Chicago Transit Authority
Rail Fleet Management Plan

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Office of the Director of Rail Maintenance, Chicago Transit Authority

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Definition of Terms

AA	Alternatives Analysis
A/C	AC (alternating current) propulsion
ADA	Americans with Disabilities Act
AAR	Association of American Railroads
APTA	American Public Transportation Association
Base service	Service periods that occur before, between and after rush periods
CAGR	Compound Annual Growth Rate
CCM	Computer Controlled Magnetic
CMAP	Chicago Metropolitan Agency for Planning
CPI	Consumer Price Index
CTA	Chicago Transit Authority
EIS	Environmental Impact Statement
FTA	Federal Transit Administration
HVAC	Heating, Ventilating, and Air Conditioning
IDES	Illinois Department of Employment Security
LEM	Lea, Elliot, McGean & Company
LPA	Locally Preferred Alternative
MMBRD	Mean Miles Between Reported Defects
MMIS	Maintenance Management Information System
NTD	National Transit Database
ODE	Origin-Destination Estimation
Peak period	7–9 AM and 4-6 PM based on average weekday hourly ridership data
PVR	Peak Vehicle Requirement
RCMP	Rail Car Maintenance Plan
RFMP	Rail Fleet Management Plan
RTA	Regional Transportation Authority
Rush period	Approximately 5:30 a.m. to 9:00 a.m. and 3:30 p.m. to 6:30 p.m. on weekdays
Slow zones	Track areas where trains are required to operate at slower-than-normal speeds
SMP	Scheduled Maintenance Program
TRT	Terminal Reserve Trains or Gap Trains
UPRR	Union Pacific Railroad
UMT	Urban Mass Transportation
UMTA	Urban Mass Transportation Administration
USDOT	United States Department of Transportation
VMT	Vehicle Maintenance Terminal

Introduction

The Chicago Transit Authority operates the second largest rapid transit system in the United States. The mission of the CTA is to provide quality affordable transit services that links people, jobs and communities. The CTA is meeting this challenge by striving to understand its customer's needs and then meeting or exceeding their expectations. In an era of limited funding, this can only be accomplished through effective allocation of its rail service and efficient utilization of vehicles to meet those service demands.

The CTA has developed this Rail Fleet Management Plan to provide a methodology for understanding and managing the relationship between rail service requirements and car availability. Through the Rail Fleet Management Plan, rail car service requirements are evaluated considering current and projected ridership, train intervals and platform and rail car passenger loading. To support the resulting service requirements, the Rail Fleet Management Plan analyzes the CTA rail car fleet in terms of size and availability. Although fleet size is generally a relatively static number, rail car availability is largely a function of proper maintenance. The CTA has developed a Rail Car Maintenance Plan that defines our maintenance practices and policies. By utilizing both the Rail Fleet Management Plan and the Rail Car Maintenance Plan, we are able to effectively manage and utilize the rail car assets of the Chicago Transit Authority.

This Rail Fleet Management Plan includes estimated service levels through 2020. Although the projections made within this Plan utilize the most current information available, they are not intended to be absolute, but rather a reflection of the CTA's best efforts to forecast the many variables that influence the Rail System. Calculations are made for the Peak Vehicle Requirement, which determines how much vehicle capacity will be required in order to meet future increase ridership demands in order to prevent overcrowding and improve service reliability.

The CTA's Rail Fleet Management Plan is a living document that will evolve as ridership, customer expectations, equipment and maintenance practices change. Certainly funding levels will also play a key role in this process, as both new car purchases and maintenance programs are heavily dependent upon adequate and consistent financial support. With the CTA's current efforts to bolster support for adequate funding, it is important to assure that the resources that are currently available will be used to their best advantage to provide on-time, clean, safe and reliable service.

Section 1.0 - System Overview

The Chicago Transit Authority provides service over eight rail routes throughout the City of Chicago and seven suburbs. Appendix 1 depicts the CTA rapid transit service area and station locations. The CTA's fleet of 1190 rapid transit cars operates over 224 miles of track, make approximately 2,157 trips each day and serve 144 stations. During 2009, the rapid transit system provided over 71 million rail vehicle miles of scheduled service and carried over 202.5 million passengers including transfers.

Around-the-clock service is provided on its two largest routes, the Red and Blue Lines. Six routes, the Orange, Brown, Pink, Purple, Yellow, and Green Lines provide daily service at all times except overnight. CTA trains make all stops along their route, except for a small number of stations closed for construction. Free connections between routes are available at certain stations.

1.1 Rail Service Operations

As with all rapid transit properties, the CTA has developed operating policies that are designed to ensure the best possible service for our customers. These policies are often dictated by the unique characteristics of Chicago's century old rapid transit infrastructure, such as the mix of block signal and ATC train control systems on some routes. Other operating policies have developed as a result of changes in ridership, such as the current all stop policy in lieu of A/B skip stops.

Scheduled rail car service for the Chicago Transit Authority includes two rush periods, one in the morning from about 5:30 am to 9:00 am and one in the afternoon from about 3:30 p.m. to 6:30 p.m. Base service periods occur before, between and after the rush periods. Trains run every 3 to 12 minutes in weekday rush hours, and every 6 to 20 minutes at most other times. Overnight or "Night Owl" service is run only on the Blue and Red Lines from 1:30 am to 4:30 am. During these times, trains run every 15 to 30 minutes, depending upon the Route.

Equipment is utilized to form the best balance between the level of service demand and rolling stock availability. Schedules are prepared to obtain the greatest use of cars with a minimal amount of switching. Fewer cars are scheduled when traffic is light; while weekday rush periods and special events find almost all equipment available pressed into service.

During certain special civic events extra service is provided. This may range from simply expanding some Base and/or Evening train consists to adding many extra trains to the schedule. While such events are few throughout the year, the ridership associated with them places a very high demand on the rolling stock. Sometimes special events occur after the afternoon rush, requiring that rush period trains stay in service longer to handle traffic.

All regular service is scheduled by headway (interval) and consist length. Ridership is checked periodically and schedules are adjusted as traffic warrants. Route management has the authority to deviate from schedules any time passenger loads warrant, by changing the interval or by altering train length.

1.2 The CTA Rail Car Fleet

The CTA rail car fleet consists of 1190 revenue rail cars. In addition, CTA is currently testing 10 prototype cars from Bombardier. The current fleet composition and route assignment is reflected in the Appendix II. Refer to Appendix III for Car Layout Diagrams.

The 1190 revenue rail cars comprise of four distinct car series, delivered between 1969 and 1994. The oldest revenue cars (2200 Series) average 40 years old and the newest (3200 Series) are approximately 17 years old. The average age of the fleet at the end of 2010 was 26.6 years. Currently 64% of the fleet meets or exceeds the FTA recommended minimum 25-year life of a rapid transit car (142 – 2200 Series Cars, 194 – 2400 series Cars, and 430 – 2600 Series Cars).

Bids were opened in 2006, and a contract awarded in May 2006 to Bombardier, for a new series of equipment called the 5000-series rail car. Ten prototype vehicles were delivered for testing purposes in the Fall of 2009, with production delivery to begin after successful completion of the testing of the prototypes. This is expected to occur in the spring of 2011. This series will be the first at CTA to have A/C propulsion and video monitoring for security and vandalism deterrence. Due to their advanced technology, these cars are not electrically compatible with the rest of the rail car fleet. Although the cars can be mechanically coupled to other series cars for movement in emergency situations, they cannot be electrically coupled and operated with other series cars. Therefore, the 5000's will be assigned to routes as the sole series on the routes as much as possible to minimize the chance of unintended couplings.

All cars are of stainless steel construction, are 48 feet long and semi-permanently coupled into married pairs. All current revenue cars, excluding the 5000-series cars, are mechanically and electrically compatible and thus can be coupled together and run in mixed series consists. Train length varies from two cars to eight cars, although car designs can accommodate train consists up to ten cars. All cars are air-conditioned and all but the 2200 series are ADA accessible.

The cars obtain 600 VDC operating power from an uncovered third rail. The 2200 and 2400 series cars are equipped with cam control groups for their propulsion systems. A microprocessor controlled cam group is utilized on the 3200 series cars as original equipment. The 2600 series car propulsion system has also been upgraded to the 3200 series style microprocessor controls as part of rehabilitation program completed in 2002. The primary braking system consists of dynamic brakes supplemented with friction brakes for service stops. All cars are also equipped with track brakes for emergency purposes.

In the next several years, the CTA's rail car fleet will change substantially. Please refer to Appendices IV and V for the historical and current Rail Fleet Capital Program Plans. There are 142 of the 2200 Series cars currently in service on the Blue Line, and 194 of the 2400 Series cars on the Green and Purple Lines. These cars will be replaced over the next several years as we receive the new 5000-series cars from Bombardier. These replacement programs account for 336 cars of the 406 cars currently on order. The remaining 70 cars will allow for increased service. The 406 cars include the base order of 206 cars and the exercised first option of 200 rail cars. The CTA is attempting to secure funding for the purchase of 300 additional cars from Bombardier by exercising the remaining options available in the purchase contract. If this is accomplished, between 250 and 300 of the 2600-series rail cars will be replaced by these additional 5000's. This would occur after delivery of the first 406 cars, beginning in 2014. The addition of these cars will require the CTA to acquire new training, tools, and some new personnel. These upcoming changes are addressed throughout the Rail Car Maintenance Plan.

1.3 Rail Car Maintenance Facilities

Ten Rail Terminal Maintenance Shops (Terminal Shops) are located throughout the rail system to maintain the rail car fleet on a day-to-day basis. These facilities perform routine inspections, running repairs and car cleaning activities. One heavy maintenance facility (Skokie Shop) performs major repairs, car overhauls, and component rebuilding activities. In addition, the Skokie Shop currently performs the scheduled and unscheduled maintenance for the non-revenue rail service vehicle fleet (cranes, flatcars, tampers, ballast regulators, diesel powered snow removal locomotives, etc.). Until 2009, this work was completed at the 61st Street Shop, which has since been condemned and demolished. A new facility is being designed to be built at 63rd Street adjacent to the Green Line to accomplish this non-revenue equipment maintenance in the future. The building is expected to be complete in 2013. See Appendix VI for a map showing shop locations, and see Appendix VII for a listing of the capabilities of each facility. More information regarding the rail car maintenance facilities, staffing, and tools is provided in the Rail Car Maintenance Plan.

Section 2.0 - Service Requirements for Rail Cars

This section provides the methodology and projections for rail car requirements from 2010 to 2020. The eight step guidance provided by the FTA in the Hiram J. Walker memo is used to determine the demand requirement for rail cars.

2.1 PVR Analysis, Step One – Peak Passenger Demand

2.1.1 Annual Rail Ridership Trend

The CTA provides 1.7 million rides on an average weekday, accounting for over 80% of all transit trips taken in the six-county Chicago metropolitan region. CTA's total ridership has increased by about 18% over the past 15 years, most of which is due to a 50% increase in rail ridership during this period (Figure 1). Rail ridership has grown at a higher rate than bus ridership during this period. In 2009, rail rides accounted for 39% of the total system ridership of 521 Million.

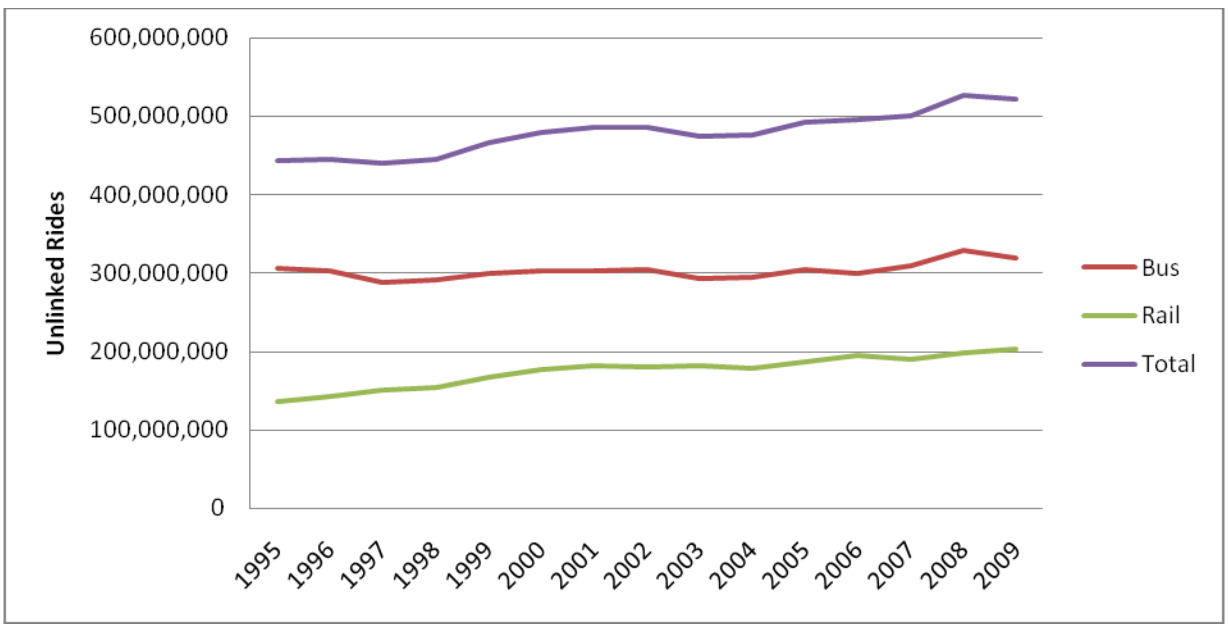


Figure 1. CTA System Ridership Trend (Unlinked Rides)

The rail system ridership increases are considered to be a result of several factors, including improved service, rail infrastructure investments, and removal of slow zones.[1] Other factors like unstable gas prices and the Authority's dedication to clean, safe, on-time, and friendly service also play a significant role. CTA completed the $530 million Brown Line Capacity Expansion Project in 2010, which included renovation of 18 stations.

CTA implemented rail and bus service reductions in the spring of 2010 to reduce costs and maximize efficiency while retaining as much service as possible. CTA bus service was reduced by 18% and rail service was reduced by 9%. The peak period changes in rail service included frequency reductions. Rail ridership has continued to increase after the service cuts.

2.1.2 Peak Rail Ridership Projection

CTA uses a linear regression model, updated annually by CTA staff with new baseline data and assumptions, to estimate annual system ridership. The model was initially developed by consultants using statistical software to identify statistically significant variables that influence ridership. The variables used in the model to project ridership are indicators of employment, labor force, service levels, fares, and gas price. Average weekday, Saturday, and Sunday ridership is modeled separately and then aggregated to get monthly ridership based on number of days of each day type in the month. The model was developed using monthly data instead of annual data to take monthly variations into account and to have more data points thereby increasing the robustness of the model. Monthly rail ridership is aggregated to get annual rail ridership projections.

The following assumptions for future years are made in the model:

- Fuel prices are assumed to increase annually by 5% from 2011. During the first half of 2010, the Consumer Price Index (CPI) for gasoline went up by 30% as compared to 2009, so 5% is a conservative assumption.

- Service levels are assumed to remain constant until 2013 because of potential operating funding shortfalls and then increase at a historic trend of 1% growth per year.

- Average fares are assumed to increase every alternate year by 7% (approximate 25 cents increase on base fare) starting 2012, to keep up with the inflation.

- Employment in Chicago is assumed to go up by 0.9% in 2011. 2010 assumption is based on the data available for first few months of 2010 from Illinois Department of Employment Security (IDES) at the time of this forecast. The 2011 assumption of 0.9% increase is in between calculated Compound annual Growth Rate (CAGR) from Chicago Metropolitan Agency for Planning's (CMAP) 2030 projections of 0.5% and IDES' CAGR for Cook County of 1.4%. It also seems likely that employment will slightly pick up in 2011 as economy recovers.

[1] Slow zones are areas where trains are required to operate at slower-than-normal speeds due to track conditions. Slow zone elimination work typically involves replacing aging rail ties and tie plates with new ties and plates, if not whole track replacement.

