Analysis of Transit 20 Year Capital Forecasts: FTA TERM Model vs. Transit Estimates

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Introduction:

The Transit Economic Requirements Model (TERM) is an analysis tool developed for the Federal Transit Administration (FTA) and designed to estimate transit capital investment needs. This tool has been used since 1995 to support preparation of U.S. DOT's biennial *Report to Congress on the Condition and Performance of the Nation's Highways, Bridges and Transit* (C&P Report). The TERM model focuses on the condition of the transit infrastructure and the capital requirements to maintain each transit system in a State of Good Repair (SGR). State of Good Repair is a variable term[1] used to define the condition of each asset and the point at which the asset requires replacement.

In its analyses, TERM defines state of good repair using a numerically based system for evaluating transit asset conditions. TERM uses deterioration schedules to rate an asset's condition on a scale of 5 (excellent), 4 (good), 3 (adequate), 2 (marginal) through 1 (poor) based on the asset's type, age, rehabilitation history and other factors. TERM considers an asset to be in a state of good repair when the physical condition of that asset is at or above a specific condition rating value of 2.5 (the mid-point between adequate and marginal). The level of investment required to attain and maintain a state of good repair is therefore that amount required to rehabilitate and replace all assets with estimated condition ratings that are less than this minimum condition value.

Three components of transit assets – rail guideway, rail systems, and rail vehicles – make up a majority of the state-of-good repair-backlog as estimated by FTA's Transit Economic Requirements Model (TERM). An error in the estimation of these three components could have a significant effect on the overall estimated backlog. To produce an empirical evaluation of TERM's estimates, this paper will compare the results of TERM runs for three major US transit agencies with the agencies' own assessments of their rail system backlog and capital spending priorities. Specifically, this paper examines and compares a 20 year capital forecast by the FTA FTA's Transit Economic Requirements Model (TERM) as compared to three major US transit agencies' internal 20 year forecasts.

The three transit agencies used in this comparison are:

- New York City Transit (NYCT); heavy rail transit only.
- Metropolitan Atlanta Rapid Transit Authority (MARTA); heavy rail transit only
- Massachusetts Bay Transportation Authority (MBTA); All systems[2]

The process used in this comparison included an initial comparison of the TERM 20 year capital outputs with the summary 20 year capital outputs for each of the three agencies. This required some degree of categorization, since the subcategories used by TERM were not the same as those used by the agencies, (which also differed among the three agencies). Following this initial comparison, discussions were held with the staff of each agency, either by direct meeting (NYCT) or by conference

[1] Definition of State of Good Repair varies with different agencies and the assumptions they use to define the condition and required replacement point of an asset.
[2] MBTA was not able to break out the heavy rail portion of their 20 year capital forecast, so the full system capital forecast was used.

call and/or e-mail (MBTA, MARTA). The meetings addressed differences in data, corresponding differences in assumptions and analysis methodologies, and other factors that affected the data comparisons.

It should be noted that the TERM analysis represents an unconstrained, State of Good Repair (SGR) projection such that there are no restrictions based on availability (or unavailability) of capital funds for repair. Wherever possible, the same unconstrained SGR projections were used for the individual agencies (or else noted otherwise).

Furthermore, the TERM analysis assumes that the assets are replaced when they fall below the TERM defined SGR level (which is the same for all agencies in the TERM analysis).

Finally, the TERM analysis does not include any system or capacity expansions nor does it include the introduction of new technologies.

NYCT

New York City Transit (NYCT) is the largest transit operator in the United States with the corresponding largest capital budget. In this study, the 20 year capital forecast for NYCT for the period 2010-2029 (prepared August 2009) was compared to the TERM capital forecast for the same period. The specific focus was on heavy rail transit only. As such busses and bus depots and the Staten Island Railway were excluded from this comparison. Table 1 presents the 20 year NYCT capital needs forecast, broken down into four five year periods. The NYCT forecast is divided into 13 subcategories. The corresponding TERM forecast was provided for each year between 2010 and 2029 (plus the calculated backlog going into 2010), divided into 31 subcategories. While several of the subcategories were directly comparable (e.g. subway cars (revenue vehicles), many of the TERM subcategories had to be combined to match a NYCT subcategory. Thus for example, the NYCT Line Equipment subcategory included the following five TERM subcategories: deep wells, emergency exists, fan plant, lighting and pump rooms. Similarly the four TERM structures categories (at grade ballast, elevated fill, elevated structure, underground) was mapped into the NYCT Line Structures category.

Figure 1 and Table 2 present the comparison between the 20 year capital programs as calculated by TERM as compared to the NYCT forecast. Note the comparison shows the difference in forecast backlog (capital investment required to bring the property up to a State of Good Repair in year 2010) and four five year forecast periods (2010-2014, 2015-2019, 2020-2024, and 2025-2029). As can be seen in the Figure and Tables, the overall 20 year NYCT capital forecast was approximately $72.2 Billion, while the corresponding TERM forecast was approximately $87.4 Billion, a difference of approximately $15.25 Billion or 17%. This appears to be primarily due to the difference in backlog between the two forecast, a difference of approximately $19 Billion or 57%. The forecast for the four 5-year periods after the backlog were within 11% to 31% of each other.

Figure 2 and Table 3 present the difference between the NYCT and TERM forecasts by subcategory. It should be noted, that the numbers in this table (and Figure) reflect a move of $1.1 Billion from miscellaneous to building to reflect the fact that this $1.1Billion capital requirement was for administrative related buildings, which are included in the TERM building category but which were included in the NYCT miscellaneous category (as shown in Table 1). In addition, NYCT had a Storage Yard category that contained all yard tracks and associated capital requirements for those tracks. . TERM included all yard tracks in the general Track category (and had a very small Yard category). As a result, the Yard Category was combined with the Track category and is included within the Track category.

It can be seen that significant discrepancies exist in the revenue vehicle category ($7.5 Billion or 40%), the line equipment category ($9.7 Billion or 58%), the communications category ($3.3 Billion or 2000%), traction power ($2.1 Billion or 42%) and the train control category ($2.5 Billion or 21%).

Figures 3A and 3B and Tables 4A and 4B show the distribution of categories with each of the forecasts. As can be seen the NYCT forecast has Train Control as it largest item at 20.1% followed by Stations and Revenue Vehicles, while the TERM forecast has revenue Vehicles as its largest item at 21.4% followed by Line Equipment and Stations and Train Control.

Table 1: NYCT Twenty Year Needs T-Category Totals By Capital Program (in $ Million)

2008$

	2010-2014	2015-2019	2020-2024	2025-2029	TOTAL
T-1 : Subway Cars	$3,037	$1,724	$3,674	$2,843	$11,278
T-4 : Passenger Stations	$3,638	$3,392	$3,396	$2,143	$12,569
T-5 : Track	$1,280	$1,205	$1,190	$1,174	$4,849
T-6 : Line Equipment	$1,118	$1,682	$1,958	$2,112	$6,869
T-7 : Line Structures	$923	$982	$1,051	$1,266	$4,222
T-8.03 : Signals	$4,043	$3,940	$3,190	$3,316	$14,488
T-8.06 : Communications	$858	$1,046	$940	$637	$3,481
T-9 : Traction Power	$728	$758	$723	$728	$2,937
T-10 : Shops	$782	$1,088	$846	$1,128	$3,843
T-11 : Yards	$649	$842	$381	$579	$2,452
T-13 : Service Vehicles	$185	$233	$110	$90	$619
T-14 : Passenger Security	$27	$27	$30	$30	$114
T-16 : Misc./Emergency	$1,098	$1,131	$1,105	$1,128	$4,463
Program Total	$18,366	$18,050	$18,594	$17,174	$72,184

