

University of Illinois

**“Commuter Railroad Engineering
and the State of Good Repair”**

November 4, 2011

**Joseph Lorenzini, P.E.
Chief Engineering Officer**

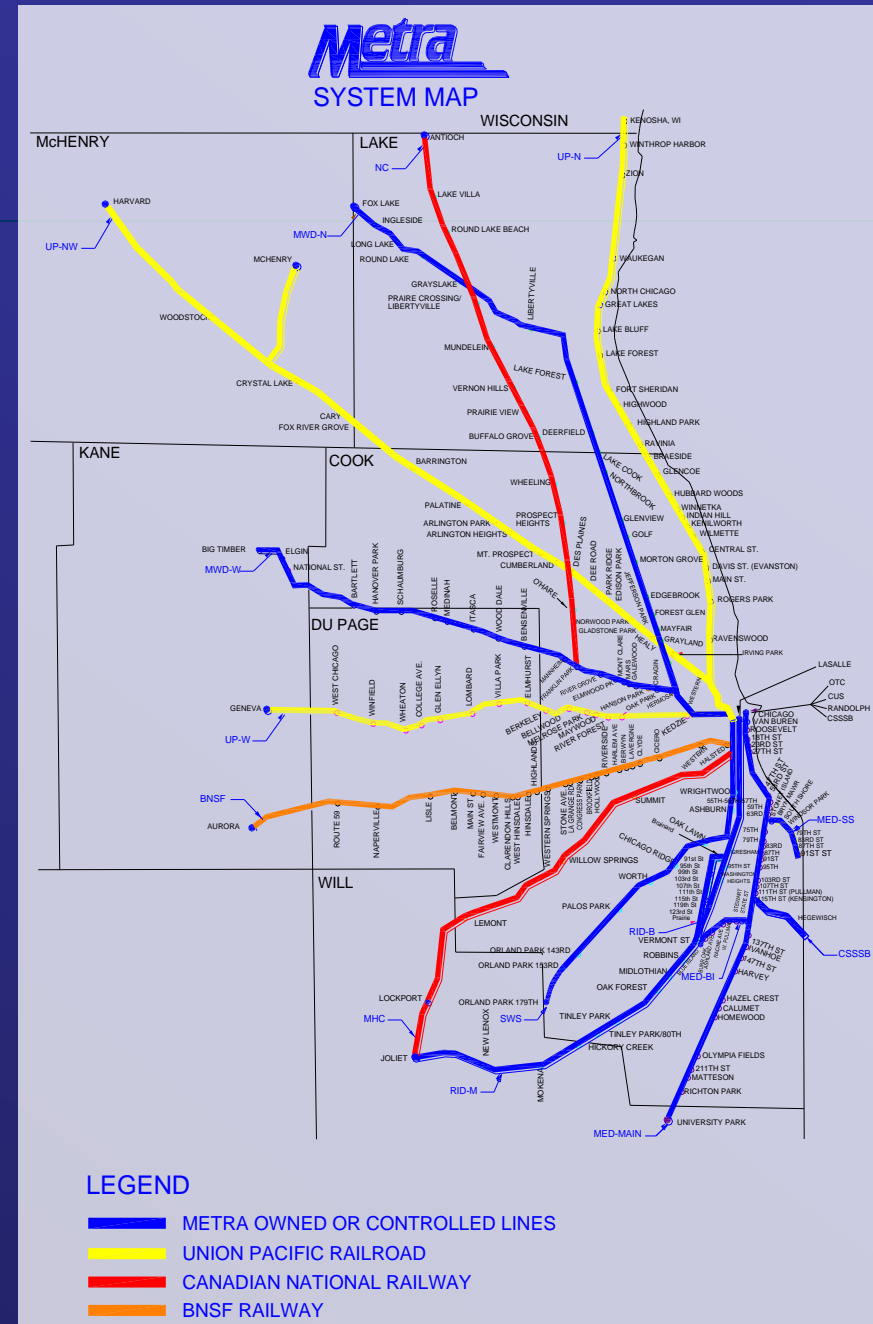




Metra

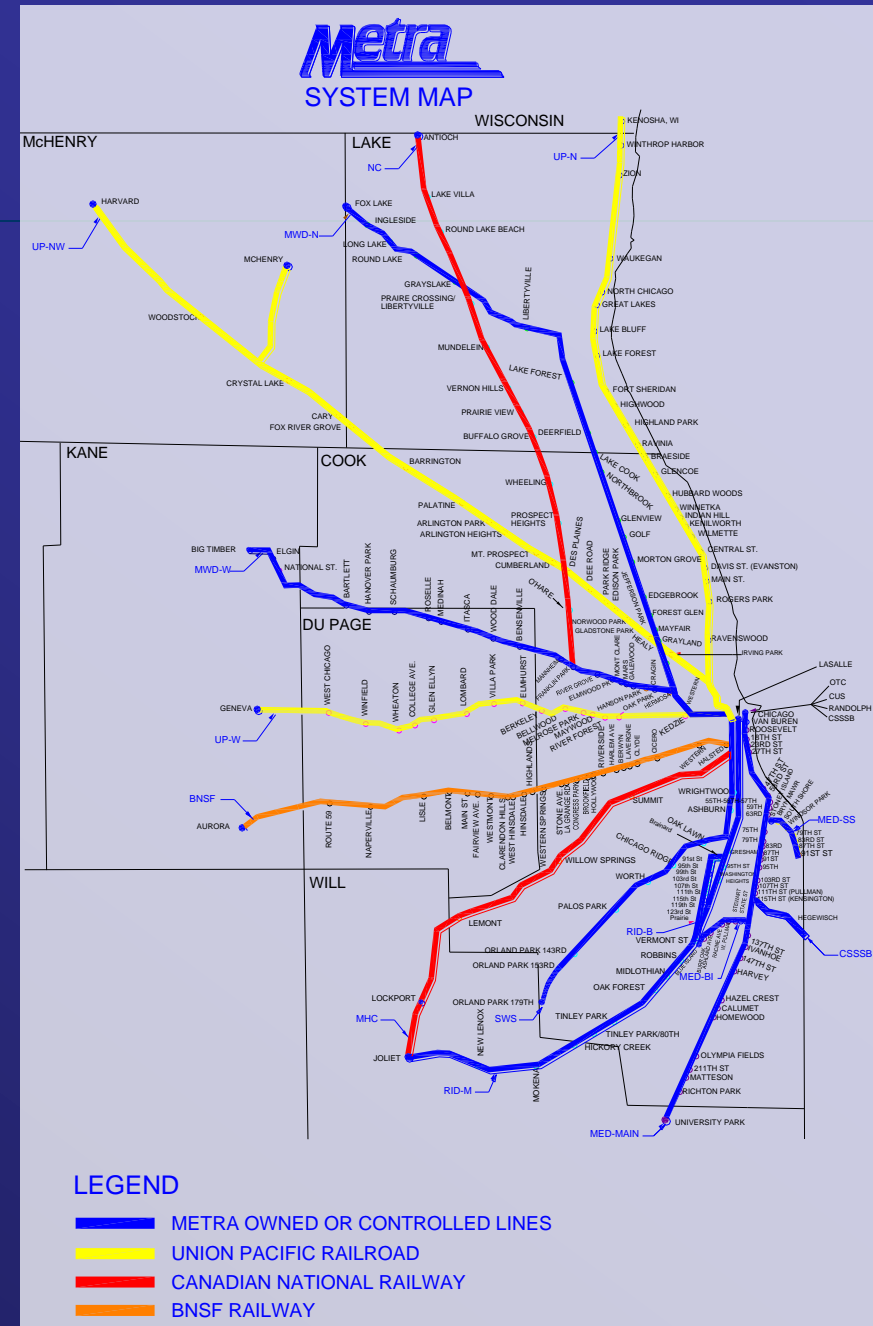


- 6 Counties
- Annual Budget \$930 Million
- 704 Trains each weekday
- 86.8 Million riders in 2008
- Largest commuter railroad in North America in terms of trackage



TERRITORY

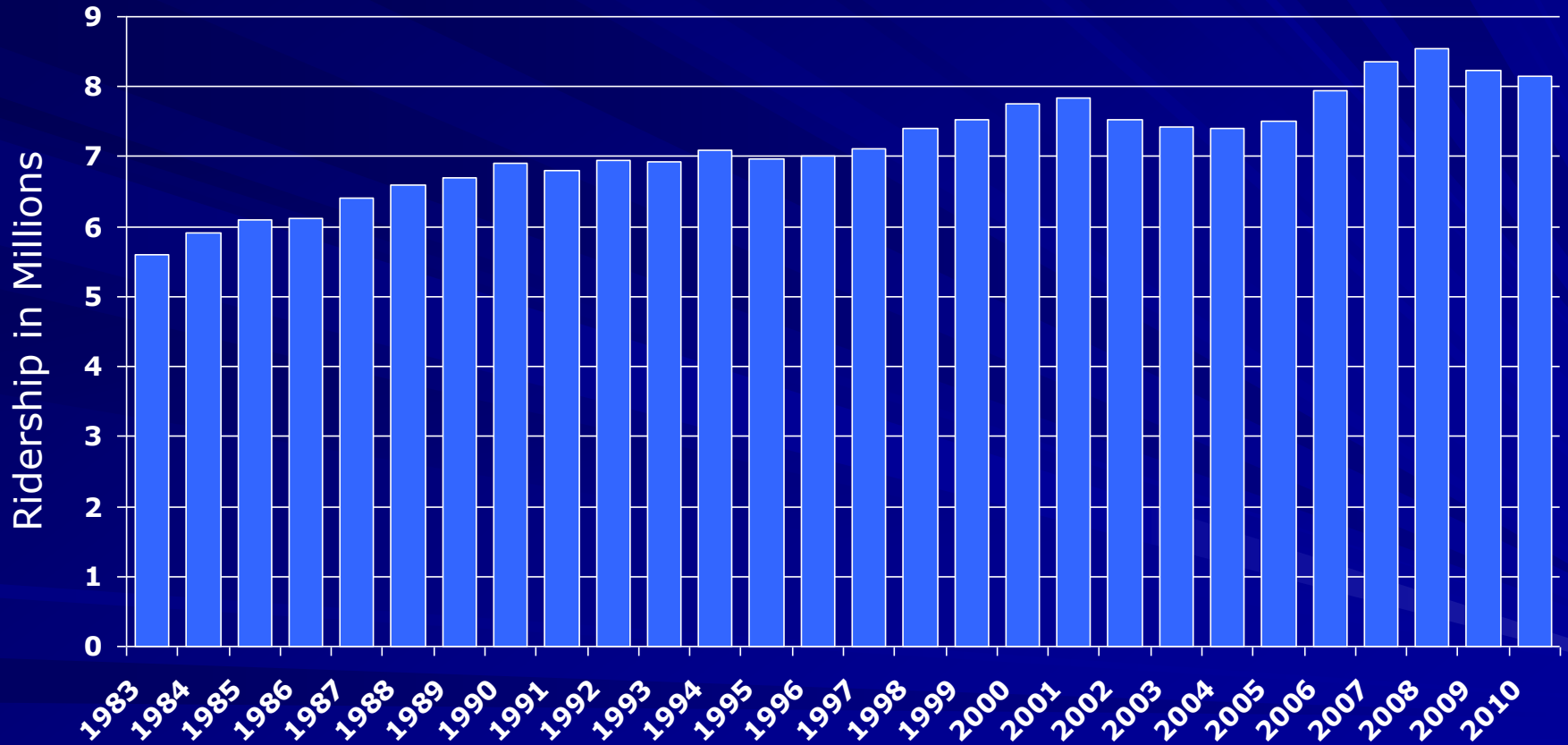
- Track Miles – 1,189
- Route Miles – 546
- Road Grade Crossings – 534
- RR Grade Crossings – 19
- Bridges – 821
- Stations – 240
- Parking Spaces – 92,995