Table 1 gives ridership projections for the next ten years. 2011-2020 ridership projections are obtained from the model and using the assumptions described above. CTA fares are not assumed to increase in 2011, whereas gas price is assumed to go up, because of which CTA would be more cost effective to customers in 2011 than in 2010 as compared to driving. Therefore ridership is expected to continue to grow at a rate of 3.4% in 2011. Besides gas price, increase in employment and a natural trend of growth in rail ridership over the past few years due to any other unaccounted factors would also contribute to growth in 2011. Fares are expected to increase in 2012, because of which, ridership is expected to grow at a slower rate of 0.7%. There is a similar drop in projected ridership in other years in which fares are assumed to increase.

2010 ridership projections are a continuation of trends observed during the first half of the year and are not obtained from the model described above. During the first half of 2010 (January to August), CTA rail ridership grew at a rate of 4%. Based on this growth trend and month-to-month variations (including seasonal and calendar day variations), it is projected that total rail ridership will increase by 2.6% and weekday rail ridership by 1.8% by 2010 year end as compared to 2009.

Year	Rail Ridership	Rail Ridership Growth Rate	Weekday Rail Ridership	Weekday Rail Ridership Growth Rate
2005	186,759,524		608,156	
2006	195,169,310	4.5%	635,439	4.5%
2007	190,272,997	-2.5%	619,764	-2.5%
2008	198,137,245	4.1%	641,783	3.6%
2009	202,569,038	2.2%	649,426	1.2%
2010	207,870,000	2.6%	661,082	1.8%
2011	215,040,000	3.4%	682,918	3.3%
2012	216,430,000	0.7%	680,572	-0.3%
2013	224,790,000	3.9%	704,081	3.5%
2014	226,090,000	0.6%	703,024	-0.2%
2015	235,400,000	4.1%	728,896	3.7%
2016	237,480,000	0.9%	727,943	-0.1%
2017	246,660,000	3.9%	754,797	3.7%
2018	248,660,000	0.8%	753,704	-0.1%
2019	259,200,000	4.2%	781,457	3.7%
2020	261,760,000	1.0%	780,390	-0.1%

Table 1. Annual Rail Ridership Projections

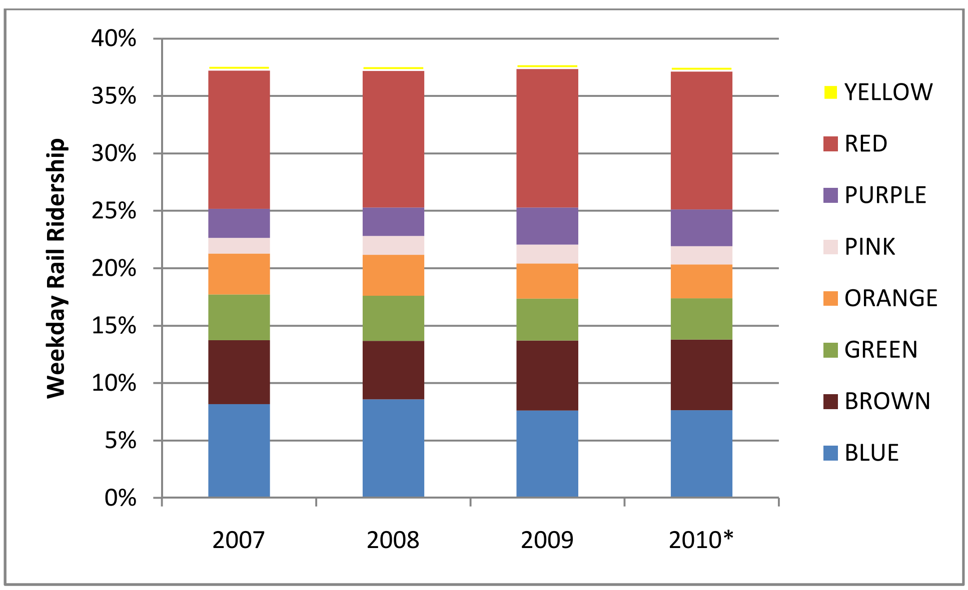
Numbers in grey are actual, numbers in black are projections

2.1.3 Weekday Peak Rail Ridership by Line Trend

The average weekday growth rates in Table 1 are for the whole system. Because the Peak Vehicle Requirement (PVR) is determined by the ridership growth during the peak period at the peak load station for each line, it is important to further understand and analyze if there is variation in peak rail ridership growth by line or if it can be assumed that the peak ridership on all lines will grow at the same rate.

Figure 2 shows peak period[2] ridership by line as a share of average weekday rail ridership for years 2007 to 2010. The Automatic Fare Card data does not segregate ridership by line for stations where several rail lines share the same rail station and is supplemented with information from CTA's internal Origin – Destination Estimation model to obtain the information presented in Figure 2. CTA's Rail System Origin-Destination Estimation (ODE) model utilizes automated farecard data to estimate the movement of passengers throughout the rail system. Ridership data at this disaggregate level is not available for years before 2007.

Figure 2 shows lower peak ridership share on Brown and Purple lines in the years 2007 and 2008 as compared to 2009 and 2010. This can be attributed to Brown Line Capacity Expansion project, which led to fewer trains during the peak period and shift of ridership to supplemental bus routes in the corridor. After the completion of the project, and restoration of the service, Brown and Purple lines gained back ridership in years 2009 and 2010. Rerouting of loop service during the Brown Line Capacity Expansion project period also led to some increase in ridership on Orange line in 2007 and 2008.



**2010 figures are based on January - September ridership*

Figure 2. Peak Weekday Rail Ridership By Line

[2] Peak period is defined as 7–9 AM and 4-6 PM based on average weekday hourly ridership data.

Because of the temporary service changes and ridership shifts caused by the Brown Line Capacity Expansion project, 2007 and 2008 ridership figures are not suitable to be used for projecting peak rail ridership by line. Between the years 2009 and 2010, each line's peak period ridership as a share of total ridership has remained almost constant (Figure 2). Therefore it is assumed that the peak weekday ridership on all lines will grow at the same rate as identified in Table 1. This growth rate is applied to each line's peak passenger demand at the maximum load point, identified and explained in Step Two under Passenger Load Factor.

2.1.4 Proposed Rail Service Expansion

The CTA has completed Alternatives Analysis (AA) studies in 2009 to extend service on the existing Red, Orange, and Yellow lines and on a new Circle line. These studies are conducted under the Federal Transit Administration's New Starts grant funding program. CTA and FTA has initiated the Environmental Impact Statement (EIS) phase of the Red, Orange, and Yellow line extension projects to evaluate the environmental effects of constructing and operating the proposed extension. CTA is also currently pursuing a project to modernize the Red and Purple Lines.

Red Line Extension and Red and Purple modernization (North Red and Purple Line Improvements) projects are in the list of fiscally constrained projects in Chicago region's long-range transportation plan developed by Chicago Metropolitan Agency for Planning (CMAP) – CMAP 2040. All the other above mentioned projects are in the unconstrained list of projects in the long-range plan. The timeline of these projects is not known and is contingent on future funding availability. PVR for each of these long-range projects is projected separately for each project and is included in Step Six. A brief description on each of these projects and estimated ridership projections are provided below:

2.1.4.1 Red Line Extension

The CTA is proposing to make transportation improvements by extending the Red Line from the 95th Street station to 130th Street. The Red Line was put into operation in 1969. Plans to extend the Red Line to the southern city limits were made shortly thereafter but have not yet been implemented. The CTA and FTA initiated an AA study for the proposed extension in 2006 and completed it in 2009 with the identification of a Locally Preferred Alternative (LPA). The proposed LPA would extend the heavy rail transit line from the existing Red Line 95th Street Station to 130th Street along the Union Pacific Railroad (UPRR) corridor.

The proposed LPA is 5.3 miles long and would include three new intermediate stations at 103rd, 111th, and 115th Streets and a new terminal station at 130th Street with new park-and-ride and bus terminal facilities at each station. Ridership estimates for the year 2030 were developed using computerized regional travel forecasting models. By 2030, the LPA is expected to carry 13 million rides per year.

2.1.4.2 Orange Line Extension

The CTA is proposing to make transportation improvements by extending the Orange Line, a heavy rail transit line, to connect Midway Station at the Midway International Airport to Ford City. The Orange Line opened in 1993, providing service to the southwest side of Chicago and

Midway International Airport. The original project proposal was for the southern terminal of the Orange Line to be located in the vicinity of the Ford City Mall. Due to funding limitations, the terminus was shortened to Midway Airport. The CTA and FTA initiated an AA study for the proposed extension in 2006 and completed it in 2009 with the identification of a LPA

The proposed LPA is a 2.3-mile extension with no intermediate stops. Ridership estimates for the year 2030 were developed using computerized regional travel forecasting models. By 2030, the LPA is expected to carry 2.4 million rides per year.

2.1.4.3 Yellow Line extension

The CTA is proposing to make transportation improvements by extending the Yellow Line from Dempster Station to Old Orchard Road. The Yellow Line opened in 1964 as the "Skokie Swift" with service from Howard Station to Dempster Station. The regional long range transportation plan developed by the CMPA has included an extension of the Yellow Line to the north since the 1980s. In addition, the Village of Skokie, with assistance from the Regional Transportation Authority (RTA) conducted a feasibility study on a potential extension to the vicinity of Old Orchard Road in 2003. The CTA and FTA initiated an AA study for the proposed extension in 2006 and completed it in 2009 with the identification of a LPA.

The proposed LPA is 1.6 miles long with no intermediate stops would extend the heavy rail transit line from Dempster Station north along the Union Pacific Railroad (UPRR) right-of-way from Dempster Street to the vicinity of Old Orchard Road. Ridership estimates for the year 2030 were developed using computerized regional travel forecasting models. By 2030, the LPA is expected to carry 1.8 million rides per year.

2.1.4.4 Circle Line

The Circle Line is a proposed circumferential line that would link CTA and Metra's radial lines, creating improved connections throughout the region. The purpose for a circumferential ("circle line") transportation project connecting the existing CTA rapid transit and the Metra commuter rail radial systems to stations located west and outside of the downtown would be to provide better access to employment and activity centers, improve the quality of transfers between transit modes, and increase overall system efficiency. The CTA and FTA initiated an AA study in 2004 and completed it in 2009 with the identification of a LPA.

The LPA leverages existing assets by utilizing existing CTA rail infrastructure for the majority of its proposed route. The alignment would follow the existing tracks for the Purple Line from the North Side of Chicago, descend into the existing State Street Subway used for the Red Line, switch to the Orange Line using the existing 13th Street Incline, and continue southwest along the Orange Line. In the vicinity of the existing Ashland station along the Orange Line, the alignment would swing north along new track to connect to the Pink Line. The alignment continues along the existing Pink Line to the Lake/Ashland station on the Green and Pink lines where the LPA would terminate. The LPA includes 2.2 miles of new aerial structure, connecting Orange and Pink lines. Ridership estimates for the year 2030 were developed using computerized regional travel forecasting models. By 2030, the LPA is expected to have 25,000 average weekday boardings.

2.1.4.5 Red & Purple Modernization

The CTA is proposing to make transportation improvements by modernizing the Red and Purple Lines from Clark Junction (north of Belmont station) to Linden terminal in Wilmette. This portion of the Red and Purple Lines was substantially built in the 1920s. The CTA initiated a Vision Study in 2009 to identify options for modernization. The modernization would improve travel times and provide for Americans with Disabilities Act (ADA) access at stations. The potential alternatives also include lengthening Purple line station platforms to accommodate eight car trains from the current six car train lengths. The corridor to be modernized is approximately 9.5 miles long and currently includes 21 stations. The Red and Purple Lines in this corridor currently carry 41.9 million rides per year.

2.2 PVR Analysis, Step Two – Passenger Load Standards and Load Factors

2.2.1 Passenger Load Standards

The CTA adopted bus and rail service standards in 2001. The service standards provide a framework for a consistent and fair evaluation of both existing and proposed services. Because markets, customer expectations and CTA's resources change over time, service standards are evolutionary by nature. CTA must be responsive to these changes in order to retain current customers and achieve and sustain ridership growth.

Table 2 gives the Service Standards for peak period rail service corresponding to different passenger flow levels. Service frequency and passenger flow are very closely related. Above the minimum service levels, service frequency is determined by customer demand. Each rail line is evaluated in terms of maximum passenger flow, which is defined as the number of passengers on rail cars, passing the busiest location(s) along the route, called maximum load point(s). Rail frequency guidelines determine appropriate service levels for a given level of demand (passenger flow per half-hour at the maximum load point). The level of service is expressed in terms of the number of cars per half-hour and the resultant trips per half-hour and interval for a given maximum train length. In Table 2, it should be noted that as the passenger flow decreases, recommended maximum average load per car also decreases from 90 to 50 to maintain minimum frequency levels on low passenger load segments, optimize passenger wait time, and prevent overcrowding in case of delays. Also different frequencies are suggested for different train lengths. Using the guidance from service standards, schedules for different lines are designed for different maximum average load per car even though the physical capacity of cars operating on all the lines is similar.

Table 2. Peak Period Rail Service Standards

Every Half-Hour at Most Crowded Location			8-Car Trains		6-Car Trains		4-Car Trains		2-Car Trains	
Passengers	Cars	Avg. per Car	Trips	Interval	Trips	Interval	Trips	Interval	Trips	Interval
6,121-7,200	80	77-90	10.0	3.0						
5,401-6,120	68	79-90	8.5	3.5						
4,681-5,400	60	78-90	7.5	4.0						
4,591-5,400	60	77-90			10.0	3.0				
3,841-4,680	52	74-90	6.5	4.5						
4,051-4,590	51	79-90			8.5	3.5				
3,511-4,050	45	78-90			7.5	4.0				
3,521-3,840	48	73-80	6.0	5.0						
2,801-3,520	44	64-80	5.5	5.5						
2,881-3,510	39	74-90			6.5	4.5				
2,641-2,880	36	73-80			6.0	5.0				
2,521-2,800	40	63-70	5.0	6.0						
2,101-2,640	33	64-80			5.5	5.5				
2,381-2,520	36	66-70	4.5	6.5						
1,891-2,100	30	63-70			5.0	6.0				
1,921-2,380	34	57-70	4.3	7.0						
1,681-1,920	32	53-60	4.0	7.5			8.0	3.8		
1,751-1,890	27	65-70			4.5	6.5				
1,441-1,680	28	51-60	3.5	8.5			7.0	4.3		
1,441-1,750	25	58-70			4.2	7.0				
1,201-1,440	24	50-60	3.0	10.0						
1261-1440	24	52.5-60			4.0	7.5	6.0	5.0		
1081-1260	21	51.5-60			3.5	8.5				
961-1200	20	48.1-60					5.0	6.0		
901-1080	18	50.1-60			3.0	10.0				
841-960	16	52.6-60					4.0	7.5		
721-900	15	48.1-60			2.5	12.0				
721-840	14	51.5-60					3.5	8.6		
551-720	12	45.9-60			2.0	15.0	3.0	10.0		
441-550	10	44.1-55					2.5	12.0	5.0	6.0
331-440	8	41.4-55					2.0	15.0	4.0	7.5
276-330	6	46.0-55							3.0	10.0
201-275	5	40.2-55							2.5	12.0
151-200	4	37.8-50							2.0	15.0

Source: CTA Service Standards, 2001; http://www.transitchicago.com/assets/1/miscellaneous_documents/servicestandards129737.pdf

2.2.2 Passenger Load Factors

When evaluating the quality of service provided by the rail system, a key indicator is the Passenger Load Factor. It is defined as the average number of passengers per seat calculated during peak travel conditions. The Passenger Load Factor is useful in analyzing two things: passenger comfort/convenience and operating efficiency. Passenger comfort/convenience concerns the rider’s ability to board the first train that arrives at the customer’s station, general availability of a seat and proximity to other standees if no seats are available. Operating efficiency may be compromised if trains are too crowded: door operation suffers, dwell time is lengthened and schedule adherence is impacted.

Table 3 gives Passenger Load Factors for both AM and PM peak periods calculated from September, 2010, rail ridership data. Maximum Load Point and Passenger Load is determined by calculations using the Automatic Fare Collection database and an Origin-Destination Estimation model algorithm. As a result of these calculations and a determination of the number of trains and rail vehicles in the consists passing the established point of maximum load on the line, the total number of passengers and the average number of riders per car throughout the peak period is calculated. An average of 45 seats per rail car is assumed for the Passenger Load Factor calculation.