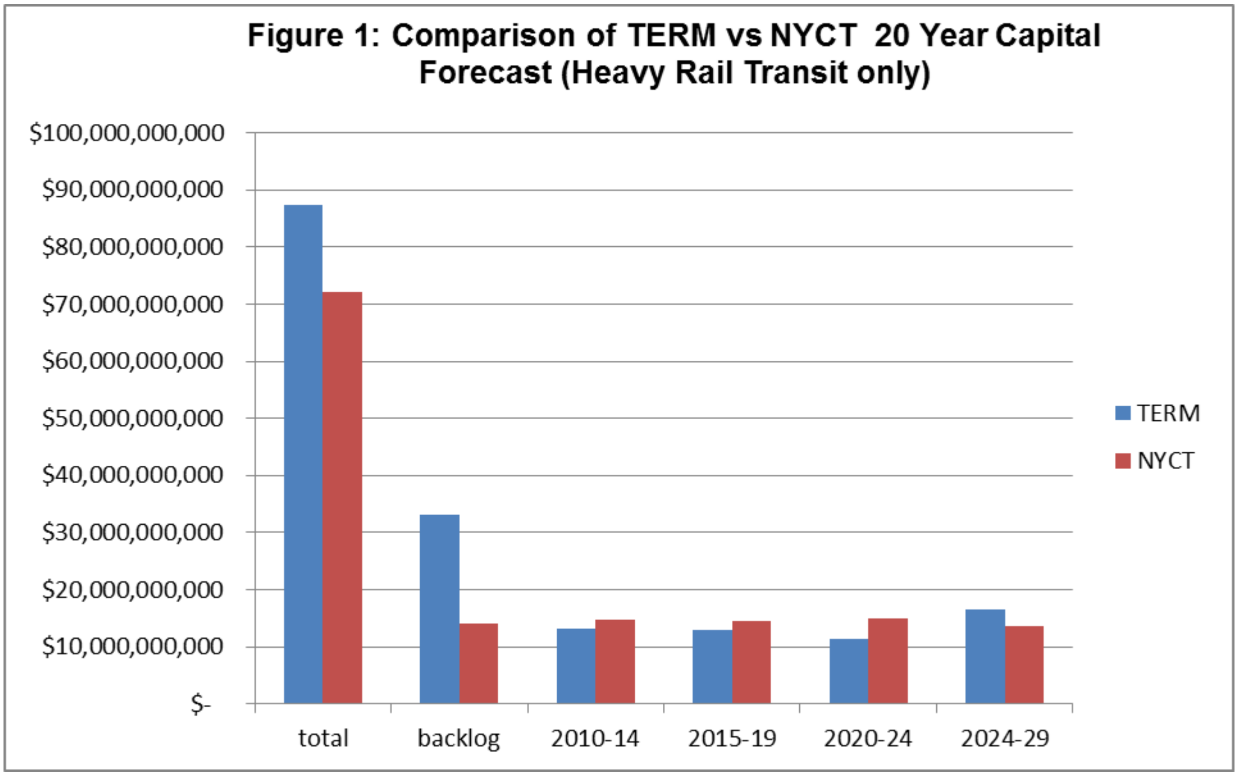


Table 2: Comparison of NYCT and TERM 20 Year Capital needs forecast (Heavy Rail Transit only)

NYCT	TERM	NYCT	% difference	$ difference
total	$ 87,434,745,782	$ 72,184,000,000	17%	$ 15,250,745,782
backlog	$ 33,145,028,608	$ 14,198,440,000	57% **	$ 18,946,588,608
2010-14	$ 13,098,821,405	$ 14,816,390,000	-13%	$ (1,717,568,595)
2015-19	$ 13,078,227,589	$ 14,500,390,000	-11%	$ (1,422,162,411)
2020-24	$ 11,509,257,248	$ 15,044,390,000	-31% *	$ (3,535,132,752)
2024-29	$ 16,603,410,932	$ 13,624,390,000	18%	$ 2,979,020,932

Table 3: Comparison by Subcategories

NYCT	TERM	NYCT	% difference		$ difference
Buildings	$ 4,863,322,505	$ 4,944,000,000	-2%		$ (80,677,495)
Structures	$ 4,557,784,639	$ 4,222,000,000	7%		$ 335,784,639
Track	$ 9,783,261,429	$ 7,300,000,000	25%		$ 2,483,261,429
Stations	$ 14,441,067,475	$ 12,569,000,000	13%		$ 1,872,067,475
Communications	$ 154,767,657	$ 3,481,000,000	-2149%	****	$ (3,326,232,343)
Traction power	$ 5,029,789,410	$ 2,937,000,000	42%		$ 2,092,789,410
Security/Surv Equipment	$ 171,227,676	$ 114,000,000	33%		$ 57,227,676
Train Control	$ 11,971,788,132	$ 14,489,000,000	-21%		$ (2,517,211,868)
Line equip	$ 16,539,237,492	$ 6,870,000,000	58%	***	$ 9,669,237,492
Service vehicles	$ 870,194,604	$ 618,000,000	29%		$ 252,194,604
Revenue Vehicles	$ 18,729,289,659	$ 11,278,000,000	40%	**	$ 7,451,289,659
miscellaneous	$ 323,015,104	$ 3,362,000,000	-941%		$ (3,038,984,896)
Total	$ 87,434,745,782	$ 72,184,000,000	17%		$ 15,250,745,782

Note: NYCT miscellaneous contains $ 1,100,000,000 in administrative related buildings
This was moved from NYCT Miscellaneous to NYCT Buildings
Also NYCT had a Storage Yard category that contained all yard tracks. TERM included all yard tracks in the general Track category (and had a very small Yard category). The Yard Category was combined with the Track category and is included within the Track category.

** Difference in condition definition
*** Not all fans replaced per NYCT
**** Possible difference in new technology requirements

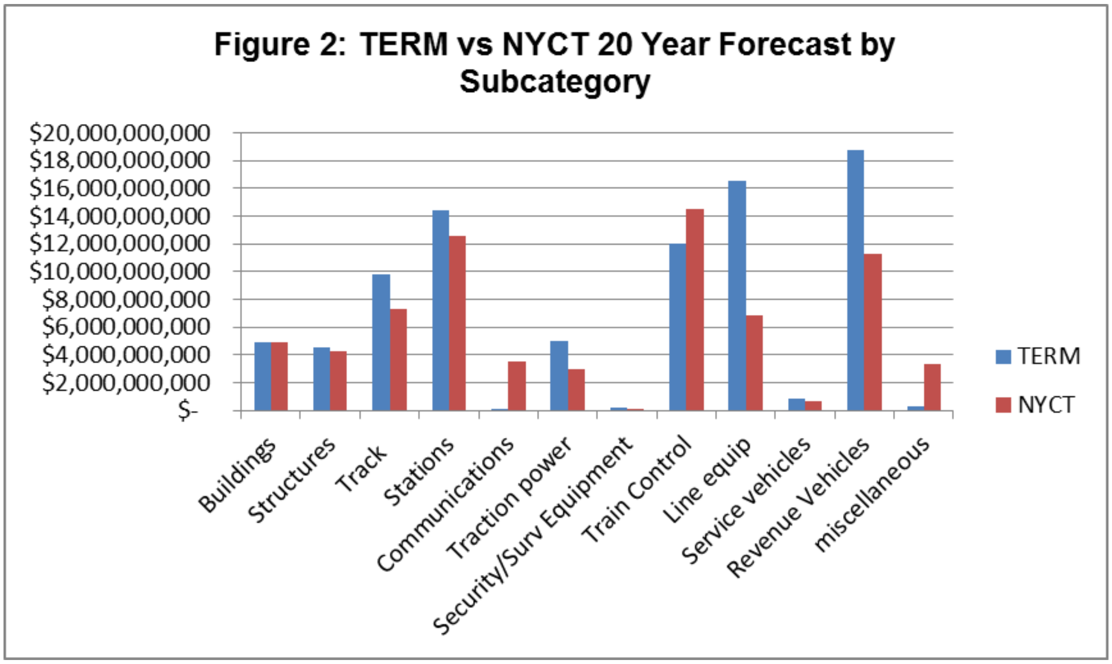


Table 4: Distribution of Subcategories
NYCT and TERM

Table 4A: TERM	TERM	
Buildings	$ 4,863,322,505	5.6%
Structures	$ 4,557,784,639	5.2%
Track	$ 9,783,261,429	11.2%
Stations	$ 14,441,067,475	16.5%
Communications	$ 154,767,657	0.2%
Traction power	$ 5,029,789,410	5.8%
Security/Surv Equipment	$ 171,227,676	0.2%
Train Control	$ 11,971,788,132	13.7%
Line equip	$ 16,539,237,492	18.9%
Service vehicles	$ 870,194,604	1.0%
Revenue Vehicles	$ 18,729,289,659	21.4%
miscellaneous	$ 323,015,104	0.4%
Total	$ 87,434,745,782	100%

Table 4B: NYCT	NYCT	
Buildings	$ 4,944,000,000	6.8%
Structures	$ 4,222,000,000	5.8%
Track	$ 7,300,000,000	10.1%
Stations	$ 12,569,000,000	17.4%
Communications	$ 3,481,000,000	4.8%
Traction power	$ 2,937,000,000	4.1%

Security/Surv Equipment	$	114,000,000	0.2%
Train Control	$	14,489,000,000	20.1%
Line equip	$	6,870,000,000	9.5%
Service vehicles	$	618,000,000	0.9%
Revenue Vehicles	$	11,278,000,000	15.6%
miscellaneous	$	3,362,000,000	4.7%
Total	$	72,184,000,000	100.0%