Metra System Ridership

Reported w/ Free Trips

August, 1983-2010



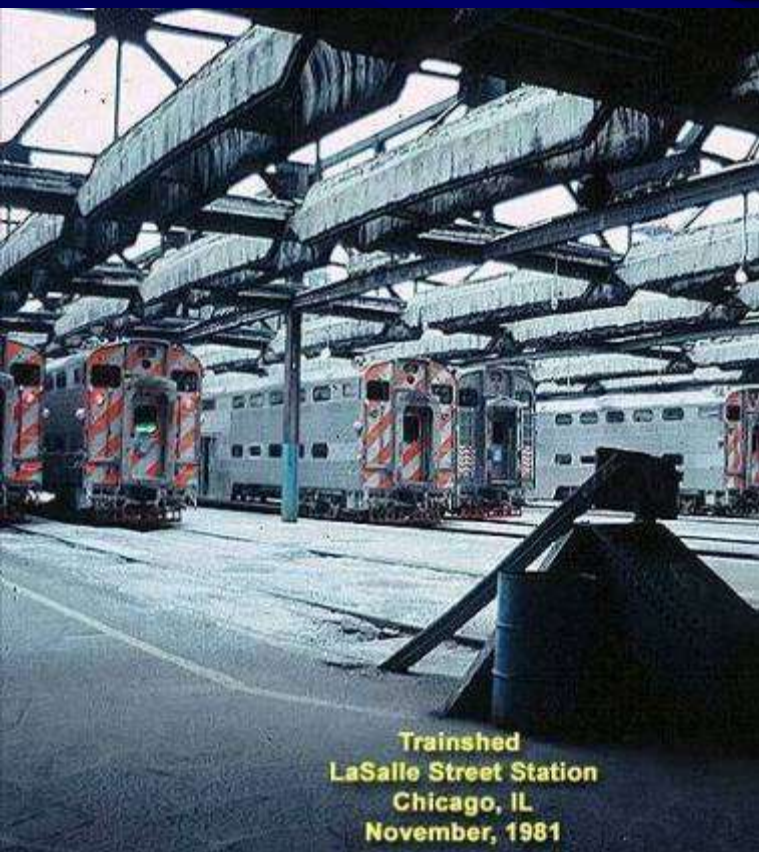
Responsible for Fixed Assets

- Stations and Parking Lots
- Track
- Maintenance Facilities
- Signal Systems
- Communications
- Electrical Propulsion
- Line Extensions and Expansions
- Bridges

Stations and Parking Lots

- 5 Downtown Stations
- 235 Outlying Stations
- 92,955 Parking Spaces
- 30 New Stations Since 1983
- 40,355 New Parking Spaces Since 1987
- 14,387 Parking Spaces Rehabilitated Since 1983

La Salle Street Station



Millennium Station (Randolph Street)



Midlothian





51st – 53rd Streets Hyde Park



Track

- 1,155 Miles of Track
- 574 Grade Crossings
- 3,800,000 Track Ties
- 115,000 Switch Ties

Tie replacement





Track surfacing

Track Renewal



Track Renewal









APR 8 2004



Maintenance Facilities

Metra Coach Yards



Facilities & Equipment



Western Avenue Yard





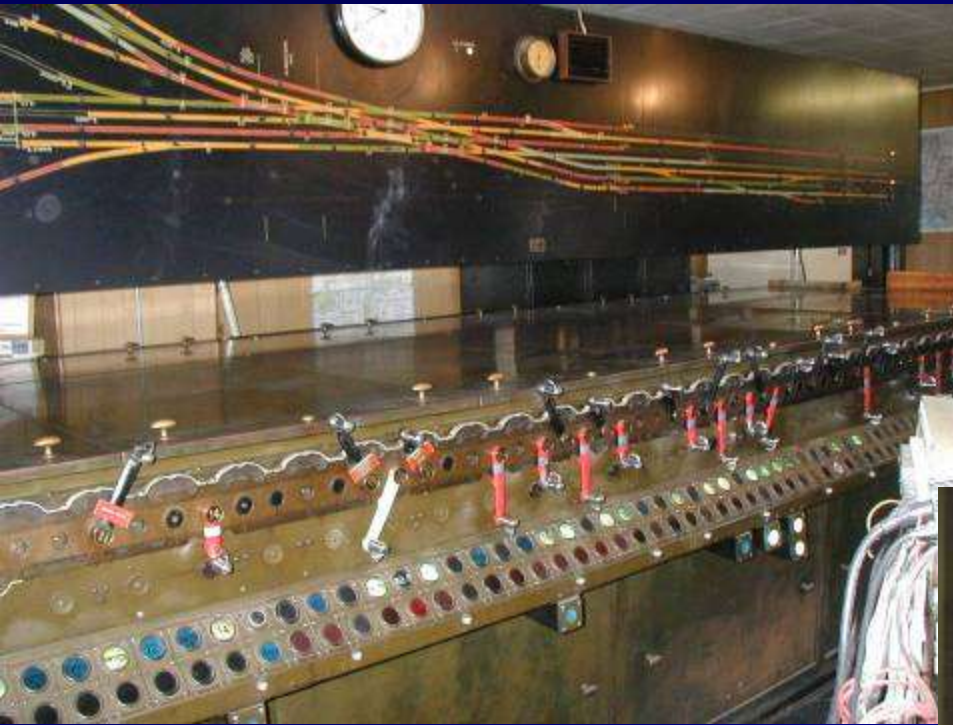


Signals & Communication

Signals, Electrical, & Communications Interlocking Upgrades



Signals, Electrical, & Communications Interlocking Upgrades



Signals, Electrical, & Communications

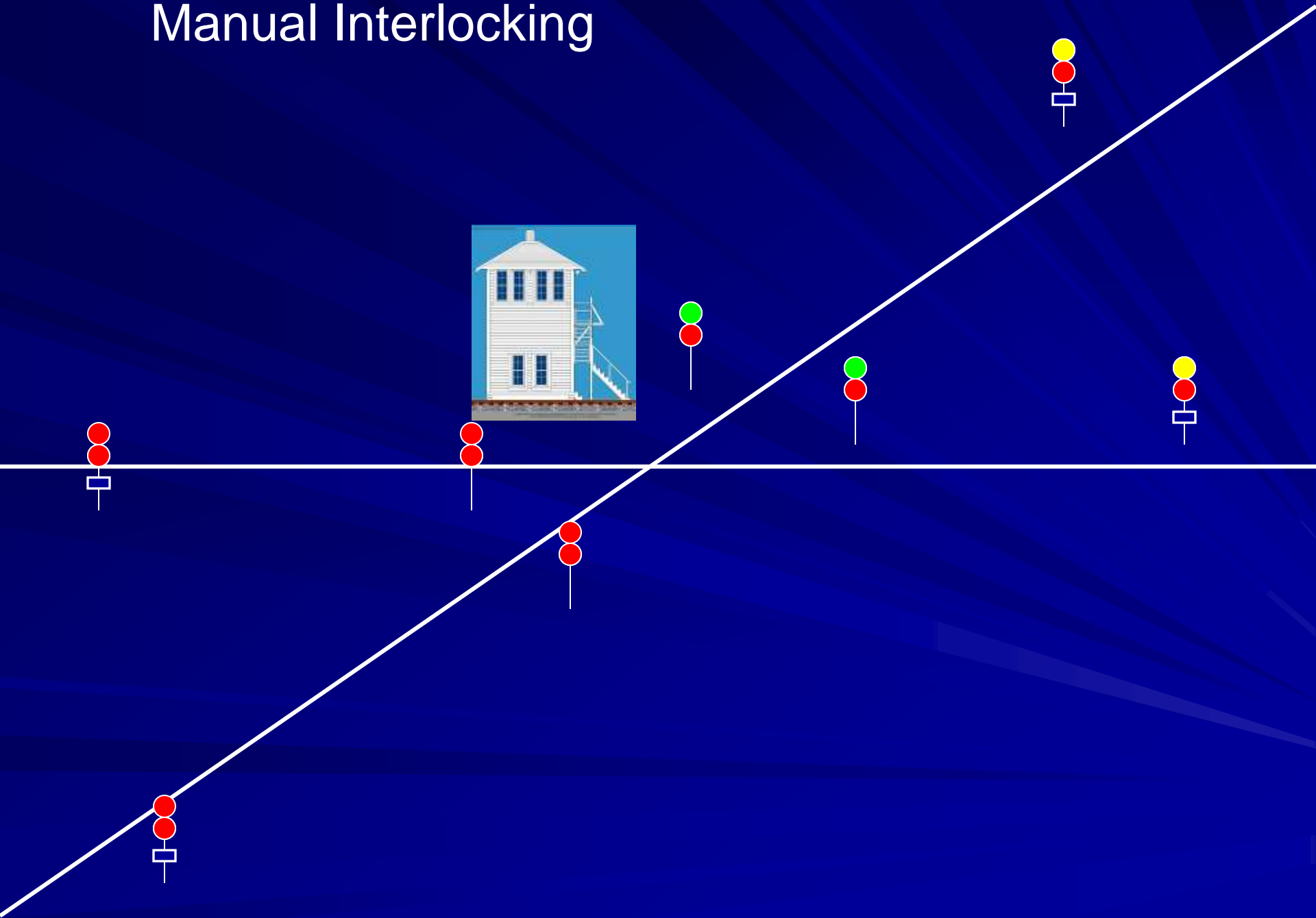


Signal Operation

Automatic Block Signal



Manual Interlocking



Positive Train Control (PTC)