The Purple and Green lines are limited to a maximum train length of six-cars by the station platform length on these lines; Pink line operates at a maximum train length of four-cars while the Yellow line is a shuttle limited to two-car trains. All other lines operate eight-car trains in the peak period. Brown line started operating eight-car trains in Spring 2008 with the completion of the Brown Line Capacity Expansion Project to relieve crowding and help offset the pressure of steadily increasing ridership.

During the AM peak period, Passenger Load Factor ranges from 0.75 on Yellow line to 1.88 on Brown line. During the PM peak period, Passenger Load Factor ranges from 0.69 on Green line in the Southbound direction to 1.78 on Purple line. The variation in the Passenger Load Factor on different lines is due to the following reasons:

- The service scheduled in the off peak direction is more than the minimum required by the CTA service standards to balance the frequency in the peak direction and due to yard capacity, additional turn back supervision required, and minimal operational savings. Currently employed service optimization methods are discussed later in this section. During AM peak period, the off-peak directions are Northbound on Blue line, Northbound on Green line, and Northbound on Red line. During PM peak period, the off-peak directions are Southbound on Blue line, Southbound on Green line, and Southbound on Red line.

- The service standards provide guidelines (Table 2) to provide minimum service on rail lines with low passenger load to optimize rider wait time and operational efficiency. This explains the low Passenger Load Factor on Yellow line. Passenger load factor on Pink, Purple, Green, and Orange lines is lower than the Blue, Red, and Brown lines due to the same reason.

Table 3. Passenger Load Factor for AM & PM Peak Period

AM PEAK LINE	MAXIMUM LOAD POINT	DIR	AVERAGE PASSENGER LOAD	TRAINS	CARS / TRAIN	TOTAL CARS	AVERAGE PASSENGER / CAR	PASSENGER LOAD FACTOR
Blue	Chicago/Milwaukee	SB	10,236	16	8	128	80	1.78
Blue	Racine	NB	2,361	8	8	64	37	0.82
Brown	Sedgwick	SB	9,457	14	8	112	84	1.88
Green	California-Lake	SB	2,819	8	6	48	59	1.31
Green	Roosevelt/Wabash	NB	2,372	8	6	48	49	1.10
Orange	Halsted-Midway	NB	4,444	9	8	72	62	1.37
Pink	Ashland	NB	1,667	7	4	28	60	1.32
Purple	Sedgwick	SB	2,816	7	6	42	67	1.49
Yellow	Skokie	SB	474	7	2	14	34	0.75
Red	Clark & Division	SB	10,676	17	8	136	79	1.74
Red	Roosevelt/State	NB	5,006	13	8	104	48	1.07
Total			52,328					
PM PEAK LINE	**MAXIMUM LOAD POINT**	**DIR**	**AVERAGE PASSENGER LOAD**	**TRAINS**	**CARS / TRAIN**	**TOTAL CARS**	**AVERAGE PASSENGER / CAR**	**PASSENGER LOAD FACTOR**
Blue	Grand/Milwaukee	NB	6,267	14	8	112	56	1.24
Blue	Clinton-Congress	SB	2,888	9	8	72	40	0.89
Brown	Sedgwick	NB	7,525	13	8	104	72	1.61
Green	Clark/Lake	NB	2,779	8	6	48	58	1.29
Green	Roosevelt/Wabash	SB	1,483	8	6	48	31	0.69
Orange	Roosevelt/Wabash	SB	4,775	9	8	72	66	1.47
Pink	Ashland	SB	1,536	7	4	28	55	1.22
Purple	Chicago/Franklin	NB	3,357	7	6	42	80	1.78
Yellow	Howard	NB	540	6	2	12	45	1.00
Red	Chicago/State	NB	9,084	17	8	136	67	1.48
Red	Jackson/State	SB	5,639	13	8	104	54	1.20
Total			45,873					
Source:	**Average Load is estimated from the Origin-Destination Estimation model using the Automatic Fare Collection database. Data is based on ridership for September 2010. Number of trains and cars for the peak period are obtained from the Fall 2010 schedules.**							

Maximum Load Point - Station where the average passenger load is maximum during the peak hour.

Average Load -- Estimated ridership average during the peak hour during weekdays for September 2010.

Trains -- Scheduled number of trains during the peak hour.

Passenger Load Factor -- Average passengers per car divided by the average number of 45 seats per car.

The ideal situation for passenger loading, from a customer perspective, would be to provide one seat per passenger, which equates to a passenger load factor of 1.0. Unfortunately, this is not a realistic or practical objective because of current ridership, operating budget constraints, yard capacity, and a static rail car fleet size. The only opportunity to reduce passenger loading is to increase service by either utilizing spare car availability or transferring cars from routes with lighter ridership. Reducing spare car availability must be carefully considered to insure that schedule requirements are consistently met while still providing for sufficient equipment to replace defective equipment in service and satisfy the needs of maintenance. Moving cars from routes with light passenger loading to those routes with heavier loading also requires considerable analysis:

- For the routes to lose cars, will the interval between trains become unacceptable?
- For the routes to gain cars, can the signal and switching systems accommodate additional trains?
- Are there opportunities to turn back trains within a route to place more equipment at the heaviest loading point during the peak rush period?

These and other issues are regularly examined using service standards as guidelines to determine if changes can be made within the existing fleet of cars to improve passenger loading. The maximum average load per car recommended by the service standards is 90, which equates to a passenger load factor of 2.0. Table 3 also shows that Total Average Passenger Load on the system is higher during the AM peak period than in the PM peak period. This explains higher PVR in AM than PM, discussed later in this section in Step Four.

2.3 PVR Analysis, Step Three – Vehicle Run Times

Table 4 gives cycle time for all the rail lines for Fall 2010 schedules. Cycle time is the round trip run time including turn back time at the terminal. Cycle times vary by year depending upon the slow zones on the rail line. The cycle time in the table does not take into account optimizing strategies like short turns and coupling of lines discussed later in this section.

Table 4. Cycle Time - Fall 2010

LINE	Cycle Time (Minutes)
Blue	150
Red	142
Brown	84
Orange	65
Purple	110
Green	128
Pink	77
Yellow	30

Cycle times for future expansions are discussed below:

- Red Line Extension LPA from 95th station to the proposed 130th station is expected to add 28 minutes to the existing Red line cycle time.
- Orange Line Extension LPA from Midway station to the proposed Ford City station is expected to add 9 minutes to the existing Orange line cycle time.
- Yellow Line Extension LPA from Dempster station to the proposed Old Orchard road station is expected to add 6 minutes to the existing Yellow line cycle time.

- Circle Line LPA would require restructuring some of the existing rail service. Additional PVR for the project is adopted from the LPA report.

- Red and Purple modernization project's impact on cycle time of Red line or Purple line is not known at this stage of the project.

2.4 PVR Analysis, Step Four – Peak Vehicle Requirement

2.4.1. Peak Service Requirement Projection

The ridership growth rate in Step One is applied to peak passenger load in Step Two to project ridership at 15-minute intervals for the peak two hour period for each rail line at the maximum load point for years 2011 – 2020. Table 5 shows peak 15 minute passenger load projections at the maximum load point for each rail line.

Table 5. Projected Peak 15 Minute Demand At The Maximum Load Point By Rail Line

Year	Ridership Growth Rate	Blue	Brown	Green	Orange	Pink	Purple	Red	Yellow
2010*	-	2,807	2,357	766	1,201	457	738	2,813	145
2011	3.3%	2,900	2,436	792	1,241	472	763	2,906	150
2012	-0.3%	2,892	2,471	790	1,238	471	761	2,898	150
2013	3.5%	2,994	2,515	818	1,282	488	788	3,000	156
2014	-0.2%	2,989	2,510	817	1,280	488	787	2,994	156
2015	3.7%	3,100	2,603	848	1,328	507	817	3,105	162
2016	-0.1%	3,097	2,601	848	1,327	507	817	3,102	162
2017	3.7%	3,212	2,698	880	1,377	526	848	3,217	168
2018	-0.1%	3,209	2,696	880	1,376	526	848	3,214	168
2019	3.7%	3,328	2,796	913	1,427	546	880	3,333	175
2020	-0.1%	3,325	2,794	913	1,426	546	880	3,330	175

**2010 is actual ridership figure for September, 2010*

Using the projected loads at 15-minute intervals and assuming current frequency and train length, average load per car is projected for future years for each rail line. If the average load per car calculated with the current frequency and train length exceeds that recommended as per the service standards, increased frequency and train length scenarios are evaluated. This yields the optimum service that would be needed on each line in each year to meet the demand at the peak load point.

Table 6 gives an example of the optimum peak service requirement estimation for Orange line. It shows that current service levels would be sufficient to meet the passenger demand for years 2011 and 2012. However, for years 2013 - 2016, 2017 – 2018, and 2019 – 2020, the loads would warrant additional trains during the peak of the peak period for 15 minutes, 30 minutes, and 45 minutes respectively. Similarly, peak service requirement is estimated for other lines. Potential operating budget constraints are not taken into consideration for developing service requirement assumptions.

Table 6. Service Requirement Estimation For Orange Line

Year	Peak 15 Minute Demand at Halsted	Duration over maximum recommended load (minutes) 8-Car Train		Estimated Service Requirement	
		8 Trains/Hour	10 Trains/Hour	Peak Frequency (Trains/Hour)	Peak Frequency Period (Minutes)
2010	1,201	0	0	8	65
2011	1,241	0	0	8	65
2012	1,238	0	0	8	65
2013	1,282	15	0	10	15
2014	1,280	15	0	10	15
2015	1,328	15	0	10	15
2016	1,327	15	0	10	15
2017	1,377	30	0	10	30
2018	1,376	30	0	10	30
2019	1,427	45	0	10	45
2020	1,426	45	0	10	45

Notes:

Peak 15 minute demand is the passenger flow at the peak location during peak of the AM peak period.

Duration over maximum recommended load determines the length of time for which the cars would be over the maximum recommended load. Based on load, frequency, train length, and using the guidance from Service Standards, maximum load per car is used as 80 for Orange Line.

Estimated service requirement is the optimum service required so that the cars don't go above maximum recommended load for any time period. Only peak of the peak period service change assumptions are provided here. Shoulder peak period frequency changes will accompany peak of the peak period service changes.

2010 figures are actual, 2011-2020 are projections.

2.5 PVR Analysis, Step Five – Peak Vehicle Requirement

2.5.1 Peak Vehicle Requirement Trend

Table 7 and Table 8 give PVR for AM and PM peak periods respectively for years 2005 to 2010. For most years, PVR is slightly higher in the AM peak than in the PM peak. This is explained by the higher passenger load at maximum load point in the peak direction in AM peak period than in PM peak period as in Table 3.

Table 7. AM Peak Vehicle Requirement By Rail Line

AM Peak	Blue	Brown	Green	Orange	Pink	Purple	Red	Yellow	Total
Fall 2005	264	132	90	96	N/A	84	304	8	978
Fall 2006	272	132	96	96	36	84	304	8	1028
Fall 2007	272	132	96	88	36	64	312	8	1008
Fall 2008	264	128	96	88	36	64	304	6	986
Fall 2009	272	136	96	80	36	66	288	6	980
Fall 2010	264	136	96	80	36	66	272	6	956

Table 8. PM Peak Vehicle Requirement By Rail Line

PM Peak	Blue	Brown	Green	Orange	Pink	Purple	Red	Yellow	Total
Fall 2005	264	126	90	96	N/A	72	296	8	952
Fall 2006	272	132	96	96	36	78	304	8	1022
Fall 2007	272	102	96	88	36	64	312	8	978
Fall 2008	264	128	96	88	36	64	304	6	986
Fall 2009	264	136	96	80	36	66	288	6	972
Fall 2010	248	136	96	72	32	66	272	6	928

PVR increased slightly in 2006 with the introduction of service on Pink line and has decreased since then in the following years, some of which can be attributed to reduction in cycle time due to removal of slow zones, service adjustments and operating strategies, as discussed later in this section. PVR on Brown line has increased by 8 cars with the completion of Brown Line Capacity Expansion Project. With the Spring 2010 service reductions, the system AM PVR has reduced by 24 cars and the PM PVR has reduced by 44 cars.

2.5.2 Peak Vehicle Requirement Projection

Peak Vehicle Requirement is calculated for the optimum maximum train throughput and its duration and train length that will be required to meet the projected ridership for each rail line during the peak period at the maximum loading point, as identified in Step Four. Table 9 gives the PVR projections. The PVR calculation is derived from the cycle time, the headway variation during the cycle time, the duration of each headway interval, and the number of cars per train during the peak period on each line. Any change to one of these variables impacts the number of rail cars that are required for service. Headway and train length variations for each line are assumed in order to project the minimum PVR required to meet the demand in each year. An assumption is made that the current cycle times will not change in future years.

Table 9. Peak Vehicle Requirement Projection By Rail Line

Rail Line	2010**	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Blue	264	264	264	272	272	296	296	296	296	296	296
Brown*	136	152	152	152	152	160	160	176	176	176	176
Green	96	102	102	102	102	102	102	102	102	114	114
Orange	72	72	72	80	80	80	80	80	80	88	88
Pink	36	36	36	44	44	44	44	44	44	44	44
Purple	66	78	78	84	84	84	84	90	90	90	90
Red	272	272	272	280	280	296	296	296	296	296	296
Yellow	6	6	6	6	6	6	6	8	8	8	8
Total	**956**	**982**	**982**	**1,020**	**1,020**	**1,068**	**1,068**	**1,092**	**1,092**	**1,112**	**1,112**

Notes:

PVRs are based on ridership projections for each line.

PVRs are based on recommended maximum passenger load per rail car, which varies by service frequency as per CTA Service Standards.

*** For year 2010, one peak train scheduled from Midway to Kimball is included in Orange line PVR.**
For years 2011-2020, one peak train scheduled from Midway to Kimball is included in Brown line PVR.

****Fall 2010 PVR is actual, 2011-2020 are projections.**

Table 10 gives estimated PVR for expansion projects. PVR for Red, Orange, and Yellow line extension projects is estimated using the cycle time identified in Step Three and is also included in the LPA service plans for these projects. PVR for Circle Line is adopted from the LPA service plan. Red and Purple modernization project is expected to allow eight car trains on Purple line with lengthened station platforms. Although, purple line passenger demand until 2020 could be met with six car trains and higher train frequency, as identified in Table 9, less frequent eight car trains would free up some train capacity in the loop for Orange, Pink, Brown, and Green line trains. It is estimated that with reduced frequency, no additional cars would be required to run eight car trains assuming that the modernization project will not induce additional ridership.

Table 10. Peak Vehicle Requirement Projection For Expansion Projects

Proposed Service	Additional Rail Cars	Spares (16%)	Total
Orange Line to Ford City	16	4	20
Red Line to 130th	64	8	72
Yellow Line to Old Orchard	2	2	4
Circle Line	32	6	38
Total	**114**	**20**	**134**

The assumptions for maximum train throughput, duration of maximum train throughput and number of rail cars per train are listed in Table 11.

Table 11. Peak Period Service Assumptions For Peak Vehicle Requirement Projection

Blue Line	
2011-2012	Trains will keep running at the current schedule.
2013-2014	Trains will run at the current headway of 3.5 minutes but for a peak of 60 minutes, instead of the current peak of 42 minutes.
2015-2020	Trains will run at reduced peak headway of 3.15 minutes for 42 minutes.
Brown Line	
2011-2014	Trains will run at the current headway of 4 minutes for a peak of 50 minutes, instead of current peak of 35 minutes.
2015-2016	Trains will run at the current headway of 4 minutes for a peak of 60 minutes.
2017-2020	Trains will run at a reduced headway of 3.5 minutes for a peak of 50 minutes.
Green Line	
2011-2018	Trains will run at a reduced headway of 6 minutes for a peak of 30 minutes instead of current headway of 7.5 minutes.
2019-2020	Trains will run at a reduced headway of 6 minutes for a peak of 60 minutes.
Orange Line	
2011-2012	Trains will keep running at the current headway of 7.5 minutes during the peak period.
2013-2018*	Trains will run at a reduced headway of 6.0 minutes for a peak of 30 minutes.
2019-2020	Trains will run at a reduced headway of 6.0 minutes for a peak of 60 minutes.
Pink Line	
2011-2012	Trains will keep running at the current headway of 7.5 minutes during the peak period.
2013-2020	Trains will run at a reduced headway of 6.0 minutes.
Purple Express Line	
2011-2012	Trains will run at the current headway of 7.5 minutes for a peak of 60 minutes, instead of current peak of 32 minutes.
2013-2016	Trains will run at the current headway of 7.5 minutes for a peak of 90 minutes, instead of current peak of 32 minutes.
2017-2010	Trains will run at a reduced headway of 6 minutes for a peak of 32 minutes.
Red Line	
2011-2012	Trains will keep running at the current schedule.
2013-2014	Trains will run at the current headway of 3.5 minutes for a peak of 75 minutes, instead of current peak of 52 minutes.
2015-2020	Trains will run at a reduced headway of 3.15 minutes for 52 minutes.
Yellow Line	
2011-2016	Trains will keep running at the current schedule.
2017-2020	Trains will run at a reduced headway of 7.5 minutes.