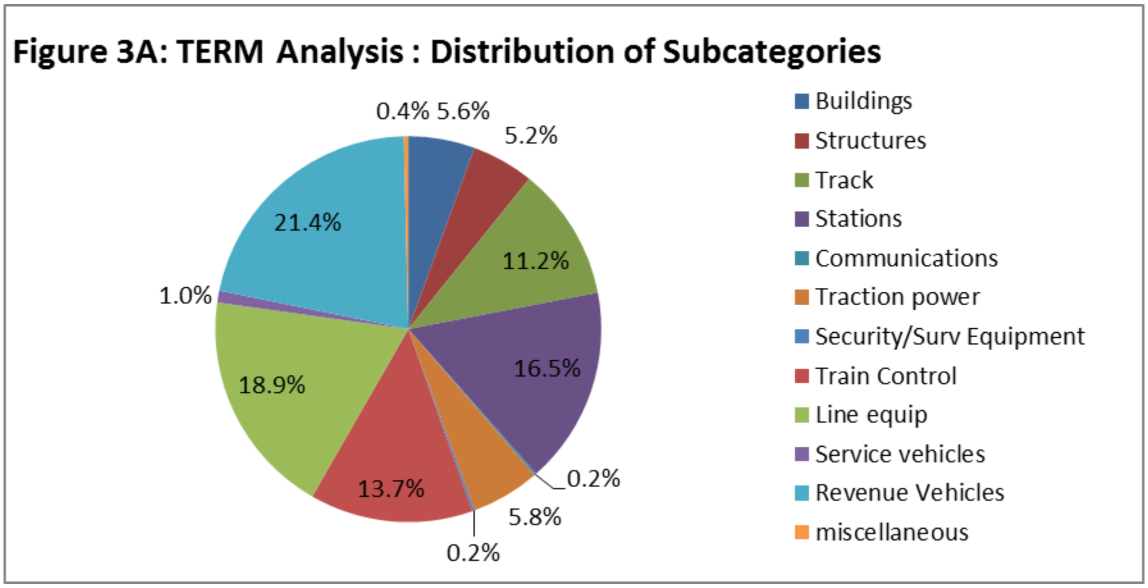


Figure 3A: TERM Analysis : Distribution of Subcategories
0.4%
5.6%
5.2%
11.2%
16.5%
0.2%
5.8%
0.2%
13.7%
18.9%
1.0%
21.4%
Buildings
Structures
Track
Stations
Communications
Traction power
Security/Surv Equipment
Train Control
Line equip
Service vehicles
Revenue Vehicles
miscellaneous

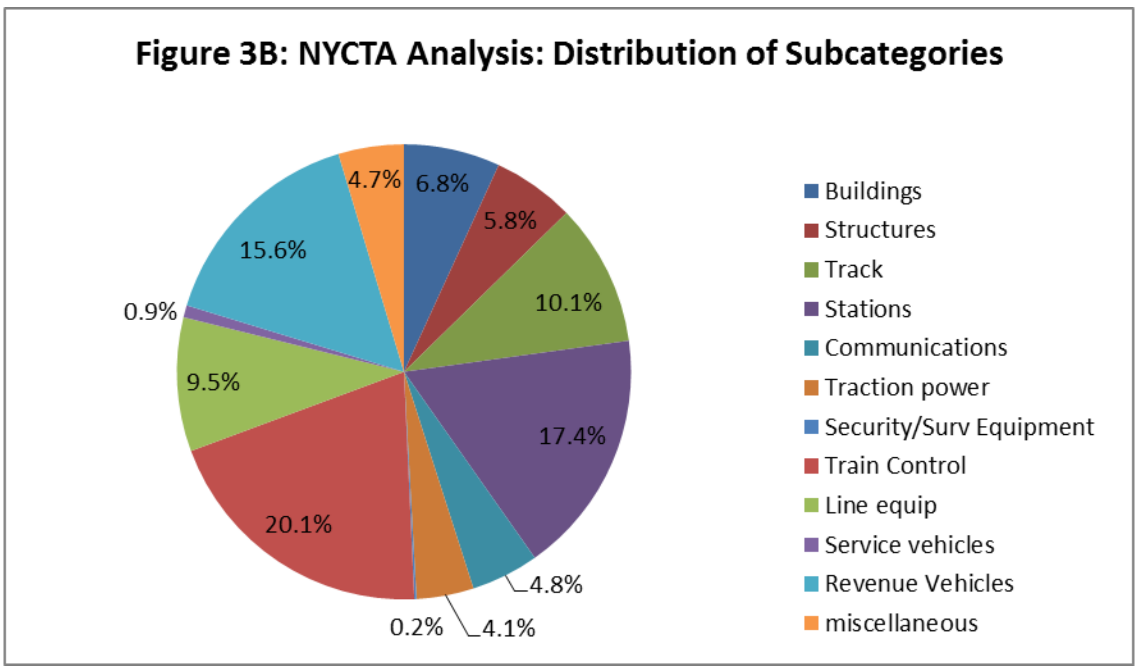


Figure 3B: NYCTA Analysis: Distribution of Subcategories
4.7%
6.8%
5.8%
10.1%
17.4%
4.8%
4.1%
0.2%
20.1%
9.5%
0.9%
15.6%
Buildings
Structures
Track
Stations
Communications
Traction power
Security/Surv Equipment
Train Control
Line equip
Service vehicles
Revenue Vehicles
miscellaneous

Based on this initial data comparison, a meeting was held with NYCT and MTA personnel to discuss the differences.

A major issue and source for the discrepancies is that NYCT has changed their replacement (backlog) definitions and are using more condition based criterion rather than simply age. Furthermore, they are using more inspection based condition criterion than in the past, and using this inspection based condition as the basis for defining when replacement is required. They have found that this type of condition based replacement criterion is more accurate and more effective than age based criterion alone. This is now being done by NYCT for many of their major capital program categories such as revenue vehicles, track, yards, buildings, etc.

As part of this redefinition, NYCT increased the age for rolling stock replacement to 40 years. The TERM model used 28 or 29 years. This represents a 38 to 43% higher replacement rate for TERM and appears to account for the difference in the Revenue Vehicle category which was 40%. It also represents about half of the total 20 year difference between TERM and the NYCT capital program forecast.

It may also account for part of the difference in backlog; (TRB $33B vs. NYCT $14B) which also covers a significant portion of the total differences.

Other discrepancy issues that were discussed with NYCT:

Buildings: NYCT had approximately $1.1B of administrative related building capital in its miscellaneous subcategory. This was moved to the buildings subcategory with the result that the building category is shown to be very close (see Table 3).

Track: here too, NYCT has changed the age based replacement to a condition based replacement. Thus for example, the definition of switch condition (switches or turnouts are part of the track category) has been changed. NYCT indicated that this has caused measurable change in capital forecast and may account for a significant portion of the discrepancy. (Another part of the initial discrepancy was due to the fact that NYCT separated its yard tracks into a Storage Yard category that contained all yard tracks (see Table 1). TERM included all yard tracks in the general Track category and had a very small Yard category. Since TERM was unable to separate out yard track from its total track category, the Yard Category was combined with the Track category in Tables 3 and 4 and is included within the Track category. The resulting discrepancy in Track was thus reduced from 50% to 25%.

Communications: NYCT's review of the TERM subcategories (TERM included three subcategories) seemed to show that several important NYCT subcategories were either not accounted for or else not shown at that level of detail. This included specific NYCT capital items such as PA systems ($570M,), CCTV ($45 good repair +$250 in improvements), Communications Rooms in stations ($500M), and some others. While TERM indicated that all asset types provided by NYCTA were included in their numbers, the order of magnitude of the discrepancy (over 2000%) suggests that either:

- Not all asset subcategories were included

- There was significant difference in the condition and asset life assumptions (similar to that discussed above under revenue vehicles/rolling stock)
- Since this communications is technology driven area, there may be monies in the NYCTA budget for the adoption of new technology which are not included in the TERM budget since TERM addresses ‘in kind” replacement and new technology upgrades are not accounted for in TERM.

Traction Power/Electrification : here again the issue of condition vs. age criterion for replacement was raised, with NYCT indicating that they had changed their replacement criterion to a condition based one. Discussions with TERM personnel indicated that this was a category where the TERM decay curve condition assessment did not appear to match the NYCT assessments of conditions; in fact it was noted that NYCT has a ‘great deal of old equipment in surprisingly good condition”. This supports the issue of condition based replacement vs. age based replacement.

Line Equipment: It was noted by NYCT that in the major Line Equipment subcategory of fans, which represents 80% of the total forecast Line equipment costs in the TERM model, NYCT has 250 fan plants/segments of which they will be maintain/upgrading only 50 of them. NYCT is not planning on any major work or replacement on remaining fan plants/ segments. This is significant in that the TERM model assumes that all facilities will be maintained or replaced unless removed from the model.

MARTA

The second major transit system analyzed was the Metropolitan Atlanta Rapid Transit Authority (MARTA) again focusing on heavy rail transit only.

In this study, the 20 year capital forecast for MARTA for the period 2013-2033 was compared to the TERM capital forecast for the same period[3]. The specific focus was on heavy rail transit only.

