to attaining a state of good repair.

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