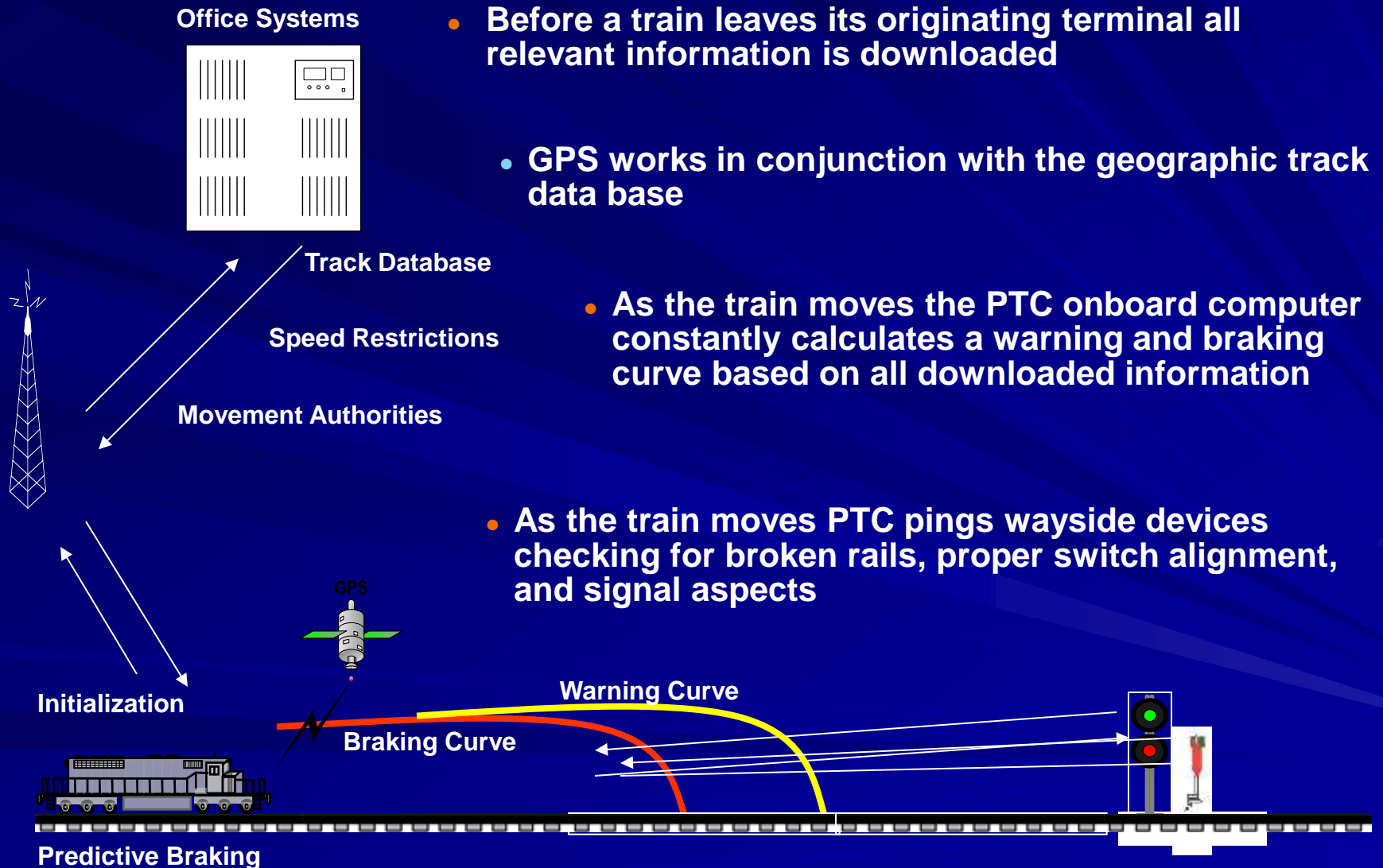


PTC Benefits

■ Safety Related Benefits

- Train Collision Avoidance
- Switch Protection
- Over Speed Avoidance

PTC – How Does It Work?



Phase 1 – Onboard & Wayside Integration

PTC Wayside

Route determined by:

- Switch Position interrogation
- Signal State interrogation



PTC Onboard Package

- Onboard Computer
- Engineer Display
- Data Communications



Railroad Communications



Passenger Communications



Passenger Communications



Passenger Communications

WIRELESS CONNECTION

GPS CENTER
547 W.JACKSON

- PROVIDES
LOCATION AND STATUS
OF TRAIN TO GPS
CENTER FROM ON-BOARD
EQUIPMENT

- GPS CENTER CAN SEND
ON-BOARD
ANNOUNCEMENTS
TO TRAINS

GPS RADIO CONNECTION

GPS
SATELLITE

PROVIDES
LOCATION OF
TRAIN TO
ON-BOARD
EQUIPMENT

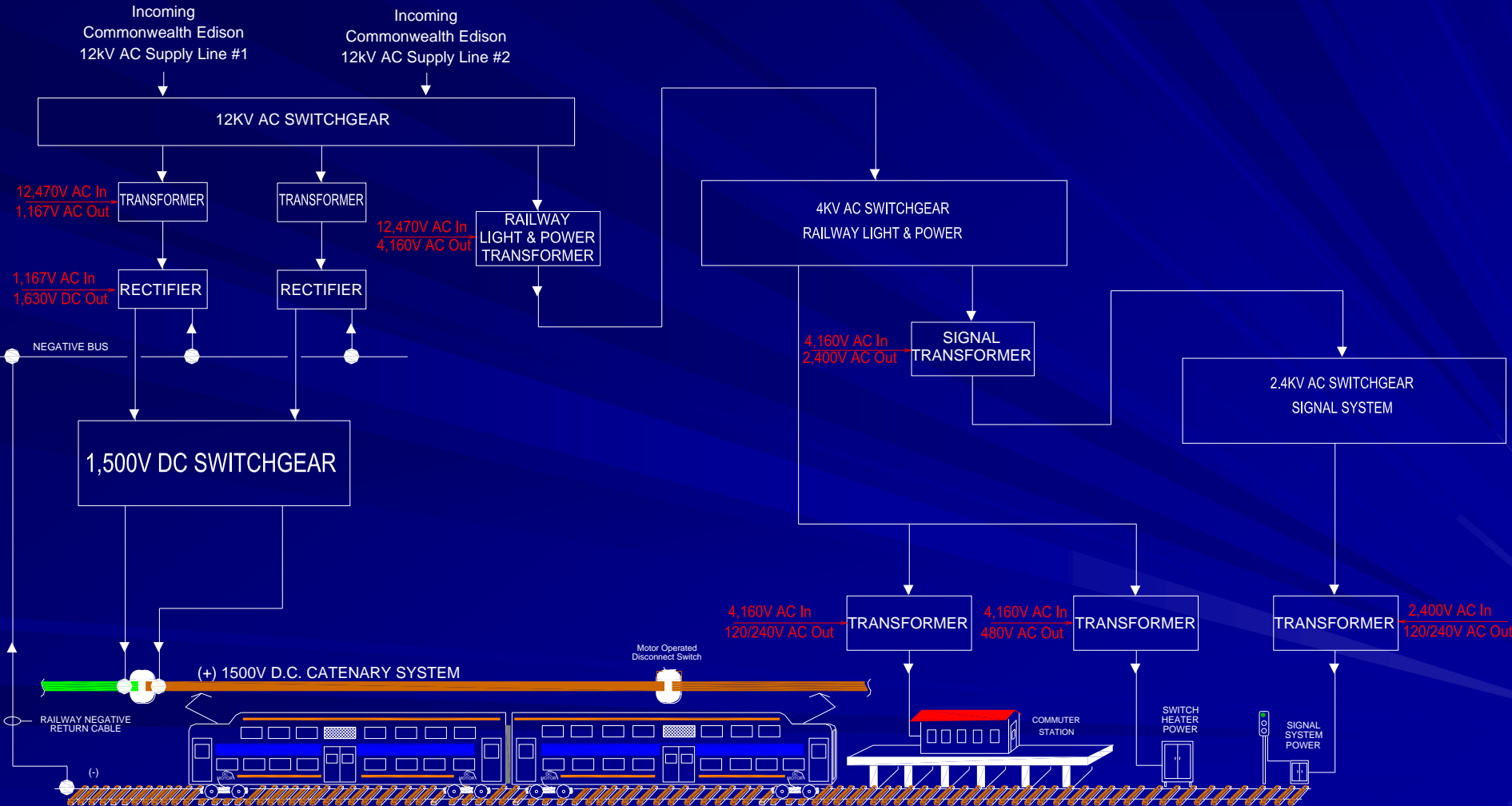


Electric Propulsion

Electrical Facilities

- 11 Substations
- 5 Tie Stations
- 109 Miles of 1500 Volt D.C. Catenary
- 114 Miles of 4kV A.C. Transmission Wire