Note: Only peak of the peak period service change assumptions are provided here. Shoulder peak period frequency changes will accompany peak of the peak period service changes.
*Peak of 15 minutes for years 2013 – 2016 requires the same PVR as peak of 30 minutes.

2.6 PVR Analysis, Step Six – Gap Trains

The CTA's PVR does not include Terminal Reserve Trains (TRT) or Gap Trains, as is the practice at some other transit properties. The CTA does not currently utilize TRTs to assist in meeting and sustaining the revenue service schedule due to service reductions made in February 2010. As the budget situation changes, the issue of utilizing TRTs will be reevaluated.

2.7 PVR Analysis, Step Seven – Spare Car Requirement

2.7.1 Spare Car Availability Trend

Table 12 provides spare car ratio for the past five years. The spare ratio has increased due to decreases in the peak vehicle requirements (the total quantity of cars in the fleet has not substantially changed during this time period). Table 12 gives the spare cars available, which does not necessarily represent the minimum spare car requirement.

Table 12. Spare Car Ratio Trend

Line	2006		2007		2008		2009		2010	
	Spares	Spare Ratio	Spares	Spare Ratio	Spares	Spare Ratio	Spares	Spare Ratio	Spares	Spare Ratio
Blue	50	18.4%	56	20.6%	64	24.2%	54	19.9%	60	22.7%
Brown	10	7.6%	10	7.6%	24	18.8%	16	11.8%	20	14.7%
Green	18	18.8%	22	22.9%	22	22.9%	22	22.9%	30	31.3%
Orange	10	10.4%	10	11.4%	12	13.6%	20	25.0%	32	40.0%
Pink	8	22.2%	8	22.2%	8	22.2%	8	22.2%	8	22.2%
Purple	10	11.9%	16	25.0%	14	21.9%	18	27.3%	10	15.2%
Red	44	14.5%	48	15.4%	50	16.4%	62	21.5%	66	24.3%
Yellow	2	25.0%	2	25.0%	0	0.0%	0	0.0%	0	0.0%
Working Totals	154	15.0%	172	17.1%	194	19.7%	200	20.4%	226	23.6%
Long Term Hold	8		10		10		10		18	
Fleet Totals	162	15.8%	182	18.1%	204	20.7%	210	21.4%	244	25.5%

2.7.2 Spare Car Analysis by Route

A complex transit system such as the CTA cannot be judged solely by the system wide spare ratio. Each route within the system has its own unique issues that result in rail car spare ratios that vary throughout the system. The CTA currently has 226 spare cars. The number of spare cars assigned to each route is dependent upon a variety of factors:

- The car series assigned to the route and number of cars available in that series. To simplify maintenance, training, and the stocking of parts, the number of different car series assigned to a route is kept to a minimum.

- The age and general condition of the cars on the route.
- Current maintenance programs for cars on the route.
- Service characteristics and requirements for the route.
- Maintenance and material requirements for the cars assigned.
- Condition of the right-of-way infrastructure and maintenance facilities.

The Blue Line is one of CTA's largest routes with 324 assigned cars that vary in age from 26 to 40 years old. There are two different car series assigned to this route that results in different repairer training, parts requirements and maintenance needs. On the Blue Line, the 2200 series cars are not ADA compliant and cannot run without a 2600 series unit to accommodate potential ADA passenger needs. This characteristic results in time consuming switching and consist make-up procedures.

On the Brown Line, the spares assigned are relatively low. This route is relatively small, has a newer maintenance facility and is assigned the CTA's newest cars, the 3200 series. The 3200's have proven to be a very reliable car with a minimum amount of unscheduled maintenance. Service is dispatched from only one location on the route. The track and structure on this route are also in generally good repair that reduces wear and tear on the cars. Kimball Yard is nearing capacity; if Brown Line service needs increase significantly more, additional cars will need to be provided on a daily basis from other yards such as Howard or Midway.

The Green Line route is relatively small and was completely rebuilt in the late 1990's, resulting in new track work and signal systems. The cars assigned to the Green Line are the 2400 series cars that are about 32 years old. These cars did receive a life-extending minor overhaul at Skokie Shops between 2005 and 2008, but the cars are again nearing the end of useful lives.

The Orange Line was built in the early 1990's and is in good condition. Similar to the Brown Line, the route has the CTA's newest cars, a newer facility, and only one terminal. At the time the 2010 spare ratio snapshot was taken, the 10 prototype 5000-series cars were being tested in-service on the Orange line. This significantly, but temporarily, increased the Orange Line spare ratio. Even so, the route has some extra cars that will be moved to the Brown Line when service requirements increase in 2011.

The Pink Line is a small route that has been recently rebuilt. It runs 2600-series cars that are 26 years old.

The Red, Yellow, and Purple Lines have somewhat special characteristics to consider. These routes share the same yard and maintenance facility at Howard, which is also the main yard and shop for the Red Line. The Yellow Line is very small with only a six car PVR. If a Yellow Line assigned unit is out-of-service, a Red or Purple Line unit is used in its place. The Purple Line has a "reverse" peak period with the higher PVR in the PM. This allows for the borrowing and loaning of cars from the Red Line, and vice versa, as required. The combined Red/Yellow/Purple spare ratio is 22%.

Comparing the Blue Line to the Red/Yellow/Purple Lines, both route groupings dispatch service from multiple locations, which results in car balancing issues from one terminal to another. Much of the track and structure on these routes are in need of repair, some of it critical, including the north and south ends of the Red Line and the Forest Park branch of the Blue Line. The maintenance shops on these routes vary in age with several facilities undersized and in need of expansion.

2.7.3 Spare Car Requirement Projection

2.7.3.1 Spare Car Projection Overview

The Total Spares Required and the resulting Spare Ratio are calculated in Table 13. The required spare ratio varies from 18% to 22% with variation in overhaul program float requirement, which is highest in 2012 and 2016. The individual lines of the table are explained below.

Table 13. Spare Care Requirement Projection

Rail Line	2010*	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
PVR	956	982	982	1,020	1,020	1,068	1,068	1,092	1,092	1,112	1,112
Base Spares Required	142	146	146	152	152	160	160	162	162	166	166
Overhaul Program	16	16	56	40	40	40	56	16	32	16	16
Engineering Tests Allowance	4	4	4	4	4	4	4	4	4	4	4
Long-term Holds	14	10	10	10	10	10	10	10	10	10	10
Total Spares Required	176	176	216	206	206	214	230	192	208	196	196
Spare Ratio	18%	18%	22%	20%	20%	20%	22%	18%	19%	18%	18%

Notes:

***Fall 2010 PVR is actual, 2011-2020 are projections. All total spare required are projections, based on unavailable cars in 2009, overhaul program float requirements, engineering test cars, and long-term holds.**

2.7.3.2 Base Spares Required

The Base Spares Required is an estimate of cars out-of-service on a daily basis for scheduled maintenance and unscheduled maintenance. It is assumed that for reliable service, enough spares should be available to meet the schedules at least 98% of the weekdays. In 2009, for 98% of the weekdays, less than 158 cars were unavailable for AM peak period service, including 16 cars for the overhaul program. Excluding the 16 cars for overhaul, the unavailable cars were 14.9% of the 2009 PVR. For purposes of calculating the Base Spares Required, we assumed that the same percentage of rail cars would be unavailable in future years due to maintenance. This is a conservative approach, as we do expect to see improved fleet performance with the addition of the new 5000-series cars and retirement of the 2200 and 2400-series cars.

Successful implementation of any maintenance program requires that rail cars be made available in sufficient numbers to support the maintenance program as defined in the Rail Car Maintenance Plan. This holds true whether the maintenance required is preventive or reactive in nature. If rail cars are not made available when needed for maintenance purposes, then the maintenance action is deferred and rail car reliability suffers. Again, the availability of rail cars for maintenance must be given the same priority as the availability of cars for revenue service. The opportunity for maximum rail car utilization lies in the development of maintenance programs and practices that interfere as little as possible with the peak rush periods, when the rail cars are most needed for service.

Level "A" Periodic Inspections are conducted within a 4-hour time frame for a two car consist. The fleet average number of miles between each of these inspections in 2009 was 9465 miles. Mileage targets vary based on rail car series and route, with an established goal of the target +/- 10%. A maximum time limit of 90 days between inspections is imposed regardless of mileage or other factors to capture vehicles out of service for extended periods as a safety measure. Level "B" Annual Inspections are performed approximately once per year, replacing one Periodic Inspection, and take an 8-hour shift to complete. Therefore, the number of inspections that must be performed each day is a mathematical function of the amount of vehicles on a particular route and the scheduled mileage of that route.

Because of the married pair car configuration and inspection scheduling logistics, the actual number of rail cars required to support the Periodic and Annual Inspection programs places the requirement at 36 cars per inspection day. While this requirement is fairly rigid, the actual time at which is performed can be adjusted so as not to impact AM rush service. In August of 2000, the inspection process was moved from a 06:00 hour start, to a shift which began at 09:30 to allow these vehicles to be used in AM rush service. Without this adjustment, CTA would have had difficulty meeting ridership demands due to a lack of available equipment. Currently four of the inspection crews start at 09:00, and another at 14:00. The remaining crews have the 05:00 or 06:00 start time (Appendix VII).

2.7.3.3 Overhaul Program

Overhaul Program requirements vary substantially from year-to-year, so they are added separately when calculating total spares required. The Level "C" Quarter-Life Overhaul and Level "D" Mid-Life Rehabilitation programs require the dedication of rail cars to assure their success. Clearly without the reliable availability of rail cars, these programs cannot work. The identification of the exact number of cars required to maintain these programs is not as straight forward as for the Periodic and Annual Inspections. Ideally, the Level "C" Overhaul and Level "D" Mid Life Rehabilitation programs would be evenly spread throughout each year. In reality, Capital funding limitations, car purchase groupings and cycles along with shop space constraints sometimes cause these programs to be delayed or bunch together. It is inevitable that during some periods, there will not be any of these major programs in place, while at other times, they will overlap. The quantity of rail cars allocated to these programs becomes a fluid number. And yet, because of the inability to easily add or decrease cars to the fleet, there must be some definite number of cars allocated to support the programs when they do occur.

For the 2600 Quarter-life overhaul currently being conducted at Skokie Shops, sixteen (16) cars are needed on a continuing basis. The last Level "D" Rehabilitation program, completed by Alstom on the 2600's between 1999 and 2002, required by contract a total of 40 cars for the contractor's float. This is typical for a contract of this size and production rate. In addition to the contractor's float, two cars in transit, and an additional six cars are required for a CTA float. This work includes car transfers to and from Skokie Shop, preparing the cars for shipment from Skokie to the contractor and inspecting and preparing the cars for service once returned from the contractor. Thus, a total of 48 cars may be required to support a similar size Level "D" Rehabilitation program. For the upcoming 3200 Level "D" overhaul program, we expect to have 40 cars out-of-service at any given time.

2.7.3.4 Engineering Tests Allowance

Throughout the life of a rail car fleet, engineering tests and modifications are continually in process to correct problem areas, upgrade systems or perform modifications for safety or because of new regulations, such as ADA issues. Between car series, it is not uncommon for at least two units (four cars) to be out of service for engineering tests or work. Because these cars are generally unavailable for peak service requirements, they are added to total vehicle requirements.

2.7.3.5 Long-term Holds

Between new car purchases, a car occasionally becomes so severely damaged, or requires such significant repairs that repair is not economically or practically feasible. As replacement cars are not generally possible to obtain, the spare car allowance for a rail transit property must include a small number of extra cars to compensate for destroyed cars until the next new car purchase. We currently have 14 long-term hold cars. Eight of these cars are 2200 and 2400 series rail cars, four of each, that will not be repaired not only because of the significant repairs required but also because the series cars will be retired in the next several years. The odd-numbered cars of the other six cars (all 2600 series) are damaged beyond repair and will be retired. The even numbered cars will be held to mate to another odd-numbered car in the event the situation arises. Going forward we include an allowance for 10 cars to be in long-term hold status. Please note the Rail Car Assignment sheet (Appendix II) shows an additional four 2600's in Long Term Hold status. At the time of the report, these cars were being prepared for temporary special service.

2.7.3.6 Other factors affecting spare ratios

The justification of a specific spare ratio for a rapid transit property is a difficult task. Each property is highly individualized and many factors influence spare ratios such as: equipment type and age, seasonal weather conditions, operating conditions (above or underground), operating policies, maintenance policies and facilities, staff availability and capability and probably most importantly, funding availability. In addition, as these factors change, it is extremely difficult to adjust the rail cars assigned to "force" the spare car ratio back to a given point. Rail cars are not easily or quickly acquired or disposed of, and with a life cycle of at least 25 years, the total car assignment tends to be a fixed number for years at a time.

Some of the factors that specifically influence the CTA's spare ratio requirements include the following:

- Married Pair Operation -- The CTA operates two car married pairs that result in two cars being out of service for each unanticipated car failure. The CTA's use of married pair cars is partially the result of our track system requirement for 48-foot length cars. Cars of this length do not have the extra space inside to allow for an operating cab at each end without a severe penalty in interior passenger space. Other transit properties utilize two, three, and greater married groupings which would require these train sets to be removed from service in the event of a single car failure.
- Climate Considerations -- The climate in Chicago is much more severe than in many other properties. Chicago's weather can vary from over 20 degrees below zero to over 100 degrees F. The Chicago sleet and snowstorms place severe stress on the CTA system, causing propulsion, door and other subsystem failures. The potential for problems during winter was made apparent at the beginning of 1999 when severe blizzard conditions resulted in over 300 rail cars removed from service because of weather related failures.
- Expressway Operation -- Our unique operation within three major expressway median strips cause unique problems. As a result of the salting that is done to melt snow and ice on the expressway systems, much of the CTA trains are subjected to a continuous salt spray during winter. The severity of this problem was made apparent during the winter of 1993-1994 when two documented and another three suspected rail car fires were directly attributed to salt slush being thrown onto rail cars by expressway snow plowing. This resulted in eight cars being unavailable for service for over a year while awaiting extensive repairs.
- Deteriorating Structures -- Much of the CTA structure is over 100 years old and is in need of hundreds of millions of dollars in repairs. This results in numerous slow zones that further stress the propulsion and braking systems of our cars.
- Inadequate Maintenance Facilities -- Several of our light maintenance shops are undersized for our current operations. The 98th maintenance shop facility at the South end of the CTA’s busiest route, the Red Line, is an example. This situation results in extra car movements, repairs being performed on pits rather on hoists and poor under car accessibility. Funding shortages have prevented the upgrading of this and other maintenance facilities.
- Budget Considerations -- The CTA is mandated by Illinois State Statute to maintain a minimum of a 50% recovery ratio for its operating budget. This effectively limits our resources for all aspects of our operation, including costly maintenance programs. Exacerbating this situation is the continuous uncertainly of future capital funding.
- Car Mileage -- The CTA runs many more average miles per car than most rapid transit properties. This results in more frequent maintenance efforts, including lengthy car overhauls, than would be required for properties that run fewer miles. It should be noted that the CTA does attempt to minimize car mileage by reducing train consist length

during base periods, unlike many other properties. The miles put on a CTA car generally place more strain on our equipment than many other properties that run fewer miles or have lighter loading.

- Rapid Transit Car Design -- The CTA's cars are unique to Chicago, as are most other transit system cars. Direct comparisons of maintenance needs are difficult between properties.