Figure 4 presents MARTA 30 year capital needs forecast, broken down into major financial areas. Noting that this is a 30 year plan and not a 20 year plan, which is the TERM forecast horizon, the MARTA specific capital need forecast for each year between 2011 and 2040 was refined by MARTA into a 20 year asset analysis. It should also be noted that MARTA projects a major capital “bump” in the period 2031 through 2040, outside the TERM horizon, which includes major rehabilitation of the rail structures. That is because the MARTA rail structures are currently projected to begin to reach the end of their design life in FY 2031 to FY 2040.

[3] The TERM forecast was actually for 2010-2029 so there was a three year offset.

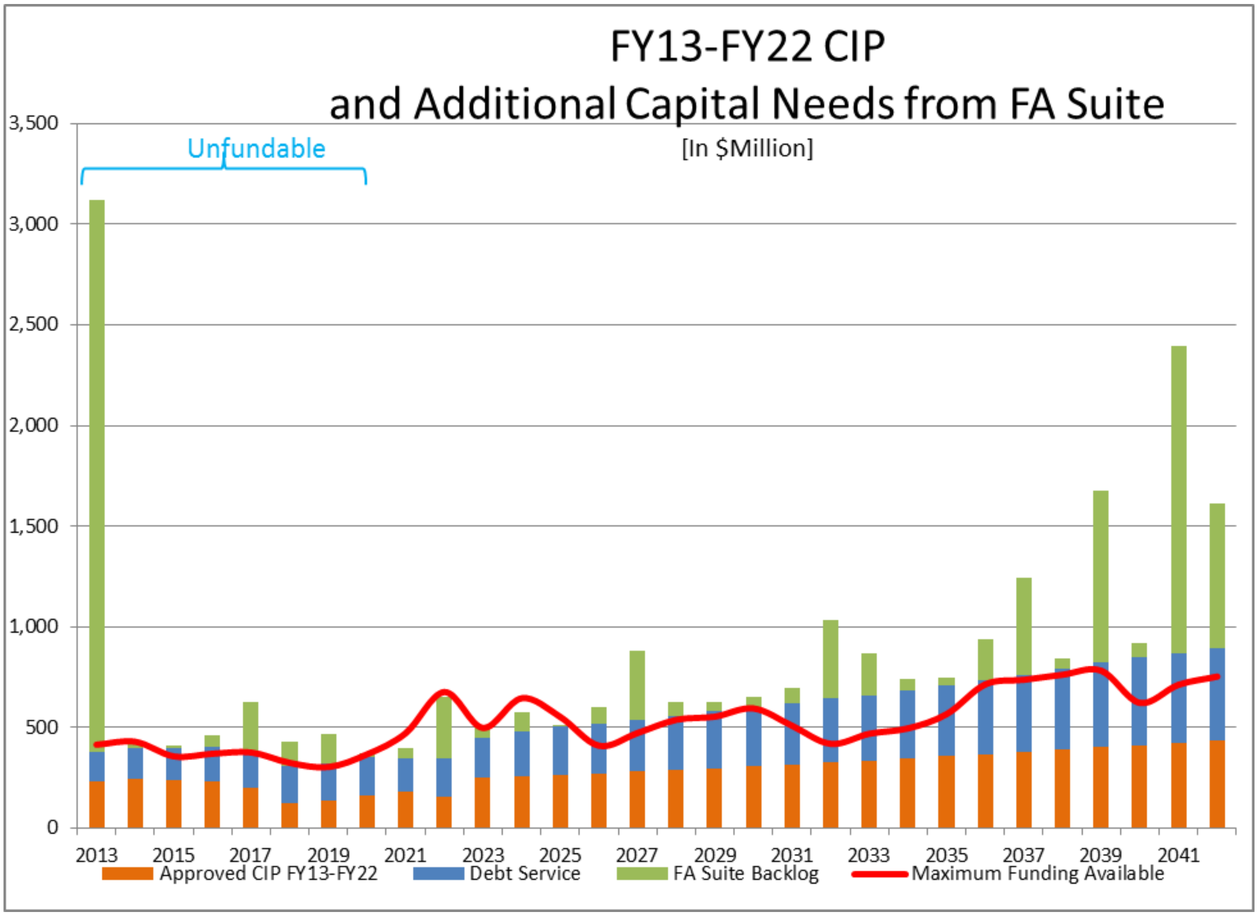


Figure 4: MARTA FY 2013- 2041 Unconstrained Capital Improvement Plan (CIP)

The 20 year projected asset needs for MARTA was reported to be $6.56 Billion dollars, as compared to the TERM projected needs of $6.853 Billion, as difference of 4% as shown in Table 5. Also seen in Table 4 is the MARTA backlog of approximately $2.6 Billion as compared to the TERM projected backlog of $1.9 Billion as shown in Figure 6, and in Table 6.

Table 5: Summary 20 year forecast for MARTA vs. TERM (State of Good Repair)

	TERM	MARTA	% difference
Total	$ 6,852,867,749	$ 6,560,500,000	4%

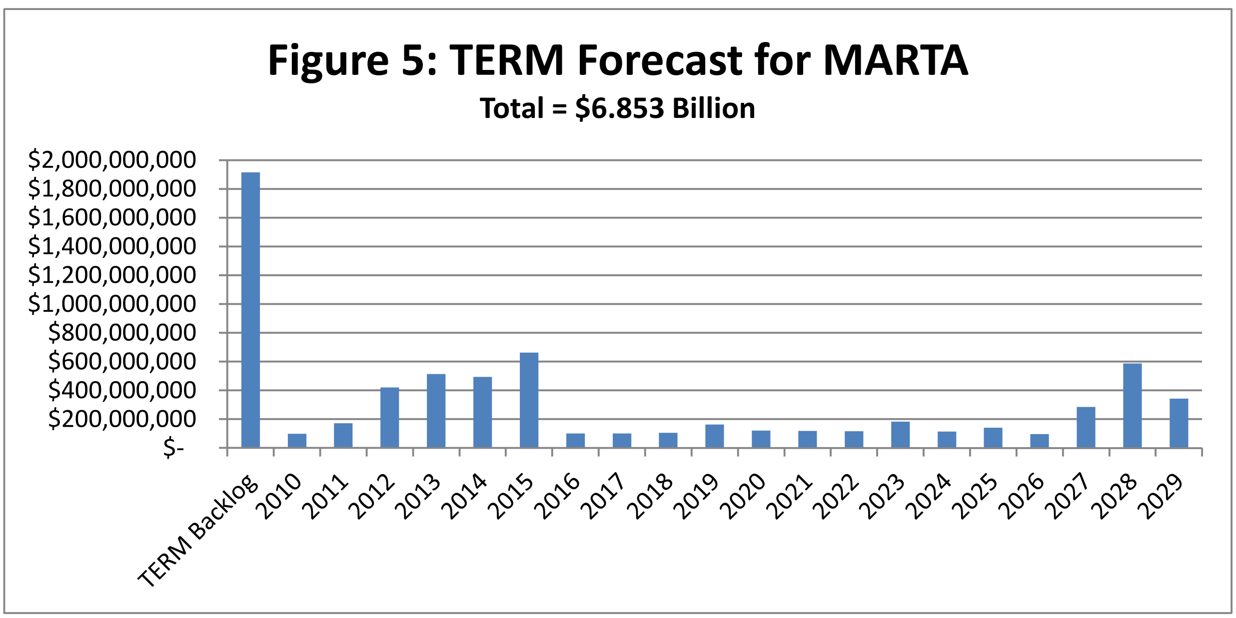
Table 6: Backlog for MARTA vs. TERM (State of Good Repair)

	TERM	MARTA	% difference
Total	$ 1,913,930,000	2,600,000,000	26%

The MARTA forecast is divided into 4 subcategories[4]. The corresponding TERM forecast was provided for each year between 2010 and 2029 (plus the calculated backlog of $1.91 Billion going into 2010), divided into 24 subcategories (see Figure 6). While several of the subcategories were directly comparable (e.g. subway cars (revenue vehicles), many of the TERM subcategories had to be combined to match a MARTA subcategory. Thus for example, the MARTA Systems subcategory included signals (train control), fare collection,   and power.

Figure 7 and Table 7 present the difference between the MARTA and TERM forecasts by subcategory. It can be seen that significant discrepancies exist in the Revenue Vehicle category ($1.64 Billion or 52%), and the Facilities category ($1.69 Billion or 1131%). Note, the Guideway Elements category and the Systems category are relatively close with a difference of 11% and 27% respectively.

Figures 8A and 8B and Tables 8A and 8B show the distribution of categories with each of the forecasts. As can be seen the MARTA forecast has Guideway Elements as it largest item at 33.1%% followed by Facilities (28.1%) and Revenue Vehicles (22.7%), while the TERM forecast has Revenue Vehicles as its largest item at 45.6% followed by Guideway Elements representing 35.6%.



[4] MARTA also provided a 5th stations category which was combined into facilities since TERM did not separately breakout stations.