Electrical Upgrades



Electrical Upgrades





Electrical Upgrades



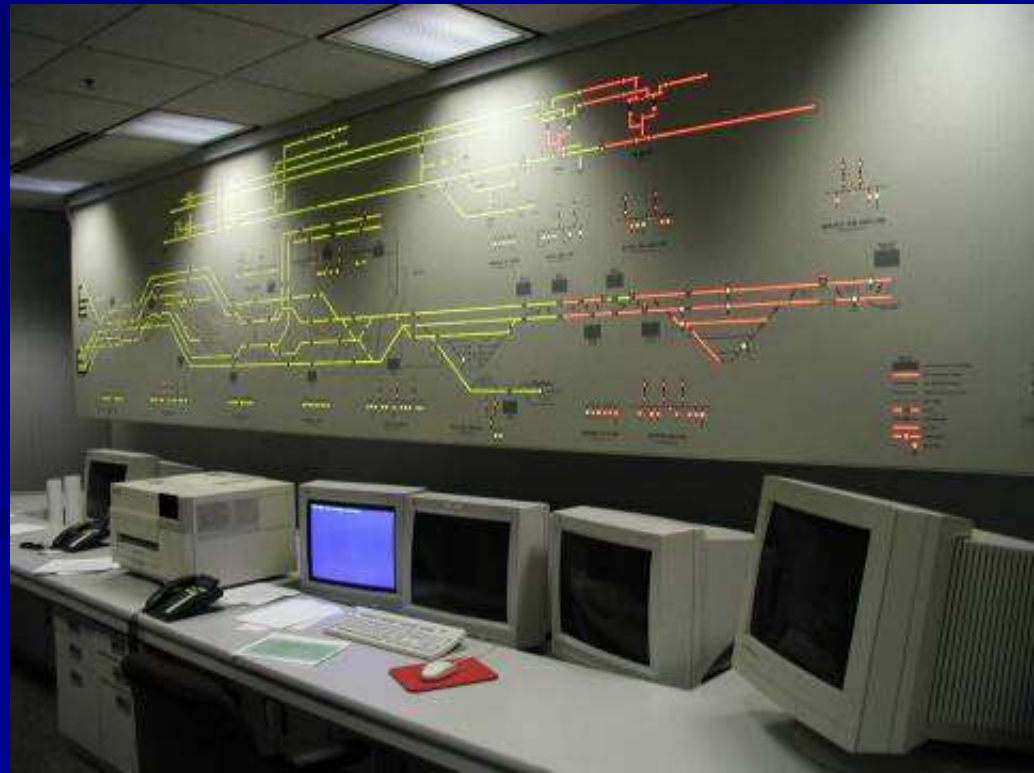
Electrical Upgrades



Electrical Upgrades



Electrical Upgrades



Electrical Upgrades

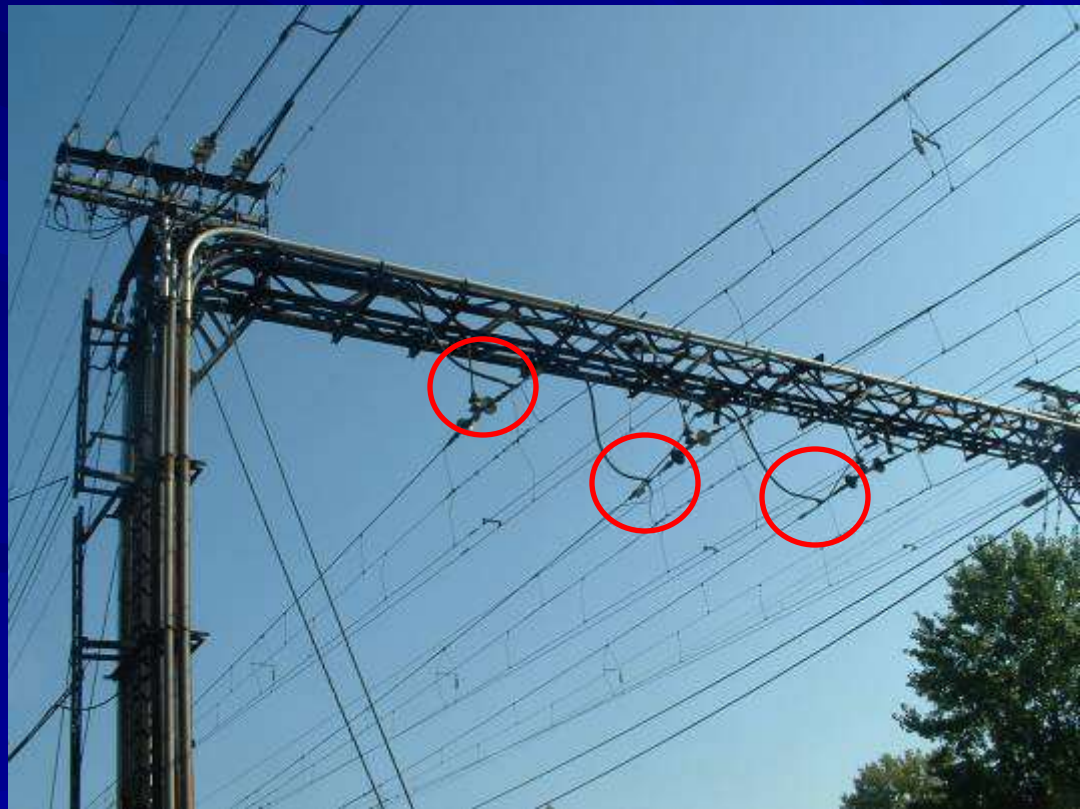






Diagram illustrating the components of an overhead catenary system, showing a main messenger wire, auxiliary wire, contact wire, and hanger.

MAIN MESSENGER

AUXILLIARY WIRE

CONTACT WIRE








HANGER

MED

PROJECT NAME	PROJ. NO. COST	REMARKS
MILLENNIUM STATION VENTILATION IMPROV. LAKE STR. FANS ADDITION Danny	3944 FY'07	Lowdenby Construction Actual cost - \$662,690 95% completed
RECTIFIERS REPLACEMENT AT BROOKDALE SUBSTATION Randy	4253	Powell electric equipment delivered. Metra installation. 100% complete \$497K
BUCHTON/MATTESSON YARD DE-ICING SYSTEM Randy	3246	Tr Technology (Equipment only) \$357,426
VAN BUREN STA. GENERATOR ROOM HVAC IMPROVEMENT		(OLD MONEY)
AC SWITCHGEAR AT BROOKDALE SUBST. Randy	4557 FY'11 958 K	Design complete Waiting for FY2011 funds.
MILLENNIUM STREET STATION FIRE PROTECTION UPGRADES. Danny	4460 FY'10 & FY'11 (AQ-372) 1,224 K	600K IN 2010 WAITING FOR FUNDING IN FY'11-ADD 600K PHASE FUNDED DESIGN COMPLETE
SUBSTATIONS BUILDINGS IMPROVEMENT PROJECT M. Covington	3462 FY'11 1000 K	DESIGN BY McDONOUGH IS ONGOING
GENERATOR SYSTEM IMPROVEMENTS AT VAN BUREN STATION Randy	3515 160 K *	Design completed. Out for bid.
ELECTRICAL SYSTEM AUGMENTATION NEW SUBSTATION AT 31ST STREET Cornell	FY'11 EST 7,765 K *	WAITING FOR FUNDING IN FY'11 \$5.5MM Design ongoing
ELECTRICAL SYSTEM AUGMENTATION NEW SUBSTATION AT 31ST STREET Cornell	4254 FY'12 2500 K	Design ongoing
RECTIFIERS REPLACEMENT AT CHELTENHAM SUBSTATION Randy	4650 FUTURE 467 K	IN HOUSE DESIGN COMPLETE
DC SWITCHGEAR REPLACEMENT AND DC BUS TIE BREAKER ADDITION AT BROOKDALE SUBSTATION Randy	4649 FUTURE 665 K	IN HOUSE DESIGN COMPLETE

Randy	IMPEDANCE BONDS REPLACEMENT	4646 FUTURE 6,162 K	IN HOUSE DESIGN COMPLETE
Randy	LIFE SAFETY AND SECURITY SYSTEM MILLENNIAL STATION	4657 809 K	DESIGN COMPLETE
Randy	PROTECTIVE RELAY REPLACEMENT AT SUBSTATIONS	4644 FUTURE 1,174 K	IN HOUSE DESIGN COMPLETE
M. Covington	SUBSTATIONS BUILDINGS IMPROVEMENT PROJECT	4643 & 3462 FUTURE 1000 K	TO BE DESIGNED BY CONSULTANT
Cornell	ELECTRICAL SYSTEM AUGMENTATION 51st STREET TIE-STATION CONVERSION TO SUBSTATION	4254 FUTURE 4,963 K	CONTRACTOR CONSTRUCT. DESIGN BY LDP ONGOING
Cornell	ELECTRICAL SYSTEM AUGMENTATION 95st STREET TIE-STATION CONVERSION TO SUBSTATION	FUTURE 4,243 K	CONTRACTOR CONSTRUCT DESIGN BY LDP ONGOING
Cornell	ELECTRICAL SYSTEM AUGMENTATION RIVERDALE TIE-STATION CONVERSION TO SUBSTATION	FUTURE 4288 K	CONTRACTOR CONSTRUCT DESIGN BY LDP ONGOING
Cornell	ELECTRICAL SYSTEM AUGMENTATION HOMEWOOD TIE-STATION CONVERSION TO SUBSTATION	FUTURE 4,213 K	CONTRACTOR CONSTRUCT DESIGN BY LDP ONGOING
Randy	AC MOTOR OPERATED SWITCHES SEE TABLE AT RIGHT Proj #4645	4645 FUTURE 410 K	IN HOUSE DESIGN COMPLETE
Randy	RECTIFIERS REPLACEMENT AT VARIOUS SUBSTATIONS. 21 EACH. SEE TABLE AT RIGHT Proj #4650	4650 FUTURE 4,440 K	IN HOUSE DESIGN COMPLETE
Randy	DC SWGR REPLACEMENT AT VARIOUS SUBSTATIONS. SEE TABLE AT RIGHT Proj #4649	4649 FUTURE 11,259 K	IN HOUSE DESIGN COMPLETE
Randy	AC SWGR REPLACEMENT AT 16TH STR. & MATTESSON SUBSTATIONS SEE TABLE AT RIGHT Proj # 4649	4649 FUTURE 1,980 K	IN HOUSE DESIGN COMPLETE
UN-FUNDED TOTAL		48,573 K **	

NOTES:

- Table arranged per project priority, top to bottom.
- Estimated costs include construction and construction management.
-  - Construction ongoing or completed.
-  - In Remarks Column - design ongoing or complete. Shall be ready to bid.
-  - FY2011 budget request.
-  - FY2012 budget request.
-  - FY2013 budget request.
-  - FY2014 budget request.
- High priority project 

PROJECT FUNDING CATEGORIES:

-  P - 029 Traction Power System Augmentation
-  P - 030 Electrical Equipment Improvements / Replacement
-  P - 031 Electrical Systems Improvements / Replacement
-  P - 039 Yard Improvements
-  P - 040 Building Improvements