Each of these factors plays a role in influencing the CTA's spare ratio, particularly when compared to other rapid transit properties that may not be subjected to the same constraining issues as the CTA. As such, the justification of a rail property spare car ratio above that required for maintenance purposes is largely based upon these somewhat intangible physical and operating characteristics that are unique to the specific property under review.

2.8 PVR Analysis, Step Eight - Total Fleet Demand, Revenue Demand/ Supply Balance

Table 14 gives total projected fleet demand, obtained from the PVR projected in Step Six and spare car requirement estimated in Step Seven. It is estimated that fleet requirement will gradually grow as the peak ridership demand grows from 2010 to 2020 and 108 additional cars will be required above the current fleet size by 2020. This will require the CTA to maintain 344 of the 2600-series cars, along with the 258 3200-series and 706 5000-series cars, until the 2600's can be replaced in the year 2022 or soon thereafter. Only 300 of the 2600-series cars will receive a quarter-life overhaul between 2008 and 2012. Therefore, forty-four (44) of the 2600's will have not had an overhaul for approximately 14 years between the mid-life, which ended in 2002, and their quarter-life starting in 2016. If the PVR and spare requirement predictions are correct, operating expenses may increase due to extra maintenance required for these cars, and the other 294 2600-series cars slated to be retired between 2014 and 2016. CTA's Rail Fleet Capital Programs, past and future, are outlined in Appendices IV and V.

The fleet requirement represents the amount of service required to meet the projected peak loads as recommended by the service standards. Infrastructure investments, additional slow zones, scheduling strategies, and operating budget constraints could affect the projected fleet requirement in future years. In addition, performance of the new 5000-series cars may also impact the fleet requirement. To be conservative, we assumed the new cars will need to be held out of service for maintenance at the same rate as the 2009 fleet. We are optimistic that once we have a significant number of 5000's in-service, the percentage of cars out-of-service will decline. This may allow for a reduction in the required spares as a percentage of the fleet in the future years, which may allow for the more timely retirement of some of the 44 above mentioned 2600-series cars.

Table 14. Total Fleet Demand

Rail Line	2010*	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
PVR	956	982	982	1,020	1,020	1,068	1,068	1,092	1,092	1,112	1,112
Total Spares Required	176	176	216	206	206	214	230	192	208	196	196
Total Fleet Requirement	**1,132**	**1,158**	**1,198**	**1,226**	**1,226**	**1,282**	**1,298**	**1,284**	**1,300**	**1,308**	**1,308**
Change from 2010 Total Fleet Requirement		26	66	94	94	150	166	152	168	176	176
Change from 2010 Total Fleet Availability**		-42	-2	26	26	82	98	84	100	108	108

Notes:

***Fall 2010 PVR is actual, 2011-2020 are projections.**

**** 2010 total fleet availability is 1200 rail cars including the 10 new 5000 series rail cars.**

Section 3.0 – Operating Strategies, Minimizing and Resolving Rail Service Disruptions, and Fleet Reliability

3.1 Operating Strategies

Ensuring that the CTA's operation is as efficient and customer friendly as possible involves various operating strategies. All such strategies fall into two basic categories:

- Optimizing normal operations
- Minimizing and resolving service disruptions

When both of these issues are effectively addressed, then it is assured that rail service is operating at peak efficiency. This will reduce the need for spare rail cars and provide for more predictable and reliable service for the CTA's customers.

3.1.1 Optimizing Normal Operations

The primary responsibility for adjusting train schedules to meet customers' needs rests with the Service Planning Department. Service Planning relies on a variety of statistics from a number of sources to analyze data and make schedule adjustments.

CTA's Rail System Origin-Destination Estimation (ODE) model utilizes automated farecard data to estimate the movement of passengers throughout the rail system, thus enabling Service Planning to analyze the relationship between passenger loads and available capacity at all points on the system at all times of the day. Any changes warranted by different riding patterns or dramatic fluctuations in passenger loadings are then incorporated into new schedules. Rail Operating employees are contractually entitled to choose their jobs a minimum of twice a year, so schedules are reviewed and adjustments made to coincide with these "picks."

One scheduling technique employed to maximize the effectiveness of service is turning trains short of the end terminal. These moves are scheduled to reflect ridership patterns and are currently employed on the Blue Line. For example, certain trips are scheduled to operate south from O'Hare to the Central Business District and turn back north to make another airport trip without operating all the way to the south end of the line.

Managers and supervisors in the field, and controllers at the central Communication/ Power Control [C/PC] Center have the authority and responsibility to adjust schedules when necessary. Situations requiring schedule alterations include special events, which often generate significantly larger ridership volumes than normally expected. In such cases, extra trips may be scheduled, train lengths may be increased, or headways adjusted to accommodate more passengers.

3.2 Minimizing and Resolving Rail Service Disruptions

Optimizing normal operations to meet ridership demands and passenger loading standards is only the first step in providing efficient service. Maintaining reliable scheduled service is the key to reliability in the eyes of the customer. Certainly maintenance plays a critical role in reliability, but there are many other situations that can arise that will disrupt service and impact the ability to maintain scheduled service. Through the years, various Operating Strategies have been developed to reduce or minimize service disruptions. If service disruptions can be held to a minimum, then the requirement for spare cars to meet existing and future Peak Vehicle Requirements can also be minimized.

3.2.1 Rail Service Disruptions

Other than the availability of adequate cars to meet scheduled service requirements, the greatest threat to meeting scheduled service is an in-service disruption or delay. Service disruptions affect operations at random. Any number of factors can impact our ability to maintain scheduled service including those that are within CTA's domain to those over which the Authority has no control whatsoever. Many service delays are attributed to outside sources such as ill passengers, raised bascule bridges or fires near the right-of-way. In these cases CTA service is at the mercy of the emergency response personnel.

Certain other types of service disruptions occur that CTA has control over. These include signal (interlocking) defects and rolling stock malfunctions. Signals may fail for any number of reasons, but one common fault is loss of commercial power. Other problems include the failure of track circuits, the tripping of circuit breakers or the locking up of software that protects movements through interlocking. The CTA's radio communication system generally enables a quick response to signal system delays.

Service disruptions can also occur with a failure of one or more rail cars within the train consist. The Operator quickly resolves most rail car defects so a train may proceed in service with little or no delay to passengers. The ability to quickly resolve a rail car defect while in service is a function of proper Operator training in rail car troubleshooting techniques. To reinforce this knowledge, Operators must pass stringent periodic recertification tests that include troubleshooting practices and techniques.

While many defects are corrected with a delay of only one or two minutes, some equipment problems compound and result in major service disruptions. Service delays that are less than ten minutes are considered to be minor delays while those that exceed ten minutes are classified as major delays.

3.2.2 Minimizing Rail System Delays

When a train experiences a problem while in revenue service, there are three options CTA uses to work with the defective equipment:

1. If the defect is considered minor and does not compromise the integrity of the train or the safety of the passengers, the car is left in service and the problem corrected as soon as practical.

2. If the defect is considered serious but does not require immediate attention, the train will complete its trip and then must be removed from service for repair.
3. If the defect is major, the train must be removed from service immediately despite any resultant disruptions to service or inconvenience to passengers.

A vast majority of defects fall into category 1 and there is little or no delay to service. A relatively few occur that may be classified as a category 3 described above. When a train is removed from service in category 3, a major delay is usually incurred and service suffers from the standpoint of both schedule and customer. The Major Delays occurring in 2009 as a result of a Vehicle Defect represent a small proportion of all the vehicle defects reported in revenue service. In these cases, service restoration techniques are used to minimize the effect of the situation on our customers and restore normal service as soon as possible.

3.2.3 Service Restoration Techniques

Service restoration can involve many techniques or procedures. The methods utilized most often involve adjusting the schedule or operating trains past stations without stopping to make up time. The least-often-used techniques are those that radically affect service, such as bus substitution or temporarily closing a rail station or line. These are used in only the direst of circumstances. The most commonly used techniques include the following practices:

- Spread or Close Interval – This option is used when trains are delayed by up to one interval, such as a minor troubleshooting event, an operator who fails to report on time and a run is annulled, or severe weather has resulted in much longer than usual travel times.

- Run Train Express — Controllers, supervisors and managers all have the authority to direct an operator to skip certain stations if a delay grows. This practice helps keep trains from becoming overcrowded, and tends to keep delays from lengthening.

- Reroute Around Defective Train – If a defective train cannot be moved on a line with more than two tracks, supervisors, controllers, and managers collaborate to use local switches and crossovers to route trains around it.

- Put Following Trains Ahead – Employed mainly on routes where two branches merge into the main line. When a train on one branch is delayed, the normal following train is allowed to precede it through the junction point in order to help maintain the normal interval.

- Trade Defective Train – Terminal supervisors sometimes have the option of laying up a defective train and replacing it with a good train that was scheduled to lay up. This simple exchange often restores service with no impact to customers.

- Add Cars or Do Not Make Scheduled Cuts – Terminal supervisors use this technique to account for increased passenger loads when the normal interval has been lengthened.

- Fill In – An extra train may be inserted into the schedule from the same route or another route when a delay is occurring. Through these and other related service restoration techniques, the impact of service delays on the CTA customer is minimized.

3.2.4 Rail System Delay Statistics

All delays to rail service greater than three minutes are recorded and categorized by the CTA Control Center. Major delays (10 minutes or greater) are of prime concern as these delays inconvenience the customer and reduce the quality of service provided.

Appendix VIII provides a historical perspective for the years 2005 through 2009 for the proportion of causes for major delays. The causes of delays are grouped into four categories, human error, vehicle defects, tracks and signals, and outside influences. Note that a new delay tracking system was initiated in October 2007, which minimizes the recording of duplicate records and improves categorizing the delay type. Therefore, a historical comparison of the total number of delays prior to 2007 would not be an accurate portrayal of trends. Assuming that tracking issues were equivalent for all four categories prior to October 2007, comparing the proportion of delays for each category is relevant. The proportion of delays caused by vehicle defects has been slowly increasing, which indicates that the aging fleet of rail cars is becoming increasing difficult to operate without incident.

During 2009, there were a total of 803 major delays of over ten minutes to the Rail System as illustrated in Appendix IX. A breakdown of the major delays for 2009 into four main categories is as follows: Vehicle Defect - 236 delays, Human Error - 94 delays (includes transportation, terminal, and yard delays), Track, Signal and power - 231 delays, and Outside CTA control, such as Police, Fire, medical emergency, and bridge/river traffic - 242 delays.

Vehicle defects were the second greatest reason for delays. It must, however, be emphasized that the Blue Line has mixed equipment (2200 and 2600). A consist can only be as reliable as its least reliable component. The 2200 Series equipment, having seen 40 years of service, experiences higher than average failures and it is not equipped with the most recent, reliable technology. The average age of CTA's rail car fleet in 2009 will be 26 years old and, as noted, is subject to increasing age related failures.

Appendix X shows Major System Delays during Rush Periods. Rush service is categorized as the hours of 0530-0900 and 1530-1830. During this time frame in 2009 the CTA had 317 delays greater than 10 minutes. This represents 39.4 % of the total delays greater than 10 minutes that fell within peak service periods.

Appendix XI illustrates that the total number of defects has been relatively constant over the last five years, despite representing an increasing proportion of delays. However, the type of vehicle defect has varied. Defects in doors, propulsion, coupling, and miscellaneous categories, likely associated with the aging fleet, totaled 236 major delays in 2009. Specifically, door problems resulted in 97 major delays followed by brake problems with 73 major delays in 2009. Brake problems can cause major delays because of the time that it takes to "clear" an in-service brake problem. The Operator must frequently exit the train and walk to the affected car to manually release the problem brake caliper. This can be time consuming, particularly with long trains and when access to the affected truck is difficult. Door problems encountered in rush hour periods can be time consuming to troubleshoot with a crush of passengers preventing quick and easy access to control panels. Miscellaneous defects, such as air conditioning or warning lights, also caused 22 major delays. Propulsion defects have increased by 60 percent from 2008 to 2009 while door defects have fallen 23 percent over the same time period. Analysis of vehicle defect and delay information allows Rail Maintenance to focus the analysis on determining root causes for significant problems, and implement corrective actions as appropriate that may include maintenance training, a component change-out program, a modification, or improved maintenance techniques. This also assists in determining scope of overhauls, and methodologies to improve, modify or upgrade vehicle subsystem and component designs. The Rail Car Maintenance Plan provides more details regarding this process.

3.3 Fleet Reliability

The effect of unscheduled maintenance generally first appears as an in-service incident or problem that results in a Reported Defect by the Rail Operator. The reported problem is logged into the Maintenance Management Information System (MMIS) computer system by the Rail Controllers at the Control Center, which creates a “work order” against the car. The problem may involve a single car or multiple cars within a consist. If multiple cars are involved, then a defect may be logged against each car in the consist. Rail Maintenance personnel are assigned to these work orders and document all work done to resolve the defects.

An analysis of the specific Reported Defects by Maintenance Category for 2009 is shown in Appendix XII. From this figure, it can be seen that the CTA’s greatest percentage of Reported Defects is for propulsion system problems followed by brake and door related defects. Car body, ATC and RCA problems make up the bulk of the remainder of Reported Defects. Note that HVAC related problems are relatively minor at 2% of the total. This is due to an extensive preventive maintenance effort over the past ten years to improve air conditioning reliability.

Historically, in 1999, the vast majority of defects occurred on the 2600-Series cars both in actual numbers and in percentage. Comprising 50% of the active fleet, they accounted for 60% of the defects. This changed as the 2600 series fleet was rehabbed and returned to service. It was a gradual but consistent change as the percentage of rehabs increased within that car series, returning to revenue service at a rate of up to 14 cars per month over a four year period. The 2600 series cars accounted for 53% of the defects in 2009.

Both the 2200 and 2400 series cars are now experiencing higher than normal failure rates in various sub systems due to scope reductions in previous overhaul programs and issues with respect to age of the vehicles (currently 40 and 32 years old respectively).

3.3.1 Mean Mileage Between Reported Defect

A good indicator of the trend of unscheduled maintenance is the Mean Mileage Between Reported Defect (MMBD). The MMBD for the past sixteen years is illustrated in Appendix XIII. Please note in 2007 we completed the transition from one computer maintenance system (VMT) to another (MMIS), which in part explains the drop in MMBD in 2007. Appendix XIV is a look at the monthly MMBD performance of the fleet since 2007. The monthly goals vary due to the impact of weather on rail car performance; the spring and fall goals are higher than winter and summer. The overall goal for 2009 was 4000 miles between failures, and the actual average for 2009 was 4159. The overall goal for 2010 is 4100 miles between failures, and the actual YTD performance through October is 3980. The basis for a future year's goal will be the actual performance in the previous year, adjusted as necessary to provide a goal that is realistic but not easily attainable. For example, the 2010 goal was slightly lower than the 2009 actual knowing that the summer of 2009 was very mild, contributing to the unusually good performance.

Over the past eight years, the MMBD has been maintained in spite of the continued aging of the fleet. An increased effort over that time period to develop and improve preventive maintenance practices also played a role. This was accomplished through a combination of several programs:

- Increased adherence to the Rail Car Maintenance Plan (RCMP) schedule
- Increased attention to the proper performance of Periodic Inspections through Quality Control inspections.
- Implementation of the Annual "B" Level Inspections for all cars as part of the RCMP
- Capital funding for "C" and "D" Level Overhaul Programs
- Development of preventive maintenance programs to address specific problematic car systems.

The projected trend for the MMBD over the next ten years is very positive. Rail Operations and Rail Engineering and Technical Services are proactive in the development of programs to reduce the occurrence of unscheduled maintenance. The implementation of the maintenance management information system (MMIS) from the 30-year old main frame database (VMT) to a web enabled modern system with enhanced reporting capabilities has helped better identify failure causes and the ability to quickly note trends. MMIS usage is more fully described in the Rail Car Maintenance Plan.

Rail Operations also implemented an "EXCEL" program in 2002, which reviews and upgrades the qualification and training of Car Repairers to improve the quality and reliability of repairs. Other plans include the continuing evaluation of inspection schedules and processes to provide for additional inspections and time for the follow-up repair process to adjust for increasing car mileage and service.