Table 7: Comparison by Subcategories MARTA vs. TERM

	TERM	MARTA	% difference
Facilities*	$ 149,547,772	$ 1,840,250,000	-1131%
Guideway elements	$ 2,436,961,904	$ 2,174,060,000	11%
Systems**	$ 835,343,545	$ 1,057,930,000	-27%
Revenue Vehicles	$ 3,126,615,820	$ 1,488,260,000	52%
Misc	$ 304,398,709	$ -	100%
Total	$ 6,852,867,749	$ 6,560,500,000	4%

* includes stations

** includes power, fare collection, train control/signals

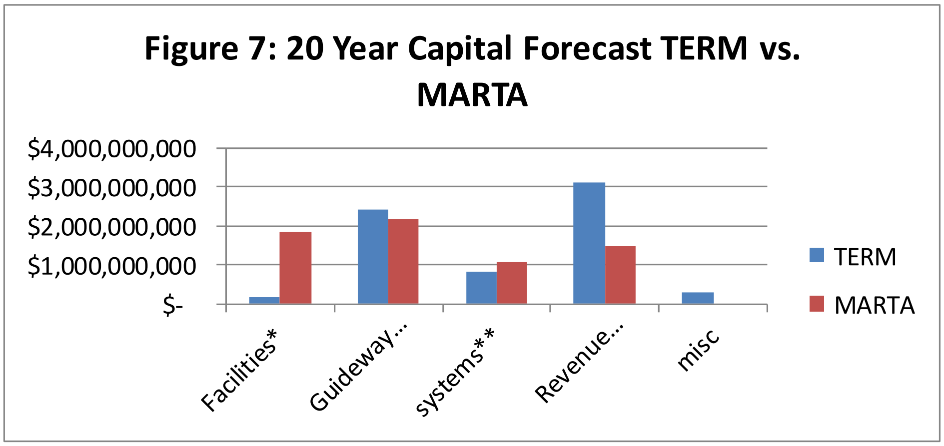


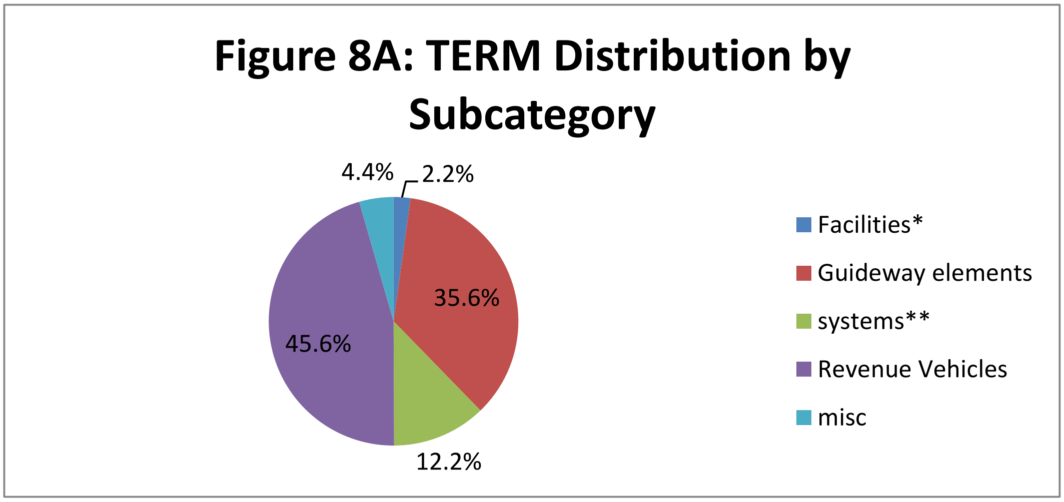
Table 8: Distribution by Subcategories

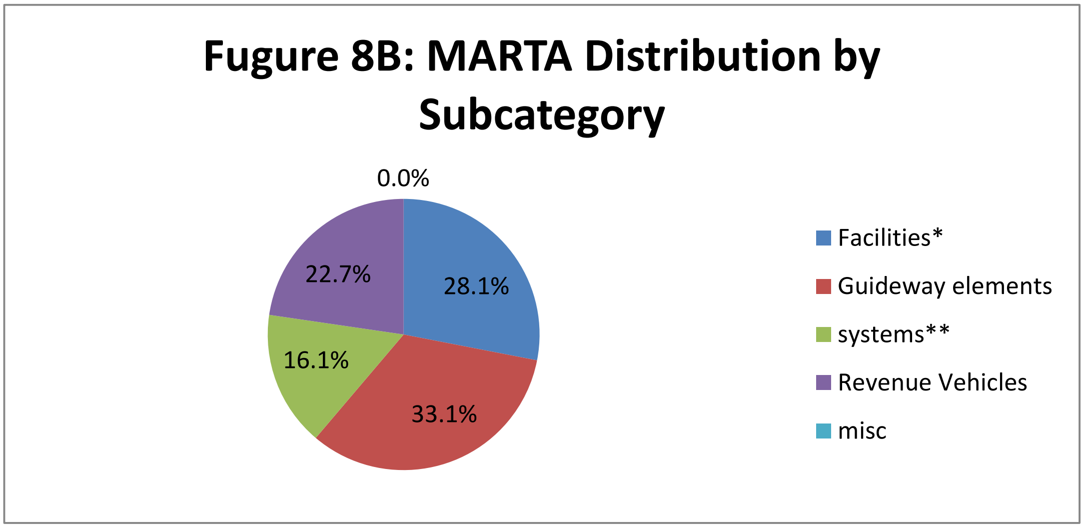
Table 8A: TERM

		TERM
Facilities*	$ 149,547,772	2.2%
Guideway elements	$ 2,436,961,904	35.6%
systems**	$ 835,343,545	12.2%
Revenue Vehicles	$ 3,126,615,820	45.6%
Misc	$ 304,398,709	4.4%
Total	$ 6,852,867,749	100%

Table 8B: MARTA

		MARTA
Facilities*	$ 1,840,250,000	28.1%
Guideway elements	$ 2,174,060,000	33.1%
systems**	$ 1,057,930,000	16.1%
Revenue Vehicles	$ 1,488,260,000	22.7%
misc	$ -	0.0%
Total	$ 6,560,500,000	100.0%





Based on this initial data comparison, several phone conversations were conducted with MARTA personnel to discuss the differences.

Revenue Vehicles represented the largest dollar difference between the two forecasts with the TERM forecast being $1.85 Billion greater than the MARTA forecast. This difference again may be due to the difference in condition definition and the current age based replacement approach of TERM. MARTA recently (2009) completed a set of major overhauls of 65% of their fleet (218 out of 338 vehicles). This extended the replacement life by 12 to 15 years, thus moving the capital replacement costs out further in the capital budget forecast cycle. MARTA noted that they found this cost effective with a $1 Million per vehicle cost for the overhaul vs. a $3-4 Million cost for new vehicles. Also MARTA noted that it does its revenue vehicle capital replacement planning on a car subcomponent level.

It should also be noted that MARTA's currently funded 20 year capital project spend plan is $3.72 Billion (see Figure 8), which is well below the projected capital needs shown by either TERM or MARTA's own internal analysis.