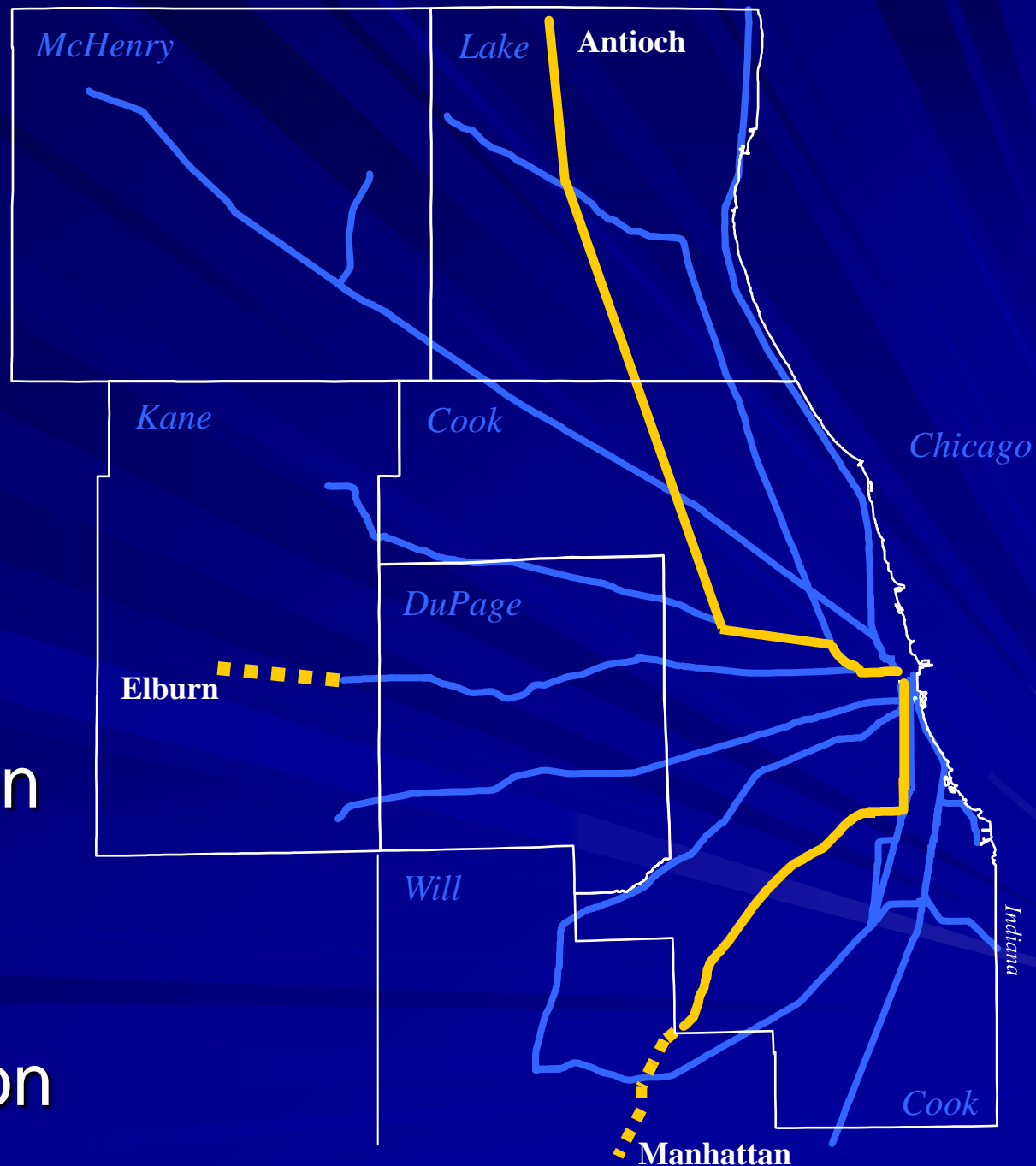
DC SWITCHGEAR REPLACEMENT Proj #4649		
BROOKDALE	665 K	FY'12
JACKSON	1091 K	FY'13
16TH ST	1371 K	FY'14
CHATELHAM	777 K	FY'15
FRONT	1155 K	FY'16
95TH ST	871 K	
LAFIN	815 K	
RIVERDALE	629 K	
HARVEY	939 K	
HOMEWOOD	683 K	
VOLLMER	777 K	
MATTESSON	997 K	
UP	689 K	
TOTAL	11,259 K	

RECTIFIER REPLACEMENT Proj #4650		
CHALTEHAM	467 K	FY'12
16TH ST	1170 K	FY'13
FRONT	701 K	FY'14
LAFIN	467 K	FY'15
HARVEY	467 K	FY'15
VOLLMER	467 K	FY'16
MATTESSON	701 K	FY'16
TOATL	4440 K	

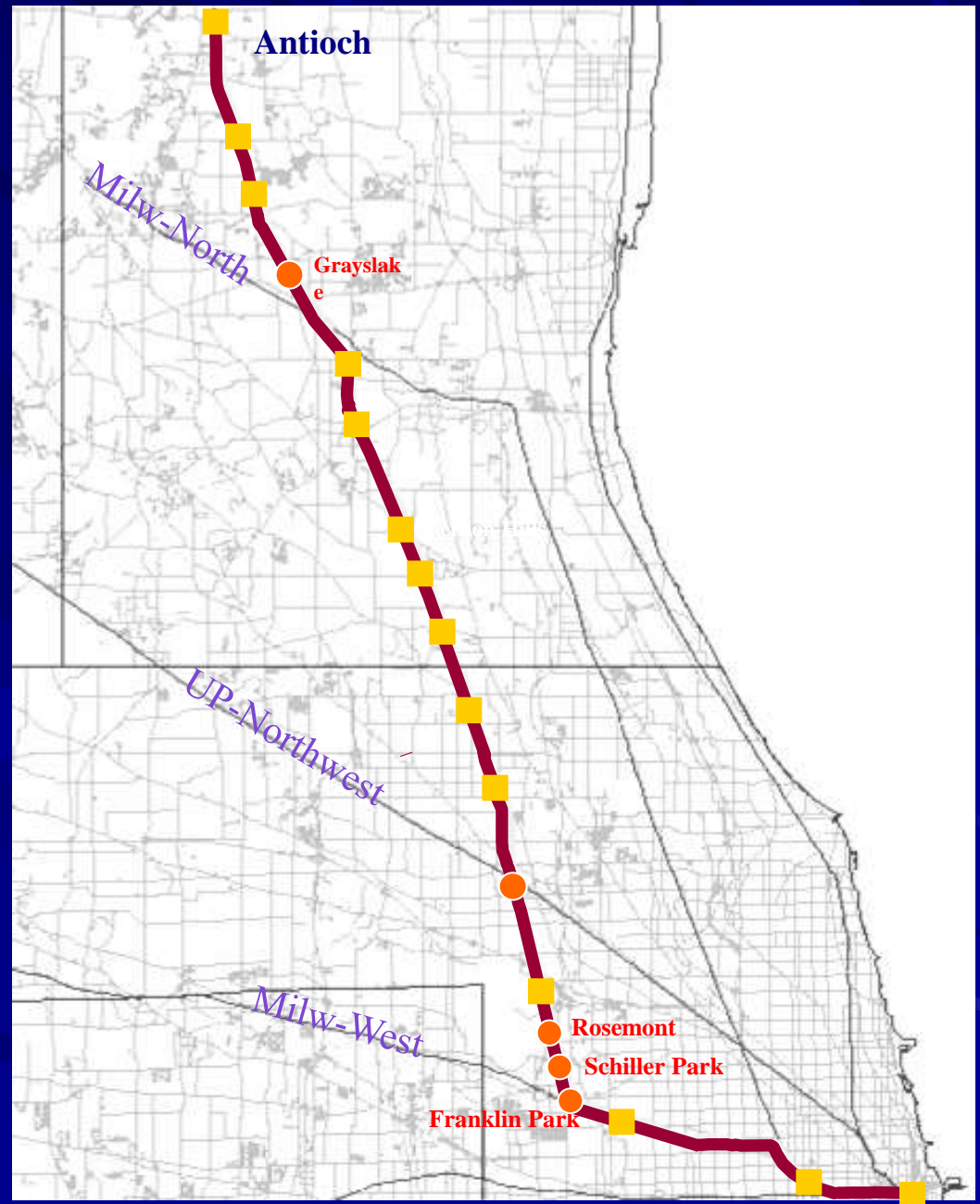
AC SWITCHGEAR REPLACEMENT Proj # 4649		
16TH ST	1340 K	FY'15
MATTESSON	640 K	FY'16
TOATL	1980 K	

Metra's Recent Expansion Projects

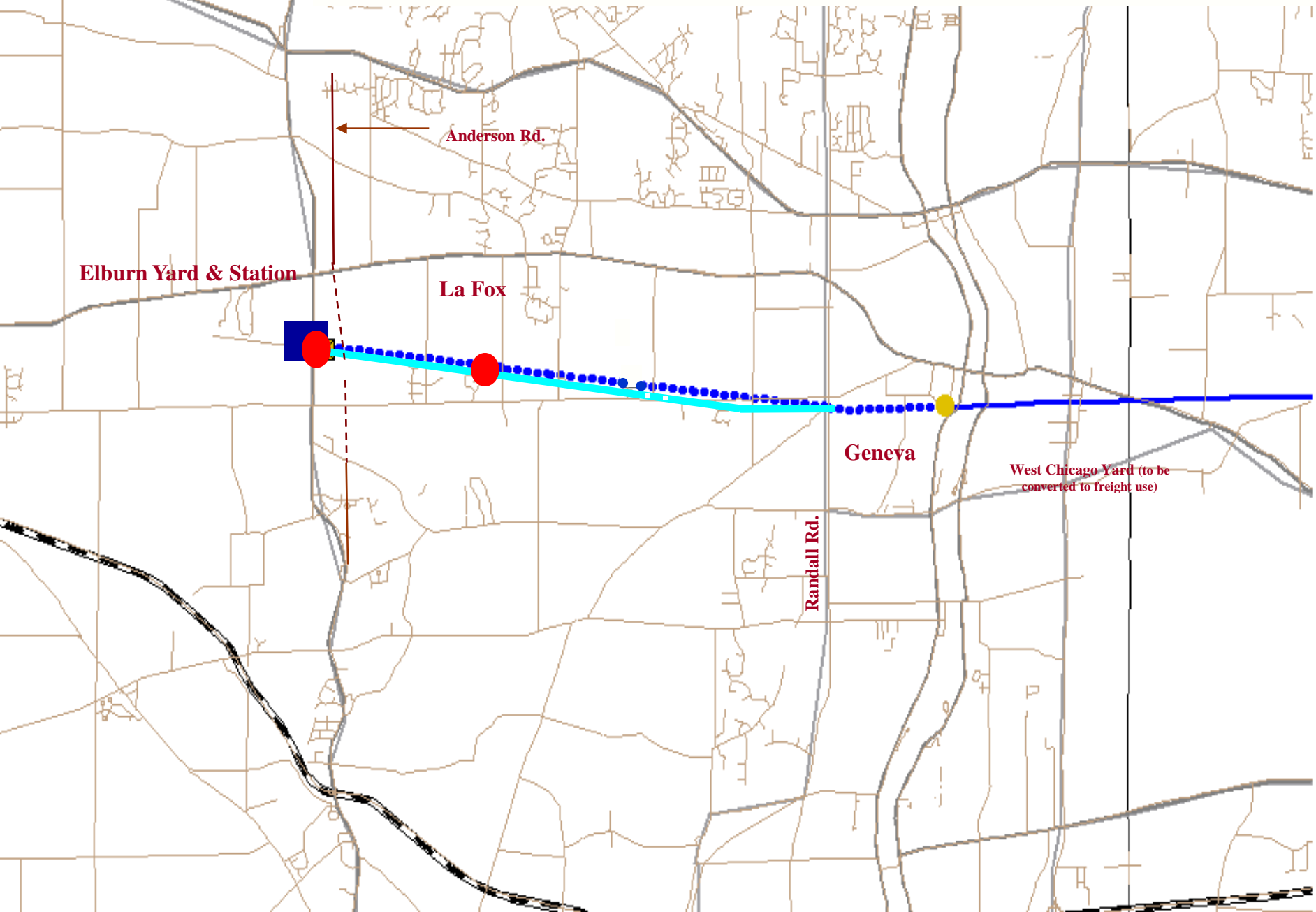
- NCS Expansion
- UP West Extension
- SWS Expansion & Extension