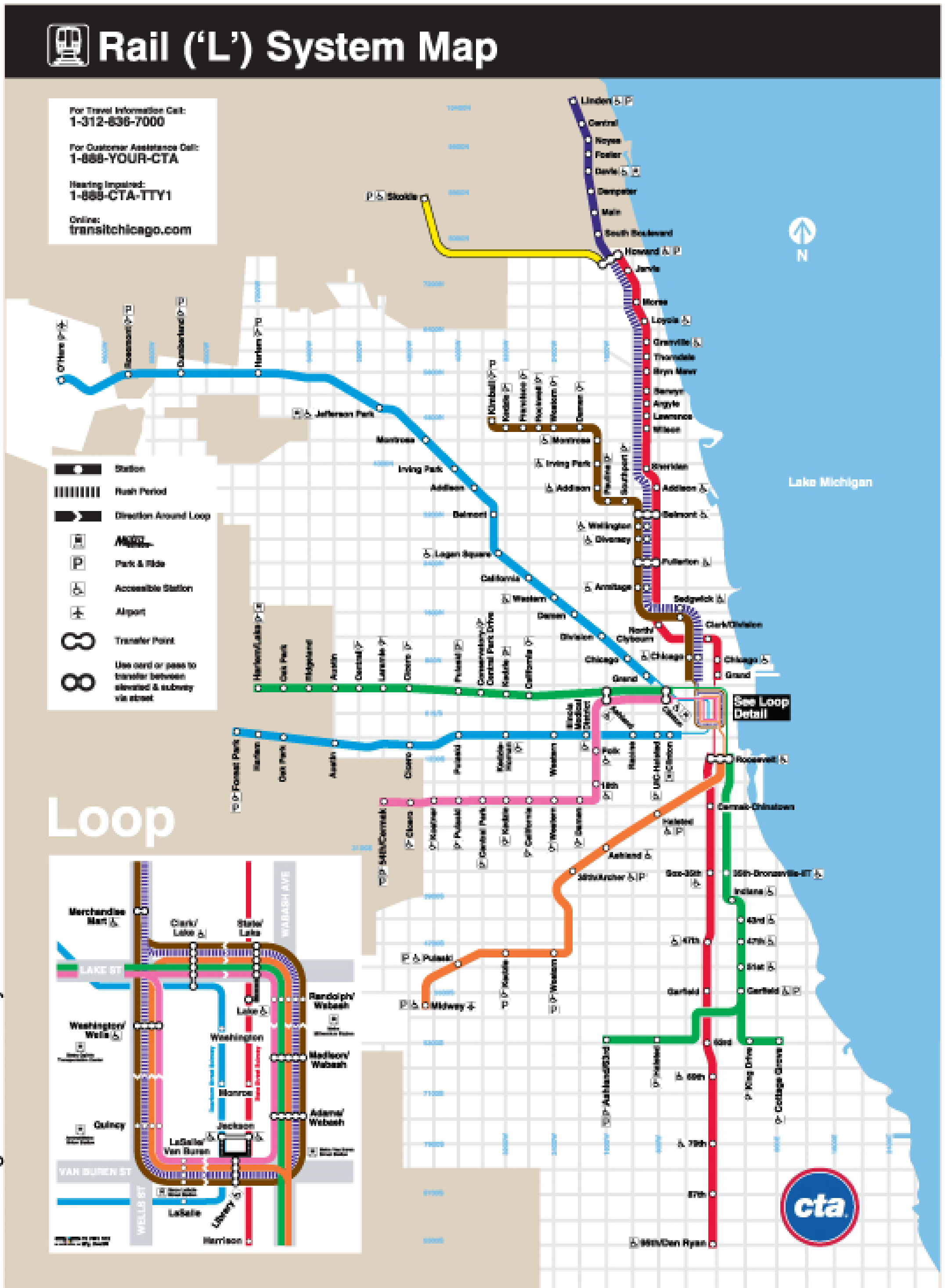
The key to long range reductions in unscheduled maintenance involves the continued implementation of the various Scheduled Maintenance Programs now in effect and planned for the near future. Again, the 2600 Series "D" Mid-Life Rehabilitation Program demonstrated that car subsystem enhancements resulted in dramatically improved reliability for over half of the CTA rail car fleet. The premise that the rehabbed 2600's would result in less unscheduled corrective maintenance was documented analyzing the difference between pre-rehab and post-rehab MMBD performance.

It was expected that the rehabbed 2600's should be at least as reliable as the successful 3200's series fleet. This is because of the new subsystems specified to be installed on the 2600's were the same or similar to the proven subsystems currently in service on the 3200 series cars. The improvement in MMBD of the rehabbed cars was substantially better than double pre-rehab, not only when compared against the same vehicles but also against a non-rehabbed control group. As the 2600 and 3200 Series fleets comprises 72 % of the CTA rail car fleet, this improvement translated to better overall performance and customer satisfaction through more reliable service and fewer delays.

The increase in MMBD for the rehabbed 2600's also resulted in a continuing increase in the system aggregate MMBD, from 1999 through 2002 and beyond, as the 2600's were returned to service. Although the fleet will continue to age, a "C" Level overhaul of 300 cars of the 2600-series, to be completed in spring 2012, is helping to once again improve this fleet's performance. The next large improvement in MMBD will take place when the 2200 series cars are fully replaced in 2012. This will be followed by another improvement when the 2400's are replaced starting immediately afterwards beginning in 2012 and continuing as the 5000 series vehicles are delivered in an approximately 11 vehicle per month delivery timetable. The return of 3200-series cars from their mid-life overhaul starting in 2014 will also help to improve fleet performance. For a more detailed explanation of the MMBD and goals, please refer to the Rail Car Maintenance Plan.

Appendices

Appendix I. Rail System Map



Appendix II. Rail Car Assignment

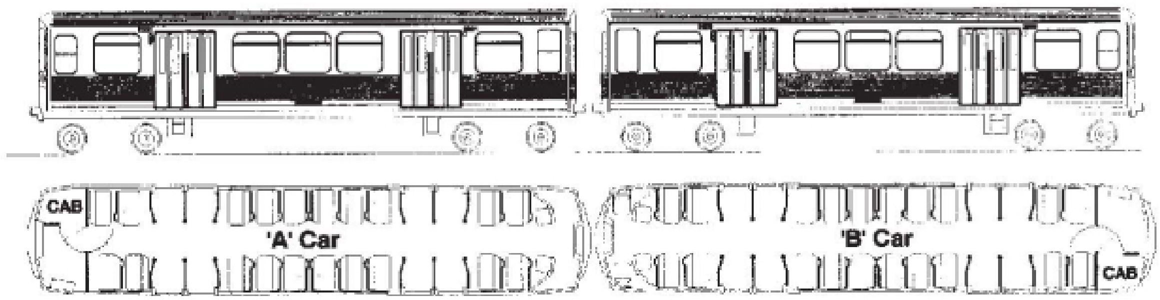
Rail Car Assignment
24-Oct-10

Route	2200 Series	2400 Series	2600 Series	3200 Series	5000 Series	Total Assigned
Blue	2201-2256 56 2259-2288 30 2293-2306 14 2309-2314 6 2317-2328 12 2331-2340 10 2343-2352 10 *138*		2967-2976 10 2979-3030 52 3033-3156 124 *186*			**324**
Pink			3157-3200 44 *44*			**44**
Red			2601-2700 100 2703-2720 18 2723-2790 68 2791-2856* 2 2793-2854 62 2857-2890 34 2901-2954 54 *338*			**338**
Purple		2401-2410 10 2545-2578 34 2581-2600 20 *64*	2955-2966 12 *12*			**76**
Yellow			*2891-2892* 2 *2897-2900* 4 *6*			**6**
Brown				3303-3320 18 3321-3326 $ 6 3327-3440 114 3441-3456 ** 16 3457-3458 * 2 *156*		**156**
Orange				3201-3302 102 *102*	5003-5012 10 *10*	**112**
Green		2411-2446 36 2449-2468 20 2469-2504 * 2 2471-2480 10 2483-2502 20 2505-2516 12 2519-2530 12 2531-2482 * 2 2533-2544 12 *126*				**126**
Sub Total	**138**	**190**	**586**	**258**	**10**	**1182**
Long Term Hold	2291-2292 2 2329-2330 2 *4*	2470 1 2503 1 2579-2580 2 *4*	2701-2702 2 2721-2722 2 2893-2896 4 2977-2978 2 *10*			**18**
TOTAL	**142**	**194**	**596**	**258**	**10**	**1200**

* Permanent Mismates: 2469-2504, 2531-2482, 2791-2856 & 3457-3458 (3458 renumbered from 3032).
** Cars with Roof Boards.
$ Cars modified to be MAX CAPACITY cars.

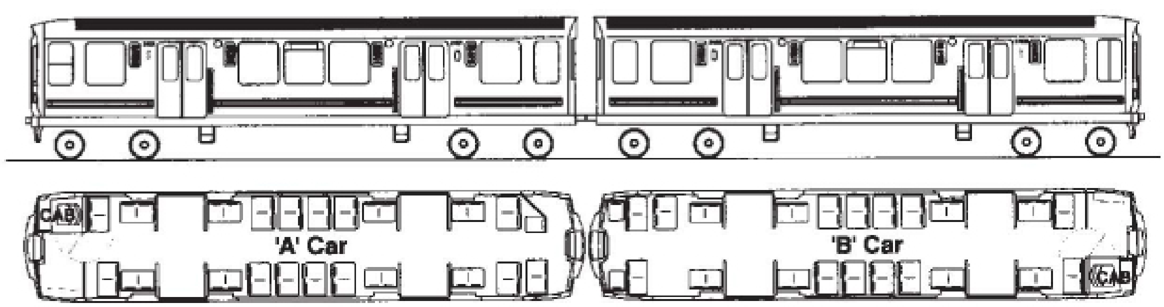
Appendix III. Car Layout Diagrams

2201-2352



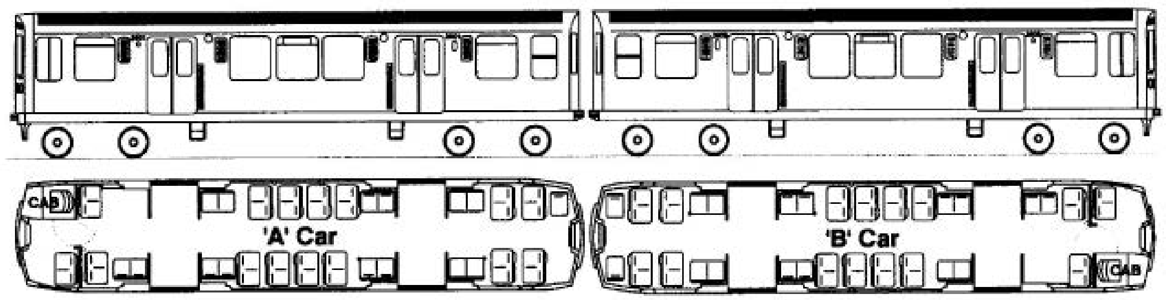
SERIES	BUILDER	YEAR	LENGTH	WIDTH	HEIGHT (ROOF)	SEATS
2201-2352	BUDD	1969-70	48'-0"	9'-4"	12'-0"	A-42 B-46
CARS ARE PERMANENTLY COUPLED IN CONSECUTIVELY NUMBERED PAIRS						
REBUILT BY NEW YORK RAIL CAR IN 1990-1992.						

2401-2600



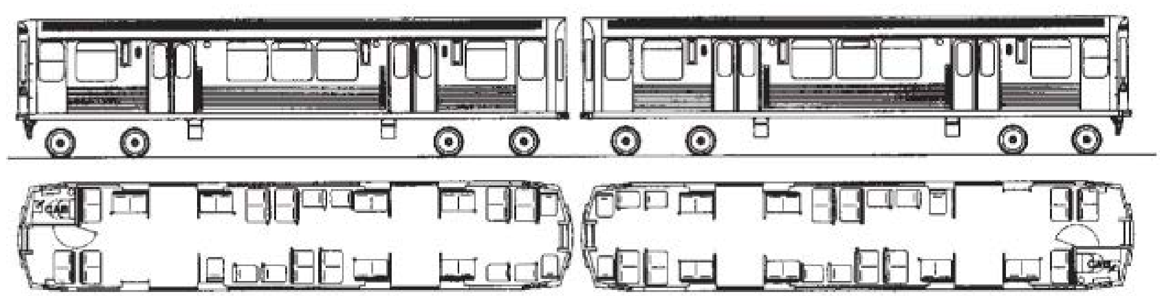
SERIES	BUILDER	YEAR	LENGTH	WIDTH	HEIGHT (ROOF)	SEATS
2401-2600	BOEING-VERTOL	1976-78*	48'-0"	9'-4"	12'-0"	A-43 B-45
CARS ARE PERMANENTLY COUPLED IN CONSECUTIVELY NUMBERED PAIRS						
*CARS REHABBED BY SKOKIE SHOP 1987-1995.						

2601-3200



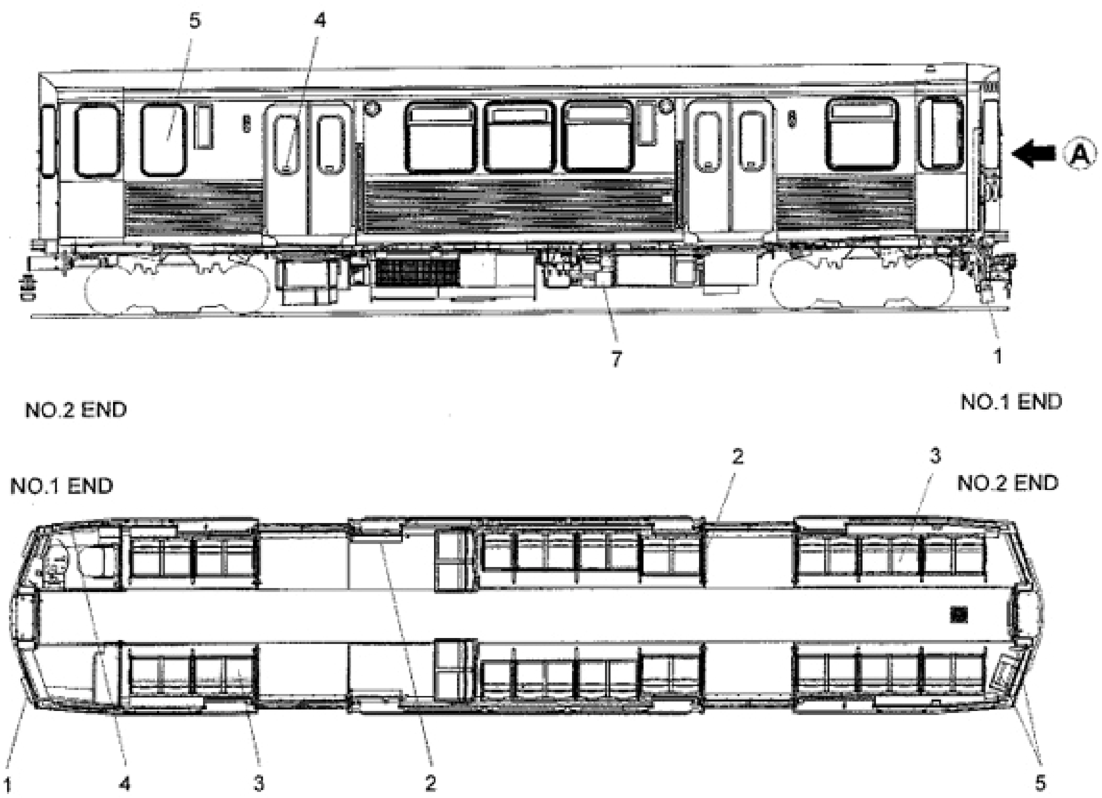
SERIES	BUILDER	YEAR	LENGTH	WIDTH	HEIGHT (ROOF)	SEATS
2601-3200	BUDD	1981-87	48'-0"	9'-4"	12'-0"	A-45 B-46
CARS ARE PERMANENTLY COUPLED IN CONSECUTIVELY NUMBERED PAIRS REBUILT BY ALSTOM 1999-2002						

3201-3457



SERIES	BUILDER	YEAR	LENGTH	WIDTH	HEIGHT (ROOF)	SEATS
3201-3457	MORRISON KNUDSEN	1992-3 1994	48'-0"	9'-4"	12'-0"*	39
CARS ARE PERMANENTLY COUPLED IN CONSECUTIVELY NUMBERED PAIRS * 13'6¼" HEIGHT TO TOP OF LOCKED DOWN PANTOGRAPH - CARS 3445-3456						