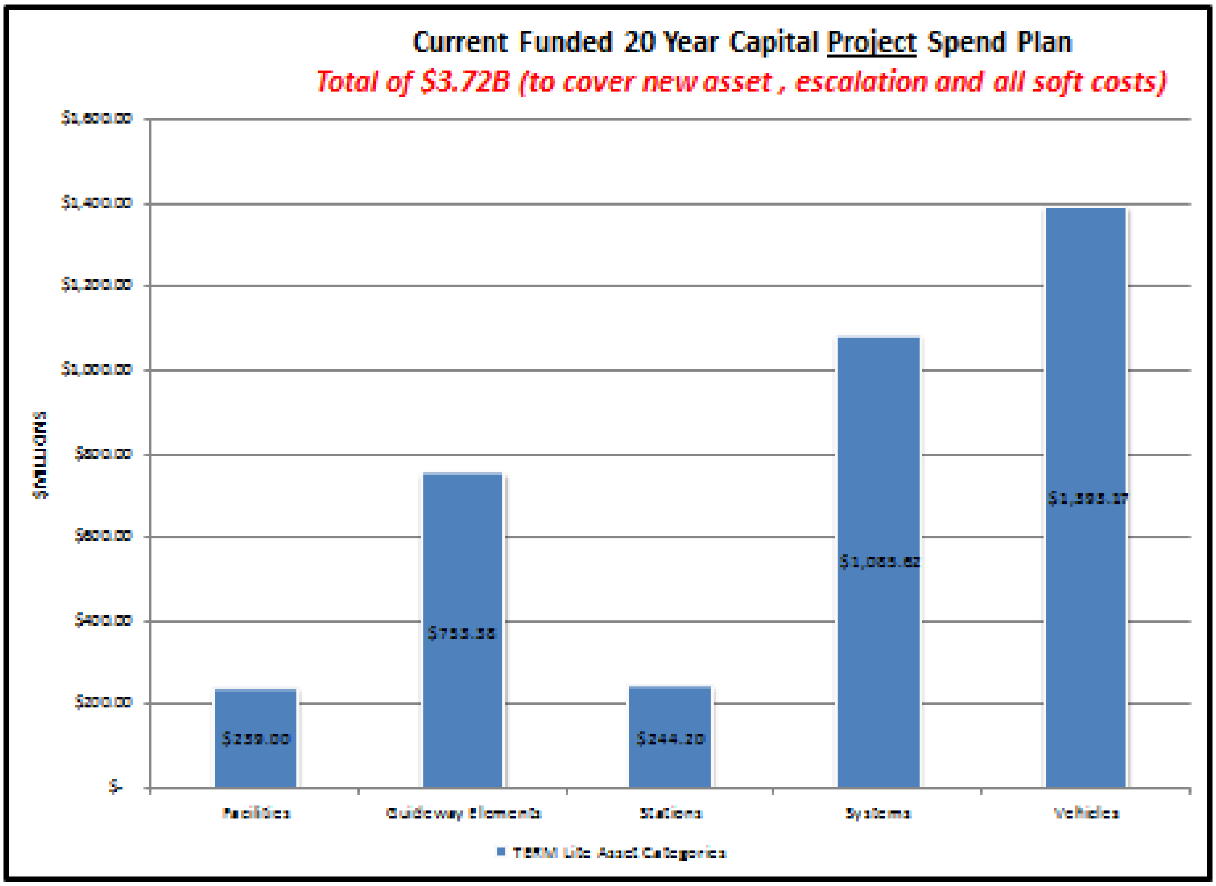


Figure 8: MARTA Current Funded 20 year Capital Project Spend Plan

MBTA

The third major transit system analyzed was the Massachusetts Bay Transportation Authority (MBTA). For this study, MBTA was not able to break out the heavy rail portion of their 20 year capital forecast, so the full system capital forecast was used

In this study, the 20 year capital forecast for MBTA for the period 2005-2024 was compared to the TERM capital forecast for the period 2010-2029. The analysis was performed on the full transit system (all modes).

Table 9 presents MBTA's 20 year capital needs forecast, broken down into major subcomponent areas. Table 10 and Figure 9 present the 20 year forecast for both TERM and MBTA; note the 5 year offset[5]. Table 11 summarizes the two 20 year forecasts with MBTA showing a $12.386 Billion capital needs forecast and TERM showing a $15.646 Billion capital needs forecast, for a difference of 21%.

Note the difference in backlog with MBTA showing a $2.576 Billion backlog and TERM showing a $5.046 Billion backlog.

The MBTA forecast is divided into 13 subcategories. The corresponding TERM forecast divided into 116 subcategories corresponding to seven broad transportation modes (heavy rail, light rail, commuter rail, bus, ferryboat, demand response, and system wide assets). As in the previous cases, while several of the subcategories were directly comparable (e.g., revenue vehicles), most of the TERM subcategories had to be combined to match a MBTA subcategory.

Figure 10 and Table 12 present the difference between the MBTA and TERM forecasts by subcategory. It can be seen that significant discrepancies exist in the track category ($1.24 Billion or 38%), the signals category ($1.17 Billion or 38%), and the facilities category ($0.85 Billion or 94%). there was also a large miscellaneous category of $1.77 Billion which was due to the fact that it was not clear where a large number of the 116 TERM subcategories belonged (they were put into the TERM miscellaneous category). There was no corresponding miscellaneous category for the MBTA.

Figures 11A and 11B and Tables 13A and 13B show the distribution of categories with each of the forecasts. As can be seen the MBTA forecast has Revenue Vehicles as it largest item at 31.7% followed by track, signals and facilities, while the TERM forecast has track and revenue vehicles as its largest items at 22% each followed by signals representing 19.7%. In both cases, revenue vehicles, track and signals represented the three largest capital forecast areas.

[5] No change in dollar value was introduced to reflect the five year offset between the two forecasts.

Table 9: MBTA 20 year Capital Program (2005- 2024)

	MBTA Capital program	
Category	Amount	% Backlog
Administration	$ 27,164,995	30%
Bridges	$ 892,212,612	30%
Communications	$ 153,040,902	42%
Elevators & Escalators	$ 141,887,575	28%
Facilities	$ 1,769,585,081	2%
Fare Equipment	$ 207,083,554	30%
Non-Revenue Vehicles	$ 147,529,401	39%
Parking	$ 290,118,937	1%
Power	$ 652,419,720	10%
Revenue Vehicles	$ 3,924,916,825	4%
Signals	$ 1,912,109,025	34%
Stations		8%
Track	$ 2,176,156,419	0%
Tunnels	$ 91,478,970	0%
Yard & Shop		19%
miscellaneous		
Total	$ 12,385,704,016	13%

Table 10: MBTA vs. TERM 20 years Capital Forecast (staggered time scale)

Year	MBTA	TERM
Backlog	$ 2,575,817,397	$ 5,046,141,261
2005	$ 435,823,094	
2006	$ 368,128,780	
2007	$ 524,611,675	
2008	$ 491,265,319	
2009	$ 489,794,712	
2010	$ 622,165,350	$ 391,973,558
2011	$ 680,549,339	$ 172,669,014
2012	$ 705,020,137	$ 1,517,819,734
2013	$ 644,898,369	$ 255,831,005
2014	$ 663,658,767	$ 596,128,705
2015	$ 439,889,037	$ 356,508,603
2016	$ 355,950,021	$ 324,293,392
2017	$ 377,244,162	$ 456,100,194
2018	$ 402,020,926	$ 342,697,227
2019	$ 457,463,405	$ 542,931,204
2020	$ 468,763,586	$ 416,594,573
2021	$ 419,207,969	$ 1,424,557,850
2022	$ 460,858,663	$ 463,265,569
2023	$ 388,797,563	$ 313,413,111
2024	$ 413,775,752	$ 563,833,621
2025		$ 50,252,767
2026	$ -	$ 275,039,094
2027	$ -	$ 257,757,047
2028	$ -	$ 1,659,360,585
2029	$ -	$ 219,417,788
Total	$ 12,385,704,023	$ 15,646,585,903

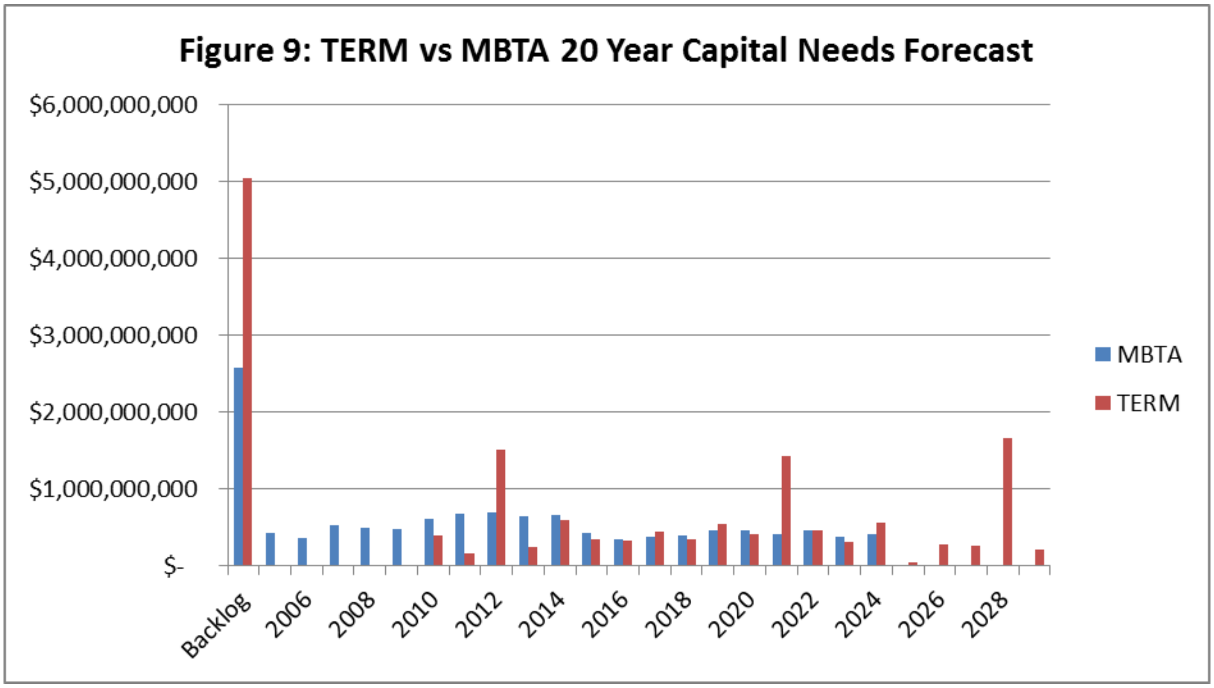


Table 11: Summary 20 year forecast for MBTA vs. TERM (State of Good Repair)