NCS Expansion Project



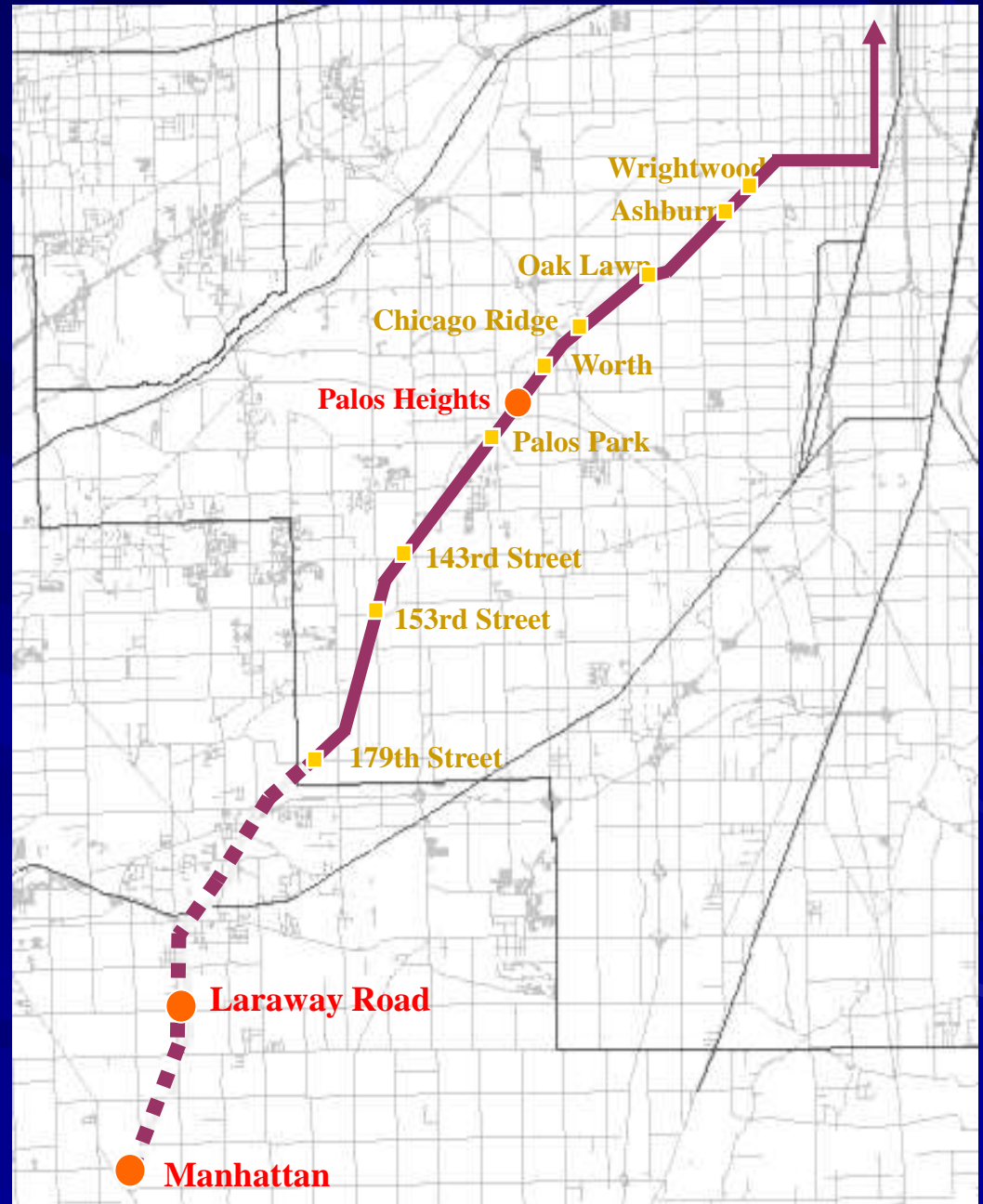
Union Pacific West Line Extension



Union Pacific West Line New Start Project

- New Yard
- New 3rd Main Track
- Signal Improvements
- Improved Train Service
- Two New Station Facilities

SWS Extension & Expansion



Southwest Service New Start Project

- Additional Rush Hour and Mid-Day Trains
- Track Improvements
- New 2nd Main Track
- Signal Improvements
- Three New Stations
- Upgraded Station & Parking Facilities

Future New Expansion Projects

Proposed Metra SES Line



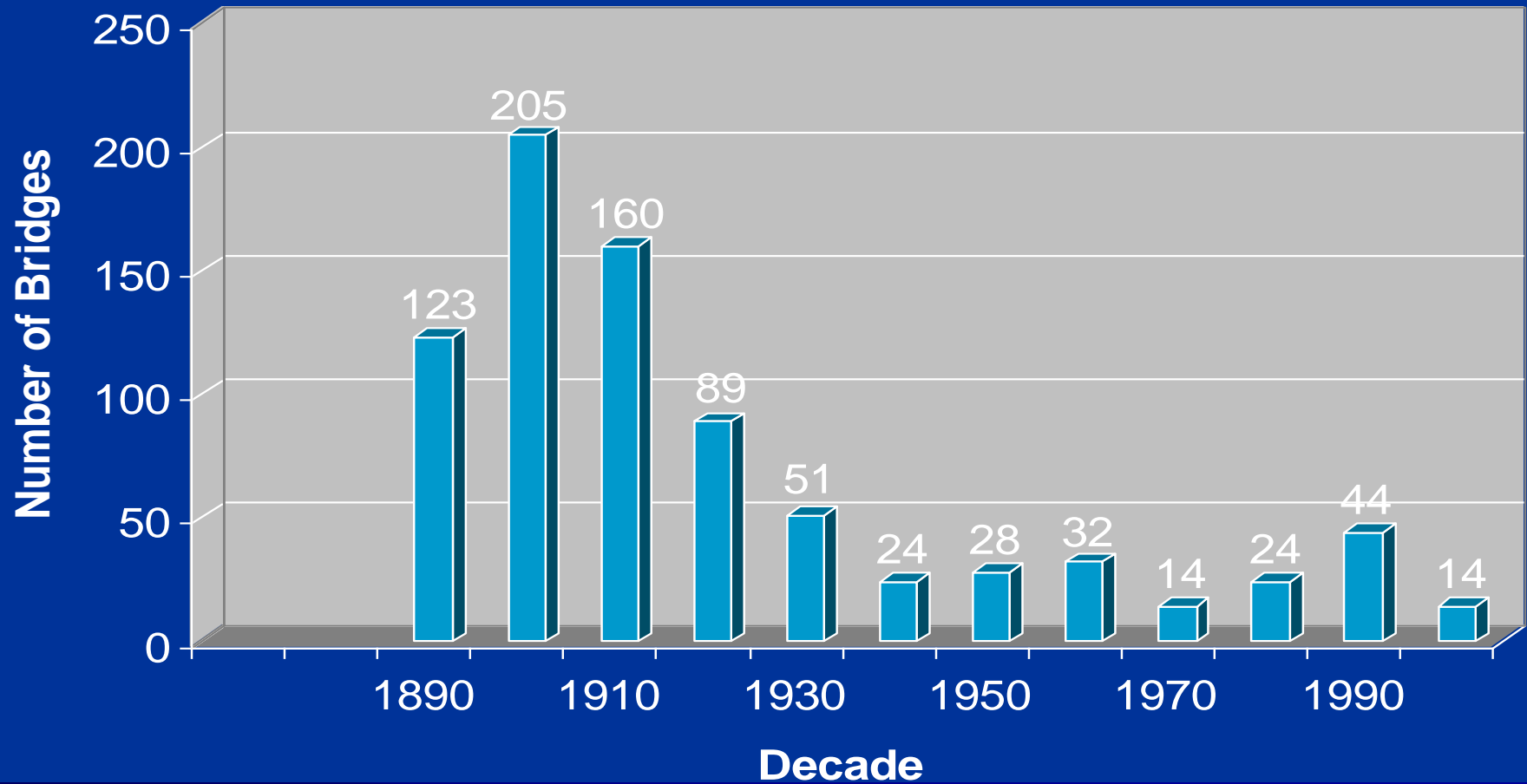
Metra's Proposed STAR Line



Bridges & Structures

- 821 Bridges
- 903 Catenary Structures
- More Than 25 Miles of Retaining Walls
- Numerous Pipes and Culverts

Construction Date of Bridges as of 2008



Bridge Replacement

- Union Pacific Northwest Line
- 14 Bridges Between Webster and Kostner
- \$120 Million







Rock Island District

- 28 Bridges from 18th Street to 60th Street
- \$125 Million





2003 9 29





2003 9 30



2003 10 1

Golf Road Bridge Replacement

Project Cost: \$8.1 Million













Metra

Union Pacific – North Line

- 22 Bridges from Fullerton Avenue to Balmoral Avenue
- \$250 Million over 10 years



FIG. 451. BRIDGE AT MONTROSE AVE., 80 FT. BETWEEN ABUTMENTS, POSTS ON CURB LINE.