5000 Series Rail Car



Series 5000
2010 prototype testing with ten rail cars
Builder Bombardier
Cars are permanently coupled in consecutively numbered pairs

Appendix IV. Rail Fleet Capital Program - 1999 through 2010

RAIL FLEET CAPITAL PROGRAM - 1999 through 2010

Car Series & Quantity	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
2200 Series (142)							X-36	X-46	X-24	X-34	X-2	
2400 Series (194)							X-44	X-56	X-62	X-30		
2600 Series (596)	D-134	D-170	D-166	D-126							C-86	C-94
3200 Series (258)			C-2	C-40	C-96	C-102	C-18					
Base + Opt 1 5000 Series (406)											10	
Option 2 5000 Series (216)												
Option 3 5000 Series (84)												

Number of Cars	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
"X" = Life extending Quarter-life Overhaul (In house)							80	102	86	64	2	
"C" = C-Level Quarter-life Overhaul (In house)			2	40	96	102	18				96	96
"D" - 1/2 Life Overhaul (Off Site)	134	170	166	126								
"N" - New Cars (min 25 Year Life)											10	

Appendix V. Rail Fleet Capital Program

RAIL FLEET CAPITAL PROGRAM

Car Series & Quantity	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
2600 Series (596)	C-86	C-96	C-96	C-22				C-110	C-134	C-90		
3200 Series (258)						D-100	D-134	D-24				
Base + Opt 1 5000 Series (406)	10	0	70	134	134	58				C-96	C-96	C-96
Option 2 5000 Series (216)						76	134	6				
Option 3 5000 Series (84)								84				

Number of Cars	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
"C" = C-Level Quarter-life Overhaul (In house)	86	96	96	22				110	134	186	96	96
"D" - 1/2 Life Overhaul (Off Site)						100	134	24				
"N" - New Cars (min 25 Year Life)	10		70	134	134	134	134	90				

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Peak Vehicle Requirement	956	956	982	982	1020	1020	1068	1068	1092	1092	1112	1112
Total required spares	166	176	176	216	206	206	214	230	192	208	196	196
Required Fleet Size	1122	1132	1158	1198	1226	1226	1282	1298	1284	1300	1308	1308
Available Cars (before retirements)	1200	1200	1270	1292	1332	1360	1360	1372	1308	1308	1308	1308
Retire 2200 & 2400			112	94	106	24						
Retire 2600						110	78	64	0	0	0	0

Note: numbers calculated as of the end of the year.
New car delivery assumed to be approx 11 per 30 days

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Average age of fleet	25	26	26	23	21	18	16	15	15	16	17	18

2009 cars required to meet service 98% of days	158	
Less overhaul float	16	
2009 cars less ovhl float - 98% of days	142	
% of PVR	14.9%	basis for future year projections to meet service 98% of days (excludes overhaul float)

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Cars to meet service 98% of days (excluding ovhl float)	142	142	145.86	145.86	151.51	151.51	158.64	158.64	162.2	162.2	165.17	165.17
Round to even car count	142	142	146	146	152	152	160	160	162	162	166	166
Overhaul program float	16	16	16	56	40	40	40	56	16	32	16	16
Engineering Tests Allowance	4	4	4	4	4	4	4	4	4	4	4	4
Long-term Holds	4	14	10	10	10	10	10	10	10	10	10	10
Total required spares	**166**	**176**	**176**	**216**	**206**	**206**	**214**	**230**	**192**	**208**	**196**	**196**
Total fleet demand	1122	1132	1158	1198	1226	1226	1282	1298	1284	1300	1308	1308
Spare ratio	17%	18%	18%	22%	20%	20%	20%	22%	18%	19%	18%	18%

Revised 12/2010: added Engineering Tests Allowance and Long-term Holds in Total required spares calculation

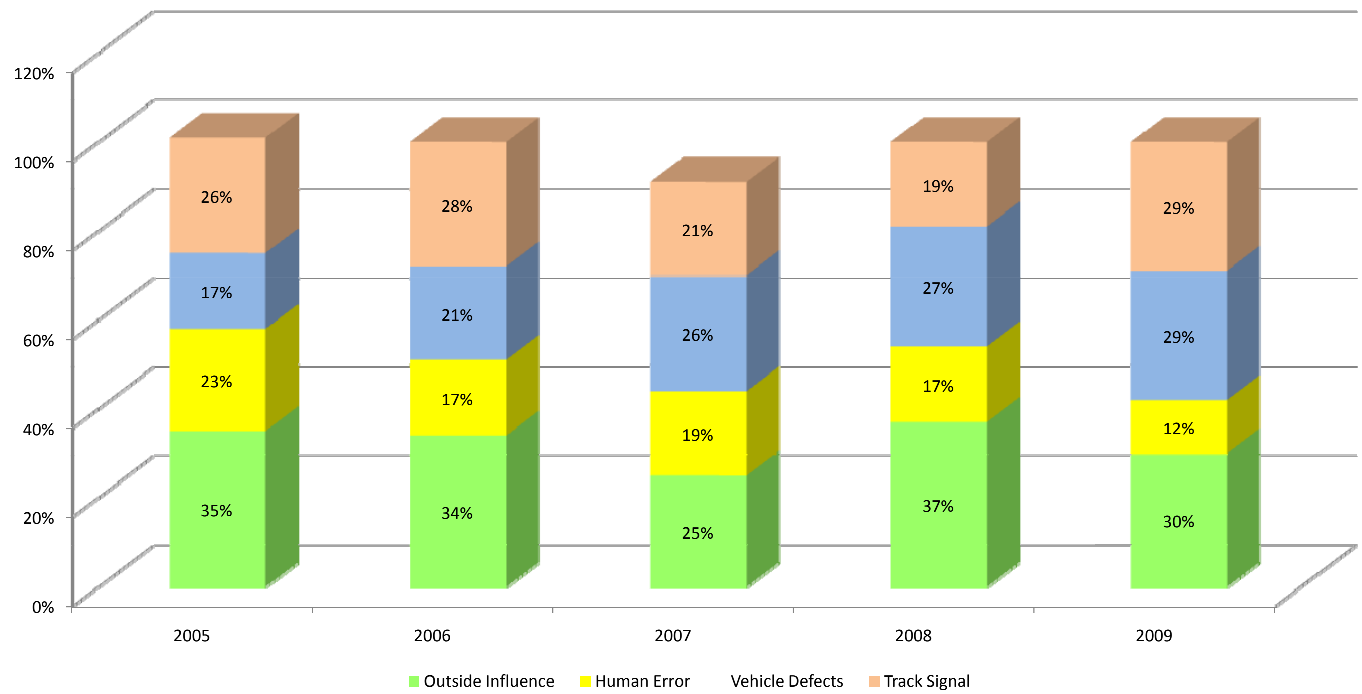
Appendix VI. CTA Rail Maintenance Shops and Storage Yards

Rail Shops	Location	Shop Area	Yard Area
Des Plaines	711 S. DesPlaines, Forest Park, IL 60130	27,361 sf	203,750 sf
Harlem	1 S. Harlem Avenue, Forest Park, IL 60130	37,570 sf	148,200 sf
Howard	1825 W. Juneway Terrace, Chicago, IL 60626	95,000 sf	653,400 sf
Kimball	3365 W. Lawrence Avenue, Chicago, IL 60625	60,923 sf	299,700 sf
Linden	Linden & 4th Street, Wilmette, IL 60091	13,690 sf	131,100 sf
Midway	5601 S. Kilpatrick Avenue, Chicago, IL 60629	88,000 sf	806,676 sf
Racine	6320 S. Racine Avenue, Chicago, IL 60636	8,872 sf	140,000 sf
Rosemont	5700 N. River Road, Rosemont, IL 60091	88,000 sf	523,000 sf
54th	2150 S. 54th Avenue, Cicero, IL 60650	27,350 sf	231,700 sf
61st	329 E. 61st Street, Chicago, IL 60637	47,373 sf	206,392 sf
98th	9800 S. State Street, Chicago, IL 60628	35,230 sf	389,760 sf
Skokie Shop	3701 W. Oakton Street, Skokie, IL 60076	236,700 sf	1,412,625 sf

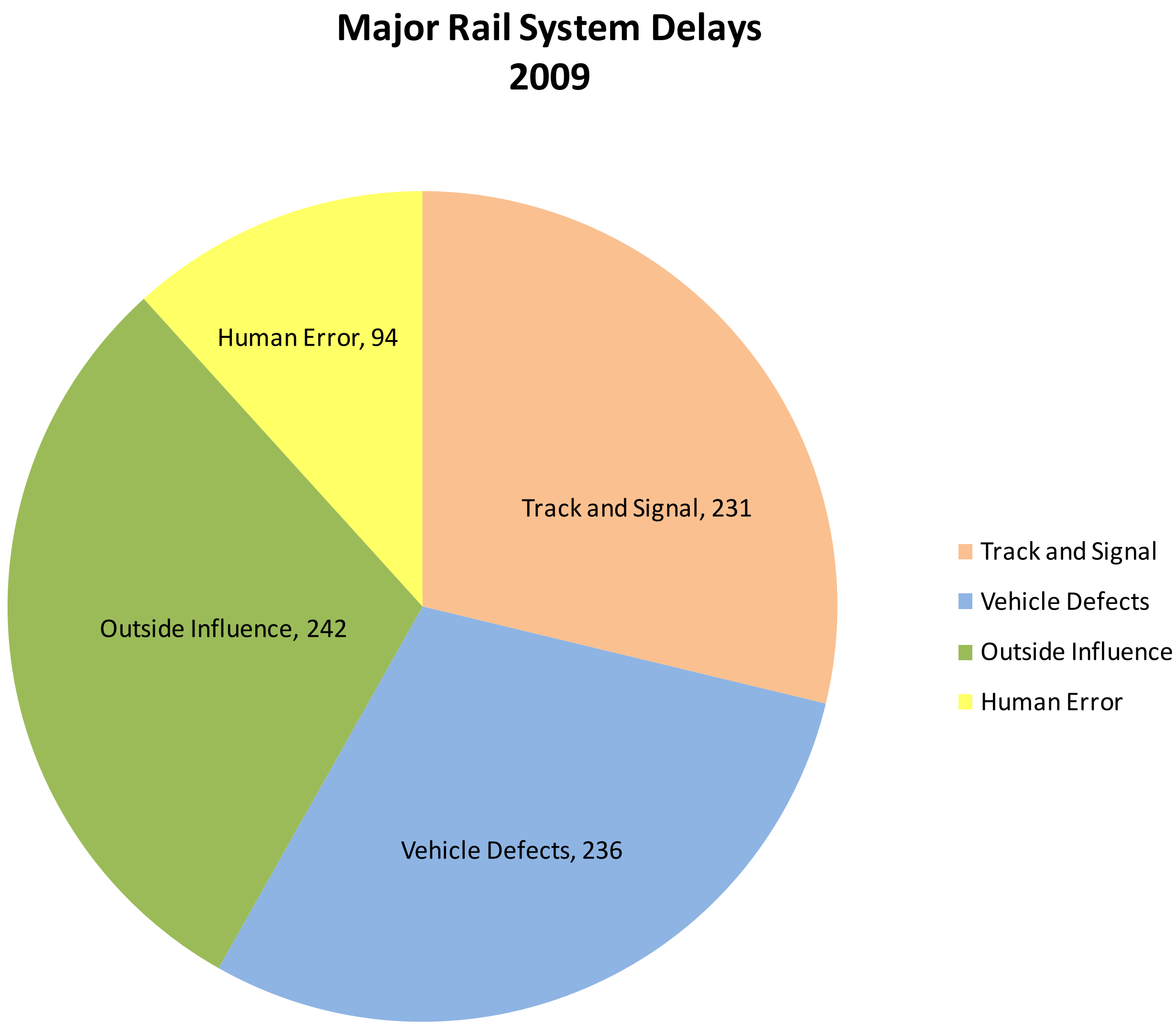
Appendix VII. Rail Shop Yard Space

Shop	Route	Inside Track Space	Pit Space	Lift Track Space	Inspection Hours	# Insp Cars Assigned	Inspections Performed	Cleaning Performed	Yard Space
Linden Shop	Purple	4 Cars	4 Cars	None	None	0 Cars	None	General Cleans, Yard Sweeping, Platform Servicing	80 Cars
Howard Shop	Red/ Yellow/ Purple	26 Cars	20 Cars	6 Position Jack Track	06:00 - 14:30 14:00 - 22:30	198 Cars	A & B Inspection	General Cleans, Yard Sweeping, Ext Car Wash	274 Cars
98th Shop	Red	8 Cars	4 Cars	4 Position Jack Track	06:00-14:30	216 Cars	A Inspection	General Cleans, Yard Sweeping, Platform Servicing	234 Cars
Kimball Shop	Brown	20 Cars	6 Cars	2 Position Jack Track	09:00 - 17:30	156 Cars	A & B Inspection	General Cleans, Yard Sweeping, Platform Servicing, Ext Car Wash	136 Cars
54th Shop	Pink	14 Cars	8 Cars	2 Position Jack Track	09:00 - 17:30	44 Cars	A & B Inspection	General Cleans, Yard Sweeping, Platform Servicing, Ext Car Wash	100 Cars
Harlem Shop	Green	12 Cars	6 Cars	6 Position Jack Track	09:00 - 17:30	126 Cars	A & B Inspection	General Cleans, Yard Sweeping, Platform Servicing, Ext Car Wash	130 Cars
Racine Shop	Green	4 Cars	16 Cars	None	None	0 Cars	None	General Cleans, Yard Sweeping	144 Cars
Midway Shop	Orange	20 Cars	16 Cars	4 Position Jack Track	09:00 - 17:30	112 Cars	A & B Inspection	General Cleans, Yard Sweeping, Platform Servicing, Ext Car Wash	192 Cars
Rosemont Shop	Blue	20 Cars	16 Cars	4 Position Jack Track	05:00 - 13:30 09:00 - 17:30	216 Cars	A & B Inspection	General Cleans, Yard Sweeping, Platform Servicing, Ext Car Wash	260 Cars
Desplaines Shop	Blue	14 Cars	12 Cars	2 Position Jack Track	05:00 - 13:30	108 Cars	A & B Inspection	General Cleans, Yard Sweeping, Ext Car Wash	122 Cars
Skokie Shop		38 Cars	8 Cars	8 Position Jack Track	None	0 Cars	Heavy Repairs	None	78 Cars
63rd - **Post Construction**	Green	16 Cars	12 Cars	Portable Jacks	N/A	Non-Revenue	Non-Revenue	N/A	84 Cars
						1182 Cars			**1834 Cars**