	TERM	MBTA	% difference
Total	$ 15,646,585,903	$ 12,385,704,016	21%

Table 12: TERM vs. MBTA 20 year Capital Program by Subcategory (All Modes)

Category	MBTA Capital program Amount	TERM Amount	% difference
Administration	$ 27,164,995	$ 10,751,966	-153%
Bridges	$ 892,212,612	$ 1,237,474,161	28%
Communications	$ 153,040,902	$ 180,699,750	15%
Elevators & Escalators	$ 141,887,575	$ 246,640,979	42%
Facilities	$ 1,769,585,081	$ 910,840,167	-94%
Fare Equipment	$ 207,083,554	$ 259,042,871	20%
Non-Revenue Vehicles	$ 147,529,401	$ 302,692,216	51%
Parking	$ 290,118,937	$ 422,221,182	31%
Power	$ 652,419,720	$ 377,688,292	-73%
Revenue Vehicles	$ 3,924,916,825	$ 3,397,510,508	-16%
Signals	$ 1,912,109,025	$ 3,079,890,330	38%
Track	$ 2,176,156,419	$ 3,450,035,068	37%
Tunnels	$ 91,478,970	$ 15,201	
misc.	$ -	$ 1,771,083,213	
Total	$ 12,385,704,016	$ 15,646,585,903	21%