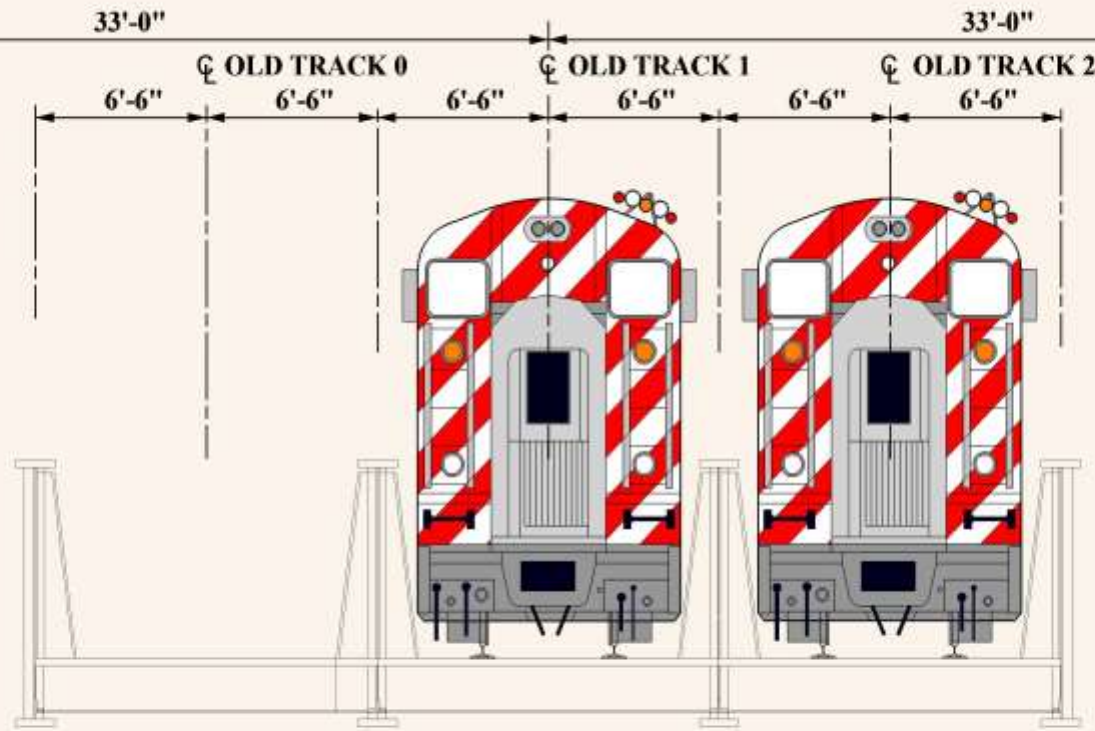






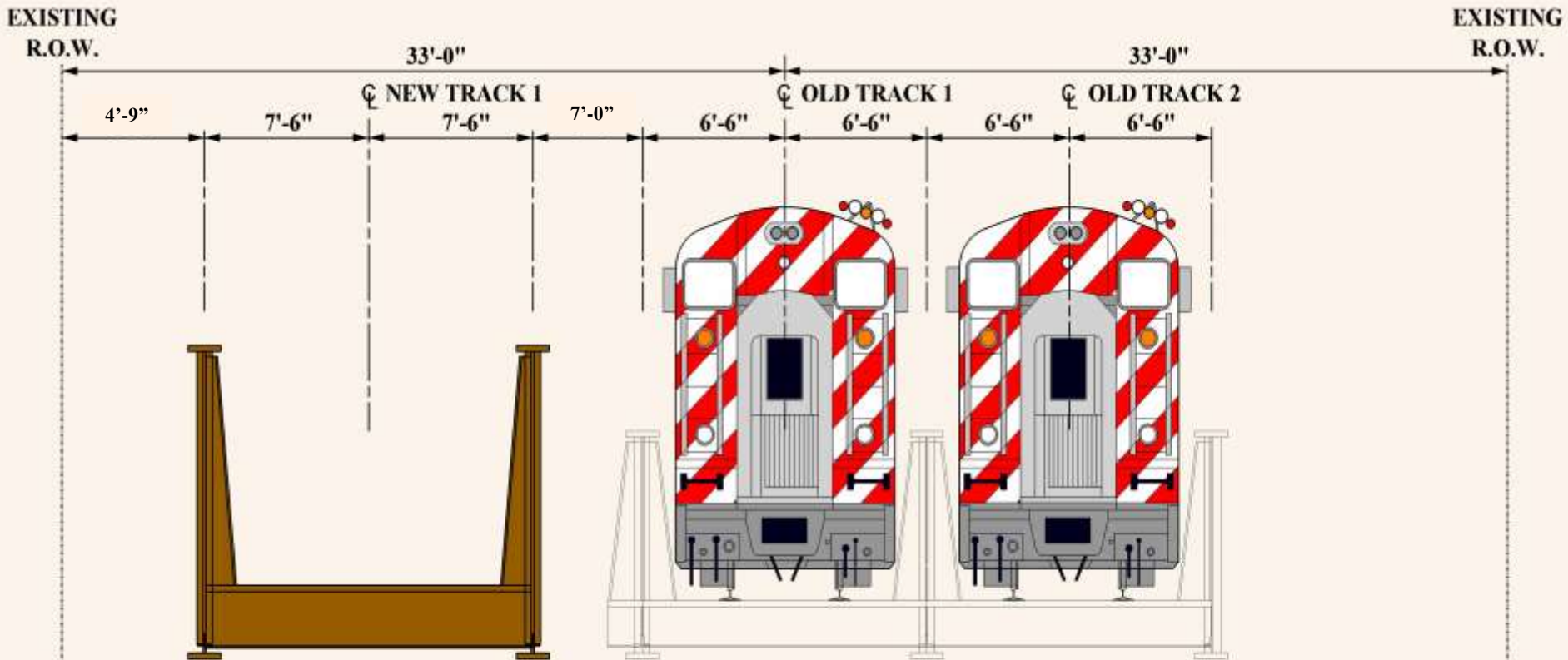


EXISTING
R.O.W.

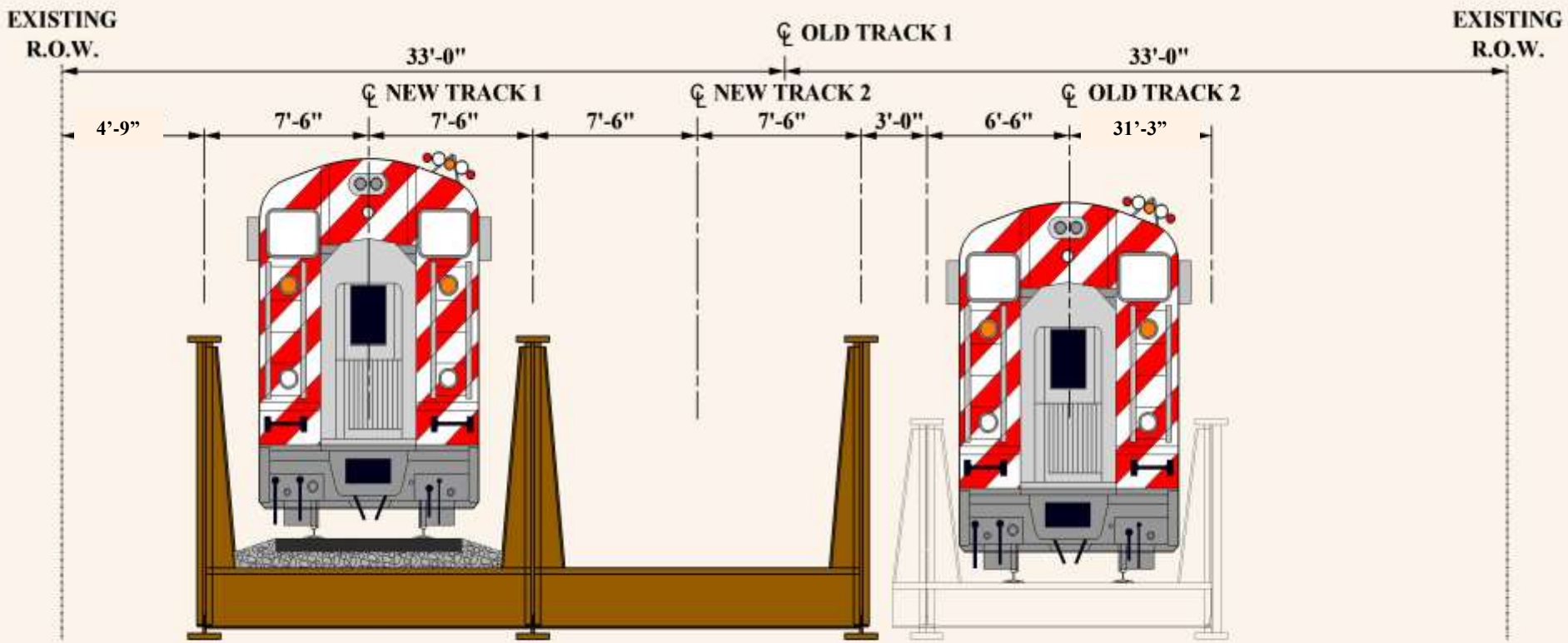


EXISTING
R.O.W.

LOOKING NORTH



LOOKING NORTH



LOOKING NORTH



New Bridge







Table 15-1-1. Structural Steel (Note 1)

ASTM Designation	F_y - Min Yield Point psi	F_u Ultimate Strength psi	Thickness Limitation	
			For Plates and Bars, inches	Applicable to Shapes
A36	36,000	58,000 min 80,000 max	To 6 incl.	All
A709, Grade 36	36,000	58,000 min 80,000 max	To 4 incl.	All
A588 (Note 2) A709, Grade 50W (Note 2) A709, Grade HPS 50W (Note 2)	50,000	70,000 min	To 4 incl.	All
A588 (Note 2)	46,000	67,000 min	Over 4 to 5 incl.	None
A588 (Note 2)	42,000	63,000 min	Over 5 to 8 incl.	None
A992 A709, Grade 50S	50,000	65,000 min	None	All
A572, Grade 50 A709, Grade 50	50,000	65,000 min	To 4 incl.	All
A572, Grade 42	42,000	60,000 min	To 6 incl.	All
A709, Grade HPS 70W (Note 2)	70,000	85,000 min 110,000 max	To 4 incl.	None
Note 1: These data are current as of January 2002.				
Note 2: A588 and A709, Grade 50W, Grade HPS 50W, and Grade HPS 70W have atmospheric corrosion resistance in most environments substantially better than that of carbon steels with or without copper addition. In many applications these steels can be used unpainted.				

1.2.5 DEFLECTION (2001)¹ R(2003)

- a. The deflection of the structure shall be computed for the live loading plus impact loading condition producing the maximum bending moment at mid-span for simple spans. The computation of component stiffness shall be based on the following assumed behavior:
- For flexural members use the gross moment of inertia.
 - For truss members without perforated cover plates use the gross area.
 - For truss members with perforated cover plates use the effective area.

The effective area shall be the gross area reduced by the area determined by dividing the volume of a perforation by the distance center to center of perforations.

- b. The structure shall be so designed that the computed deflection shall not exceed $1/640$ of the span length center to center of bearings for simple spans.
- c. Lateral deflection of spans shall be limited to $3/8$ inch (10 mm) for tangent track as measured on a 62 foot (19 meter) chord. On curved track, lateral deflection shall be limited to $1/4$ inch (6 mm) as measured on a 31 foot (9.5 meter) chord. Allowable lateral deflection for spans shall be calculated based on these limits taken in squared proportion to the span length under consideration.

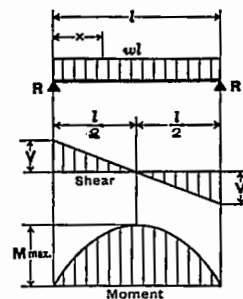
The lateral deflection calculated is to be the maximum lateral deflection at track level due to all applicable lateral forces and loads specified in Section 1.3 excepting those due to earthquake (seismic) or wind on unloaded bridges. The maximum lateral deflection at track level shall be referenced to the point on a vertical plane below which lateral deflection is restrained (i.e. base of structure, span bearings, bottom flange of girder; depending on the lateral deflection being considered).