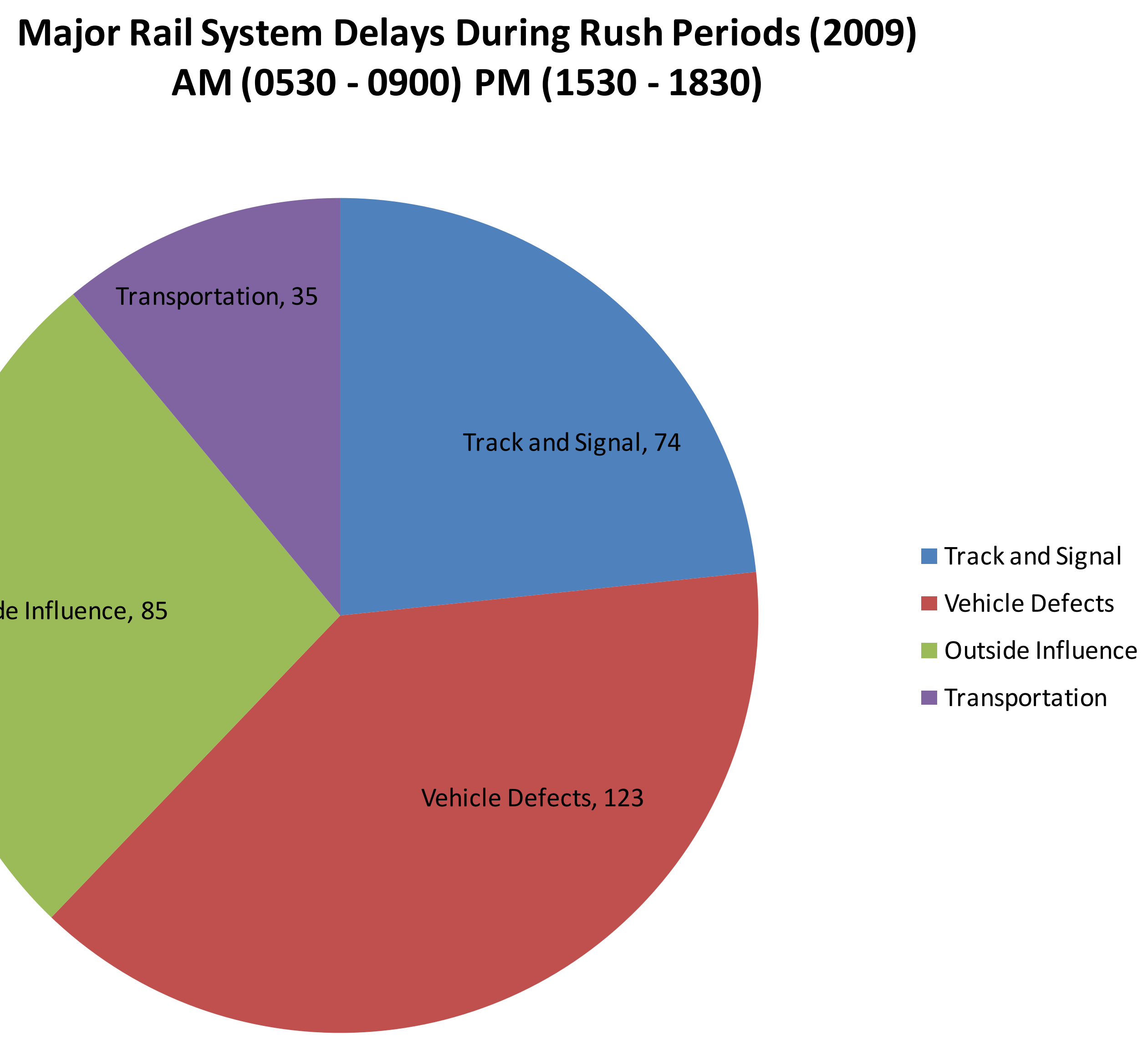
Appendix VIII. Major Rail System Delays 2009



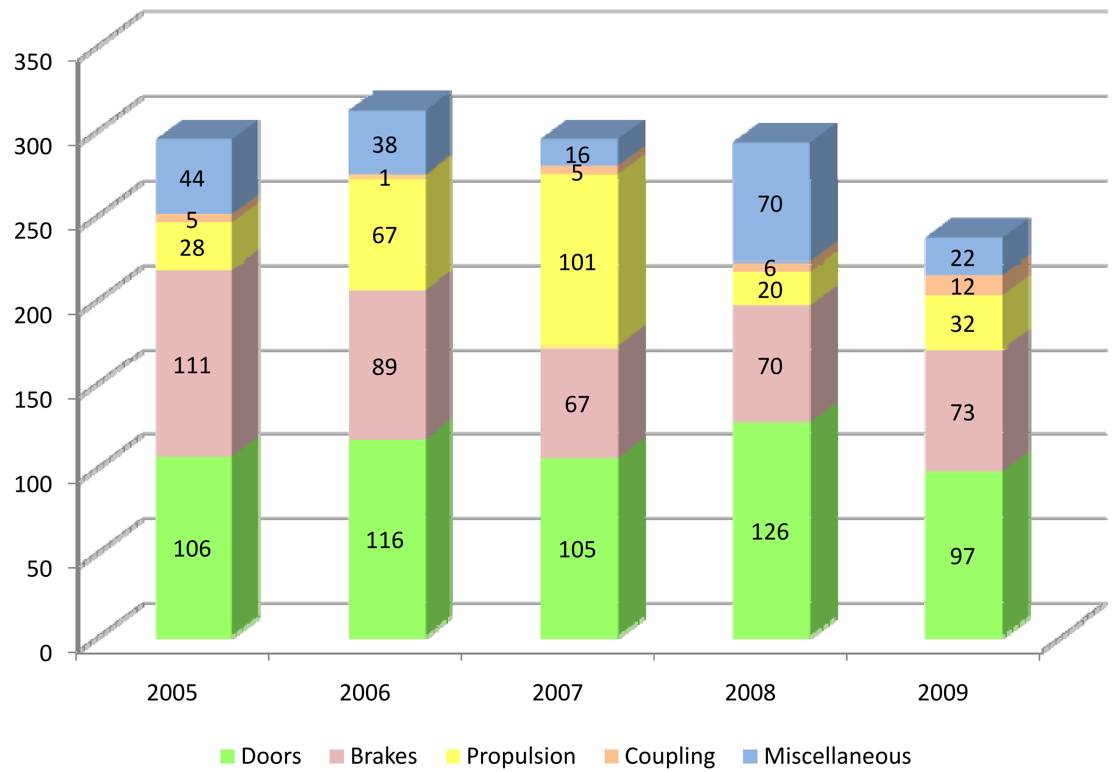
Appendix IX. Provides a breakdown by symptom of the Major Delays caused by Vehicle Defects.



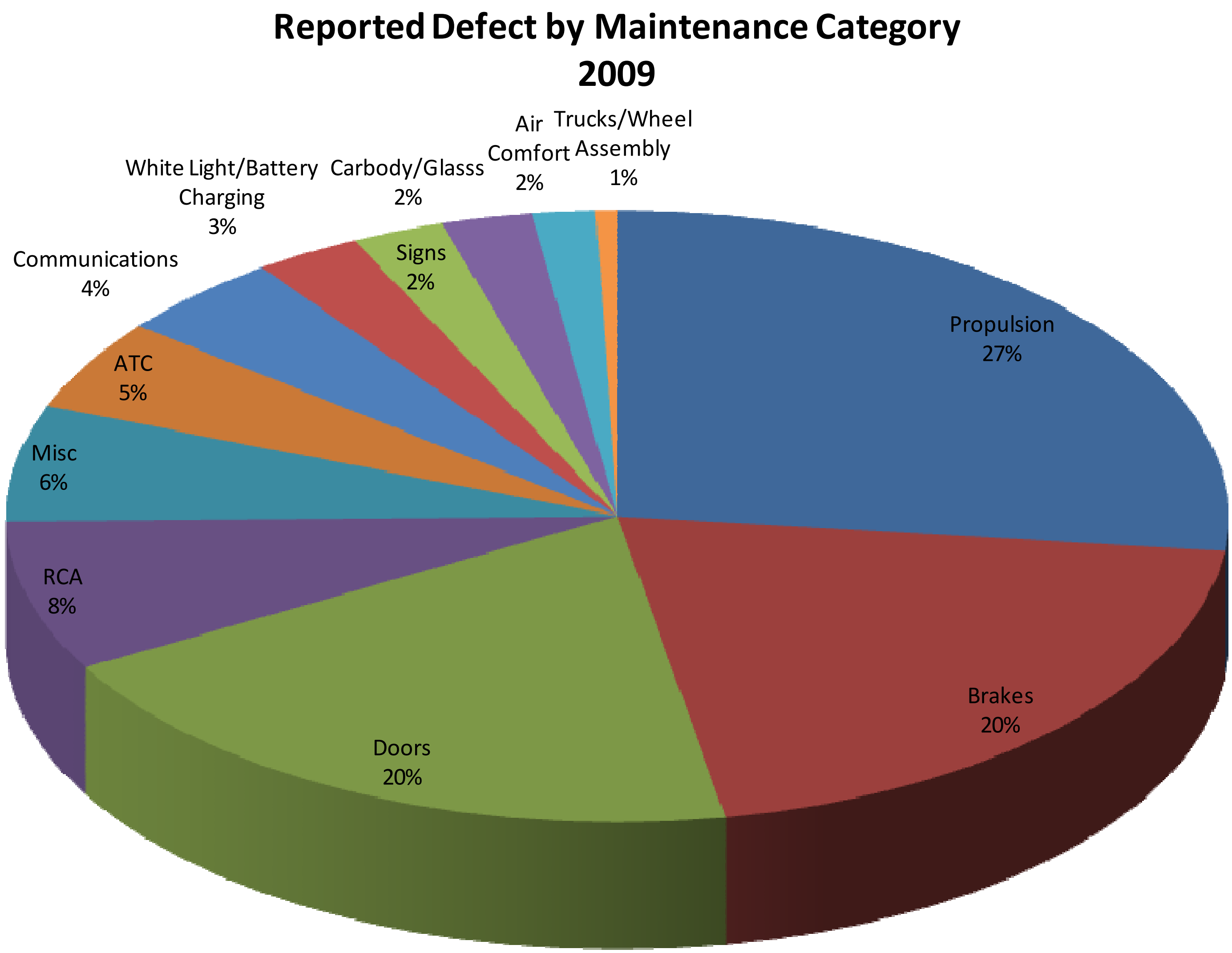
Appendix X. Major Rail System Delays During Rush Periods – 2009



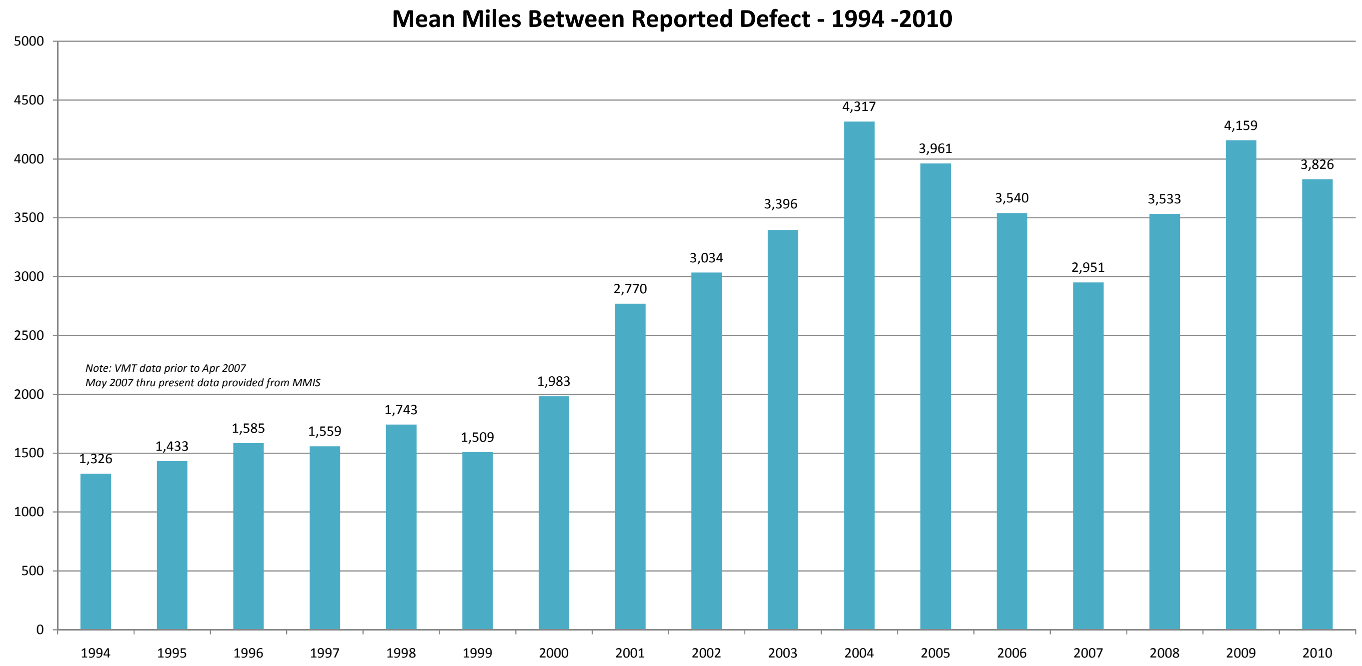
Appendix XI. Major Rail System Delays by Vehicle Defect 2005 – 2009



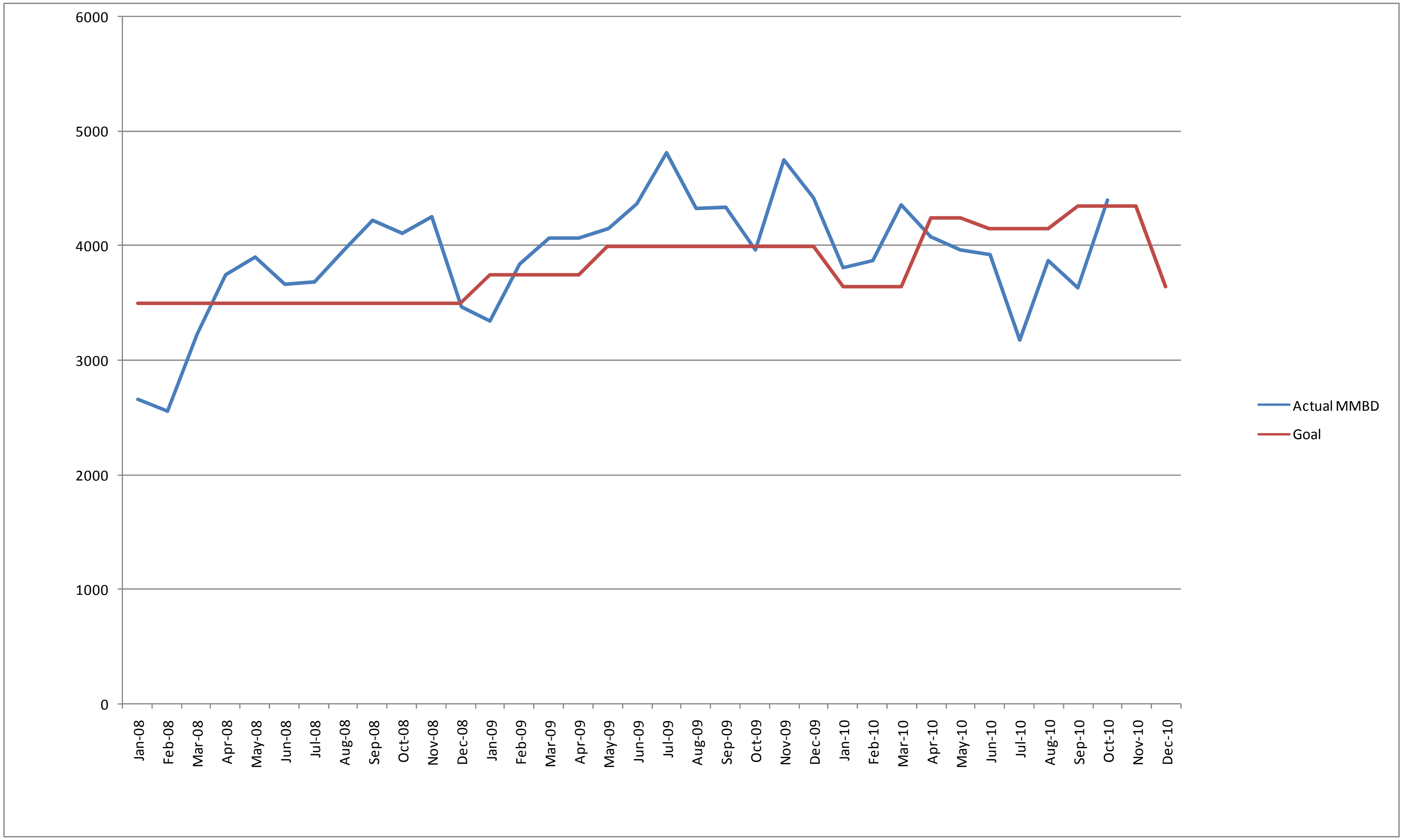
Appendix XII. Reported Defect by Maintenance Category



Appendix XIII. Mean Miles Between Reported Defect - 1994 -2010



Appendix XIV. Actual Mean Miles Between Reported Defects (MMBRD) Compared to Goal Line



List of Reasons for Revisions

Revisions December 2010:

1. Revised RFMP layout to improve readability.
2. Updated RFMP to reflect recommendations by PMOC.
3. Renamed Glossary of Acronyms to Definition of Terms. Added items to reflect updated definition content.
4. Added tables and appendixes to support revised document.