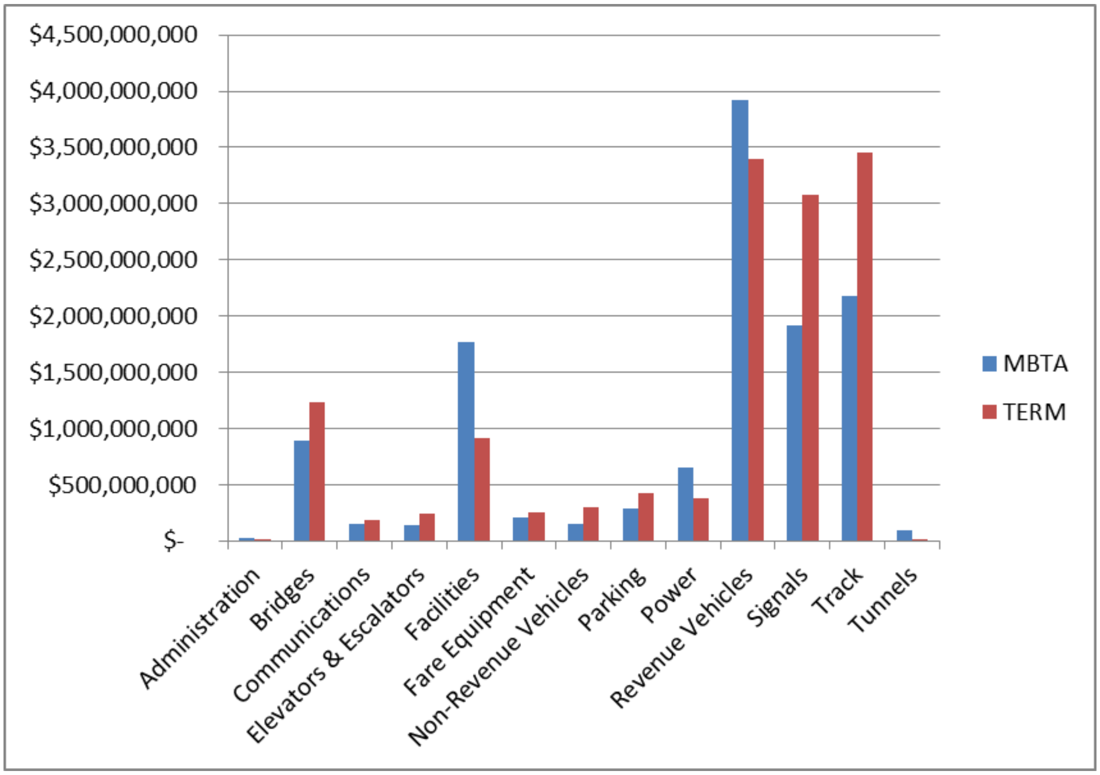


Figure 10: TERM vs. MBTA 20 year Capital Program by Subcategory

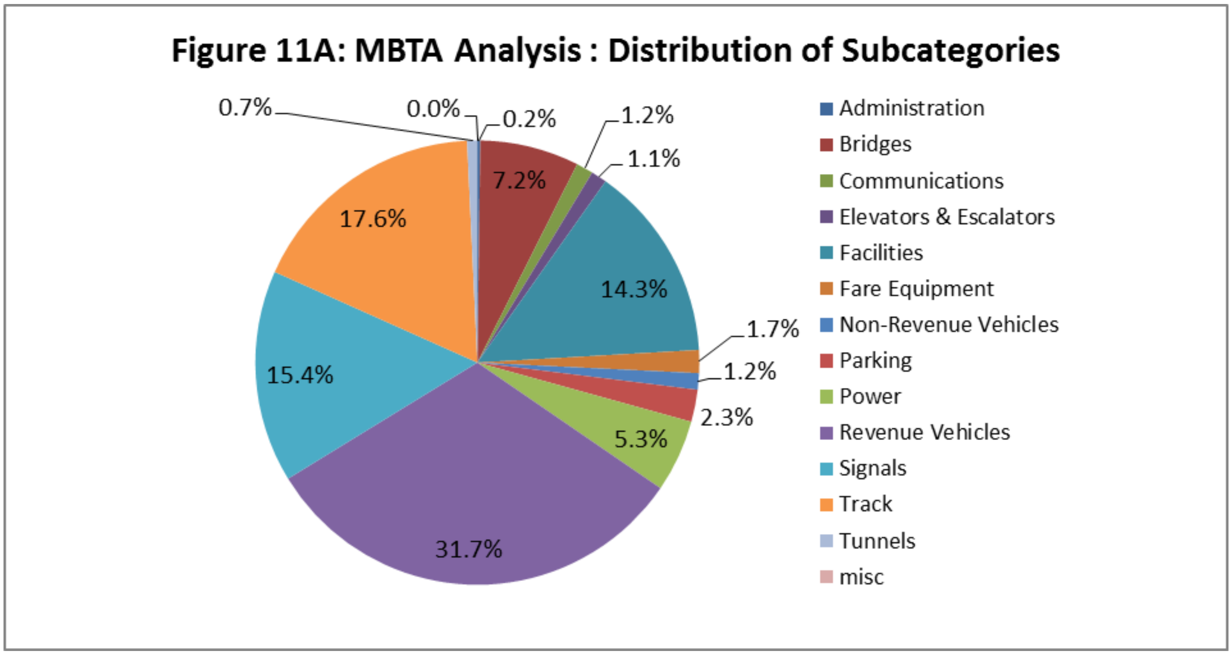
ALL MODES

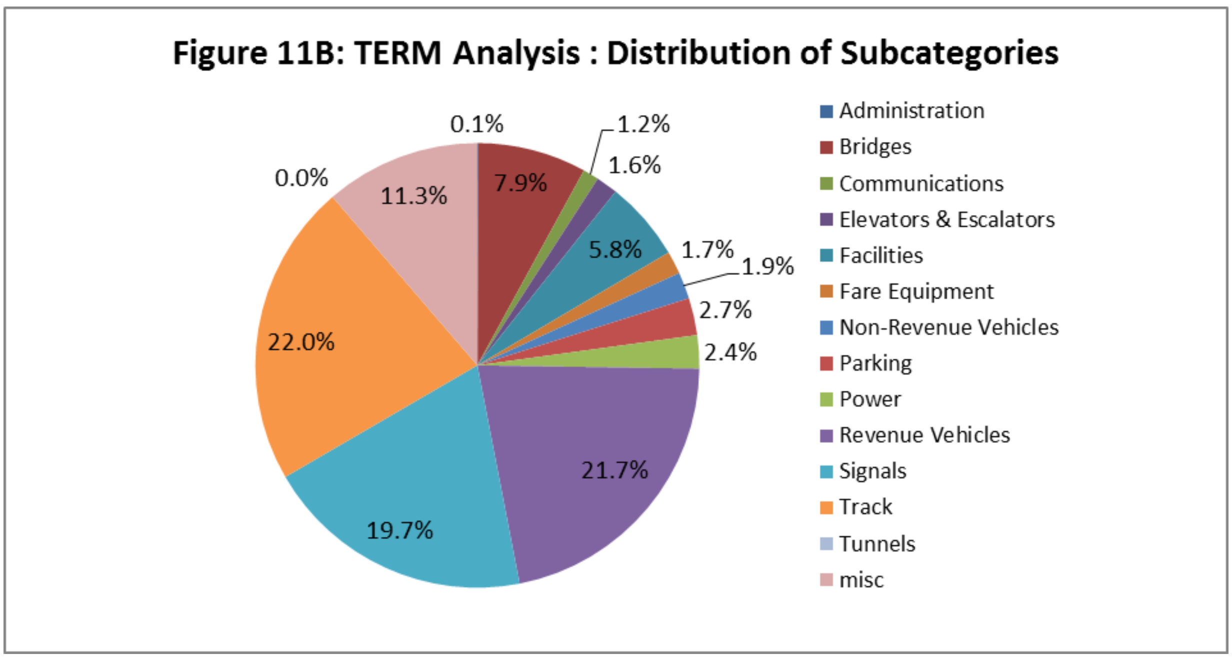
Table 13: Distribution by Subcategories

Table 13A: MBTA

Category	MBTA Capital program Amount	
Administration	$ 27,164,995	0.2%
Bridges	$ 892,212,612	7.2%
Communications	$ 153,040,902	1.2%
Elevators & Escalators	$ 141,887,575	1.1%
Facilities	$ 1,769,585,081	14.3%
Fare Equipment	$ 207,083,554	1.7%
Non-Revenue Vehicles	$ 147,529,401	1.2%
Parking	$ 290,118,937	2.3%
Power	$ 652,419,720	5.3%
Revenue Vehicles	$ 3,924,916,825	31.7%
Signals	$ 1,912,109,025	15.4%
Track	$ 2,176,156,419	17.6%
Tunnels	$ 91,478,970	0.7%
miscellaneous	$ -	
Total	$ 12,385,704,016	100.0 %

Table 13B: TERM	TERM Capital Program for MBTA	
Administration	$ 10,751,966	0.1%
Bridges	$ 1,237,474,161	7.9%
Communications	$ 180,699,750	1.2%
Elevators & Escalators	$ 246,640,979	1.6%
Facilities	$ 910,840,167	5.8%
Fare Equipment	$ 259,042,871	1.7%
Non-Revenue Vehicles	$ 302,692,216	1.9%
Parking	$ 422,221,182	2.7%
Power	$ 377,688,292	2.4%
Revenue Vehicles	$ 3,397,510,508	21.7%
Signals	$ 3,079,890,330	19.7%
Track	$ 3,450,035,068	22.0%
Tunnels	$ 15,201	0.0%
miscellaneous	$ 1,771,083,213	11.3%
Total	$ 15,646,585,903	100.0 %





Analysis of the differences in the two sets of forecast suggests here to that differences in definition of asset condition and asset replacement life may be present, particularly in the areas of track, signals and facilities.

SUMMARY

The comparison of 20 year capital forecast by the FTA FTA's Transit Economic Requirements Model (TERM) was compared to following three major US transit agencies' internal 20 year forecasts.

- New York City Transit (NYCT); heavy rail transit only.
- Metropolitan Atlanta Rapid Transit Authority (MARTA); heavy rail transit only
- Massachusetts Bay Transportation Authority (MBTA); All systems[6]

Overall, the results of the comparison were quite close. The specific comparisons were as follows:

- NYCT heavy rail transit 20 year forecast was approximately 17% lower than the TERM forecast
- MARTA heavy rail transit 20 year forecast was approximately 4% lower than the TERM forecast
- MBTA full system 20 year forecast was approximately 21% lower than the TERM forecast

From the outset, it was observed that forecasts within 20% of each other were considered "good" in light of the large amounts of data, the large range of assets analyzed, and the diversity of the different transit systems.

However, more detailed analysis of the forecast by subcategory area and backlog showed some significant variation in some of the individual categories.

Thus for example, in the case of NYCT, the largest transit system in the US, the overall 20 year NYCT capital forecast was approximately $72.2 Billion, while the corresponding TERM forecast was approximately $87.4 Billion, a difference of approximately $15.25 Billion or 17%. Given that the difference in backlog between the two forecasts is approximately $19 Billion or 57%, this suggests that the difference in backlog may be a key factor in this difference.

Looking into the criteria used to determine asset replacement (and thus backlog when the asset life exceeds the replacement date), and based on discussions with NYCT personnel, it appears that NYCT has changed their replacement (backlog) definitions and are using more condition based criterion rather than simply age. This includes using more inspection based condition criterion than in the past, and using this inspection based condition as the basis for defining when replacement is required. They have reported that this type of condition based replacement criterion is more accurate and more effective than age based criterion alone and is now being done by NYCT for many of their major capital program categories such as revenue vehicles, track, yards, buildings, etc.

As an example, in the case of revenue vehicles, which had a $7.5 Million discrepancy between the two forecasts,   NYCT increased the age for rolling stock replacement to 40 years while the

[6] MBTA was not able to break out the heavy rail portion of their 20 year capital forecast, so the full system capital forecast was used.

TERM model used 28 or 29 years. This represents a 38 to 43% higher replacement rate for TERM and appears to account for the difference in the Revenue Vehicle category which was 40%. It also represents a significant portion of the total 20 year difference between TERM and the NYCT capital program forecast as well as a significant part of the difference in reported backlog.

In addition, other significant discrepancies showed up in the line equipment category ($9.7 Billion or 58%), the communications category ($3.3 Billion or 2000%), the yard category ($2.2 Billion or 750%), and traction power ($2.1 Billion or 42%).

Still other forecast categories like buildings, structures, stations, track, and train control were in within 25% of each other, and in some cases, within less than 10% of each other.

In the case of MARTA, likewise some categories showed good agreement while others showed significant discrepancies. Thus significant discrepancies exist in Revenue Vehicle category ($1.64 Billion or 52%), and the Facilities category ($1.69 Billion or 1131%). However, good agreement was seen in the Guideway Elements category and the Systems[7] category with differences of 11% and 27% respectively.

Here too, Revenue Vehicles represented one of the two largest dollar difference between the two forecasts with the TERM forecast being $1.85 Billion greater than the MARTA forecast. This difference again appears to be due to the difference in condition definition and the current age based replacement approach of TERM. As noted, MARTA recently (2009) completed a set of major overhauls of 65% of their fleet extending the replacement life by 12 to 15 years, thus moving the capital replacement costs out further in the capital budget forecast cycle.

In the case of the MBTA (full system comparison) significant discrepancies were noted in the track category ($1.24 Billion or 38%), the signals category ($1.17 Billion or 38%), and the facilities category ($0.85 Billion or 94%). There was also a large miscellaneous category of $1.77 Billion which was due to the fact that it was not clear where a large number of the 116 TERM subcategories belonged (they were put into the TERM miscellaneous category). There was no corresponding miscellaneous category for the MBTA.

In both cases however, revenue vehicles, track and signals represented the three largest capital forecast areas.

Here too, analysis of the differences in the two sets of forecast suggests here to that differences in definition of asset condition and asset replacement life may be present, particularly in the areas of track, signals and facilities.

Overall, it appears that the TERM model did provide meaningful and valuable guidance as to the capital needs of the three agencies examined. While there were significant discrepancies in some areas, there was reasonable agreement in others. This can be seen in Table 14 where the major

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[7] Note that the systems category combined several major subcategories to include Power, fare Collection and Signals.

subcategories were consolidated into four major subcategories and the TERM results compared with the agency results[8].

TABLE: 14 Consolidated Subcategories by Agency (Millions of $)

	New York			MARTA			MBTA		
Category	**TERM**	**Agency**	**%Diff**	**TERM**	**Agency**	**%Diff**	**TERM**	**Agency**	**%Diff**
Facilities	4,863	4,944	-2%	150	1,840	-1127%	911	1,770	49%
Guideway Elements	14,341	11,522	20%	2,437	2,174	11%	4,688	3,160	-48%
Systems*	33,696	27,777	18%	835	1,058	-27%	4,144	3,067	-35%
Revenue Vehicles	18,729	11,278	40%	3,127	1,488	52%	3,398	3,925	13%

* This category includes signals, fare collection, power, communications, etc.

In order reduce these discrepancies and improve the agreement between TERM and agency internal forecasts the following recommendations are presented:

1. It appears to be appropriate for TERM to reexamine its current asset life criterion in light of the apparent move by several of the transit agencies to more condition based replacement criterion. This may overcome some of the largest of the discrepancies, particularly those that contribute to large backlog requirements. This is particularly important since agencies have trouble playing "catch-up" on their backlogged assets.
2. Likewise TERM should reexamine some of its planning horizons, particularly if it could include major asset replacement forecasts such as key structures with very long lives.
3. TERM should work with transits to allow for better (and more standardized) definition of asset categories and subcategories. A major problem encountered was that of matching subcategories between the TERM and the transit forecast.

[8] The % difference was calculated with respect to the TERM forecast, so that the TERM forecast was the denominator in the % calculation equation.

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