BEAM DIAGRAMS AND FORMULAS

For various static loading conditions

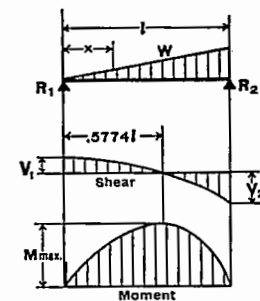
For meaning of symbols, see page 2 - 293

1. SIMPLE BEAM—UNIFORMLY DISTRIBUTED LOAD



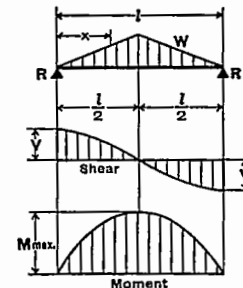
$$\begin{aligned} \text{Total Equiv. Uniform Load} &= wl \\ R = V &= \frac{wl}{2} \\ V_x &= w \left(\frac{l}{2} - x \right) \\ M \text{ max. (at center)} &= \frac{wl^2}{8} \\ M_x &= \frac{wx}{2} (l - x) \\ \Delta \text{ max. (at center)} &= \frac{5wl^4}{384EI} \\ \Delta_x &= \frac{wx}{24EI} (l^3 - 2lx^2 + x^3) \end{aligned}$$

2. SIMPLE BEAM—LOAD INCREASING UNIFORMLY TO ONE END



$$\begin{aligned} \text{Total Equiv. Uniform Load} &= \frac{16W}{9\sqrt{3}} = 1.0264W \\ R_1 = V_1 &= \frac{W}{3} \\ R_2 = V_2 \text{ max.} &= \frac{2W}{3} \\ V_x &= \frac{W}{3} - \frac{Wx^2}{l^2} \\ M \text{ max. (at } x = \frac{l}{\sqrt{3}} = .5774l) &= \frac{2Wl}{9\sqrt{3}} = .1283Wl \\ M_x &= \frac{Wx}{3l^2} (l^2 - x^2) \\ \Delta \text{ max. (at } x = l\sqrt{1 - \sqrt{\frac{8}{15}}} = .5193l) &= .01304 \frac{Wl^3}{EI} \\ \Delta_x &= \frac{Wx}{180EI l^2} (3x^4 - 10l^2x^2 + 7l^4) \end{aligned}$$

3. SIMPLE BEAM—LOAD INCREASING UNIFORMLY TO CENTER



$$\begin{aligned} \text{Total Equiv. Uniform Load} &= \frac{4W}{3} \\ R = V &= \frac{W}{2} \\ V_x \text{ (when } x < \frac{l}{2}) &= \frac{W}{2l^2} (l^2 - 4x^2) \\ M \text{ max. (at center)} &= \frac{Wl}{6} \\ M_x \text{ (when } x < \frac{l}{2}) &= Wx \left(\frac{1}{2} - \frac{2x^2}{3l^2} \right) \\ \Delta \text{ max. (at center)} &= \frac{Wl^3}{60EI} \\ \Delta_x \text{ (when } x < \frac{l}{2}) &= \frac{Wx}{480EI l^2} (5l^2 - 4x^2)^2 \end{aligned}$$





Belmont Road Grade Separation

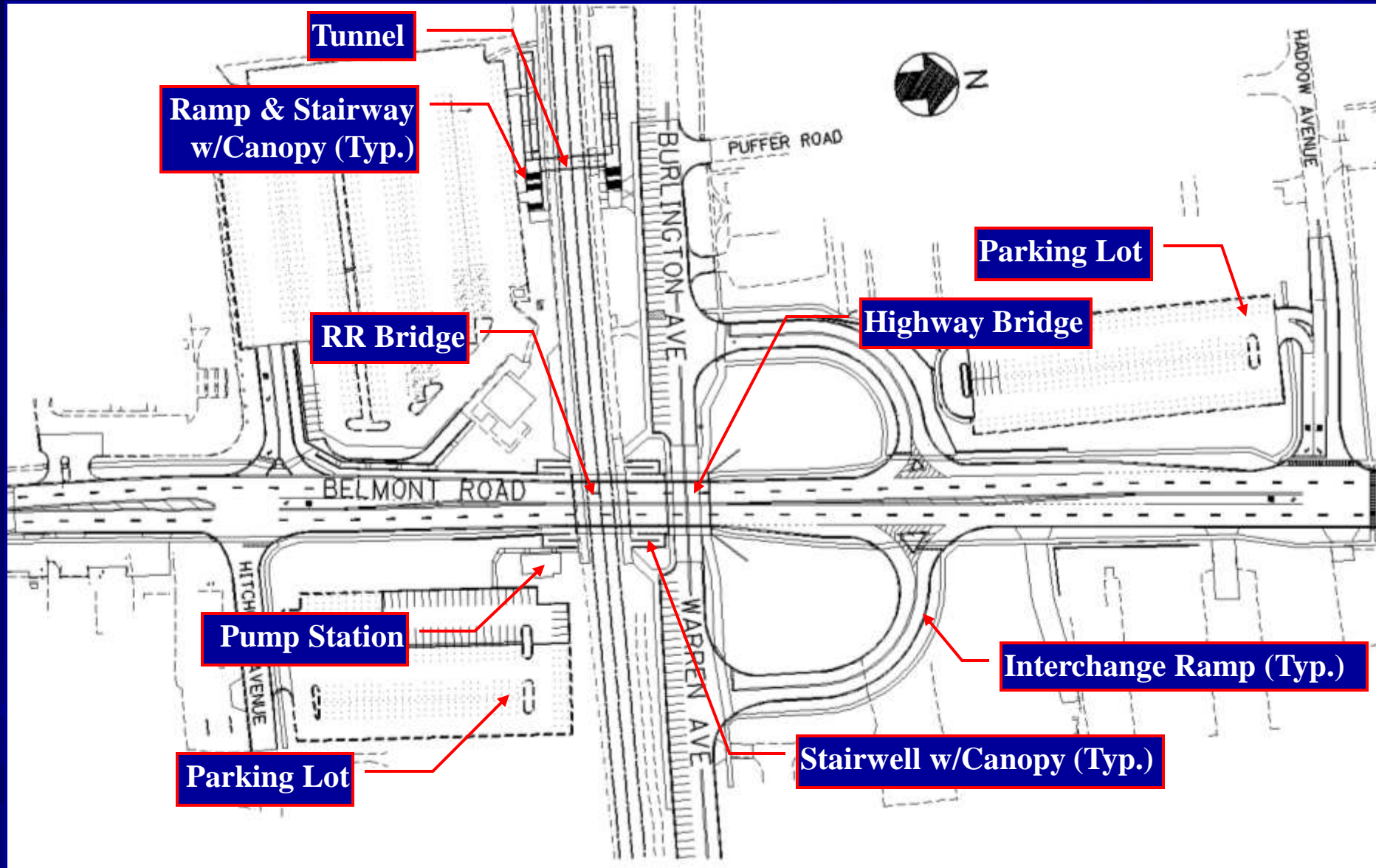


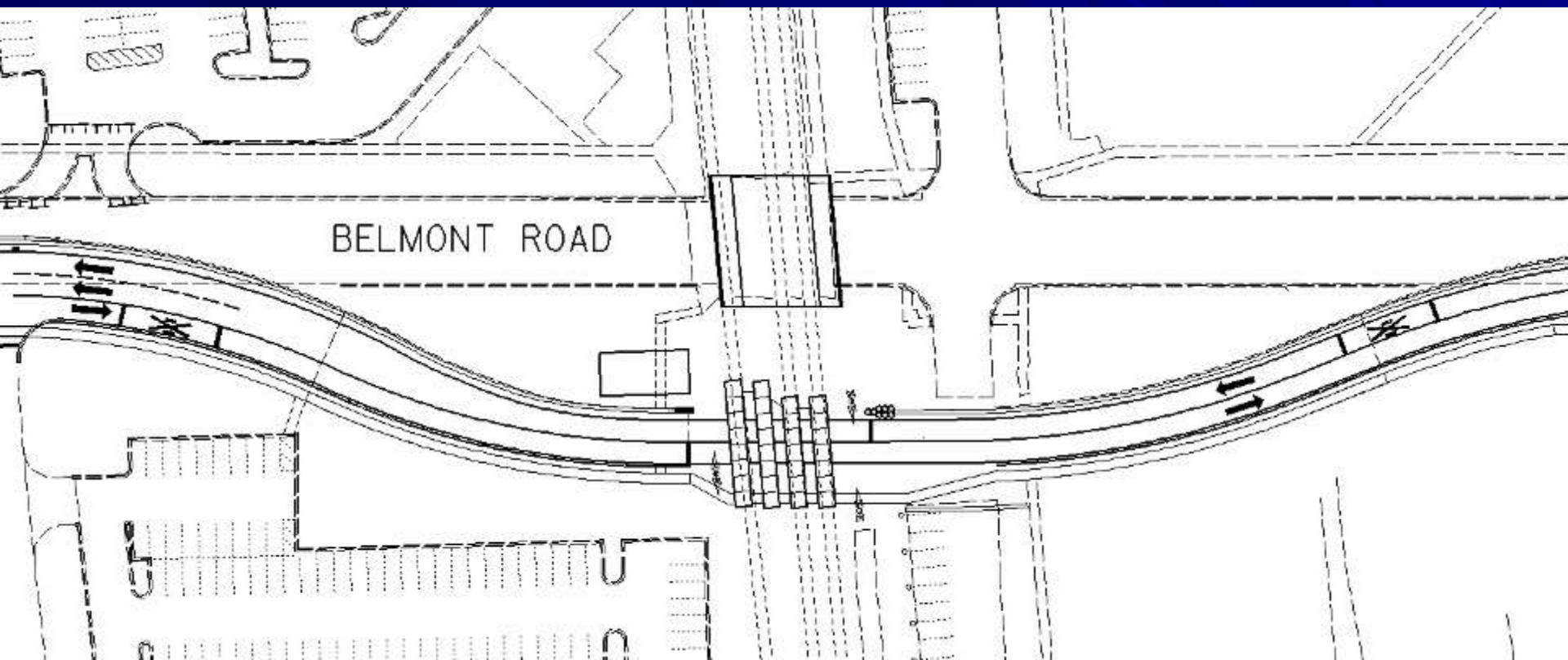
Existing Grade Crossing



Existing Pedestrian Crossing







**Temporary Run-around of Belmont Road
(July 2010 through September 2011)**



10/07/2010 07:50



07/28/2010 11:12



08/12/2010 09:29



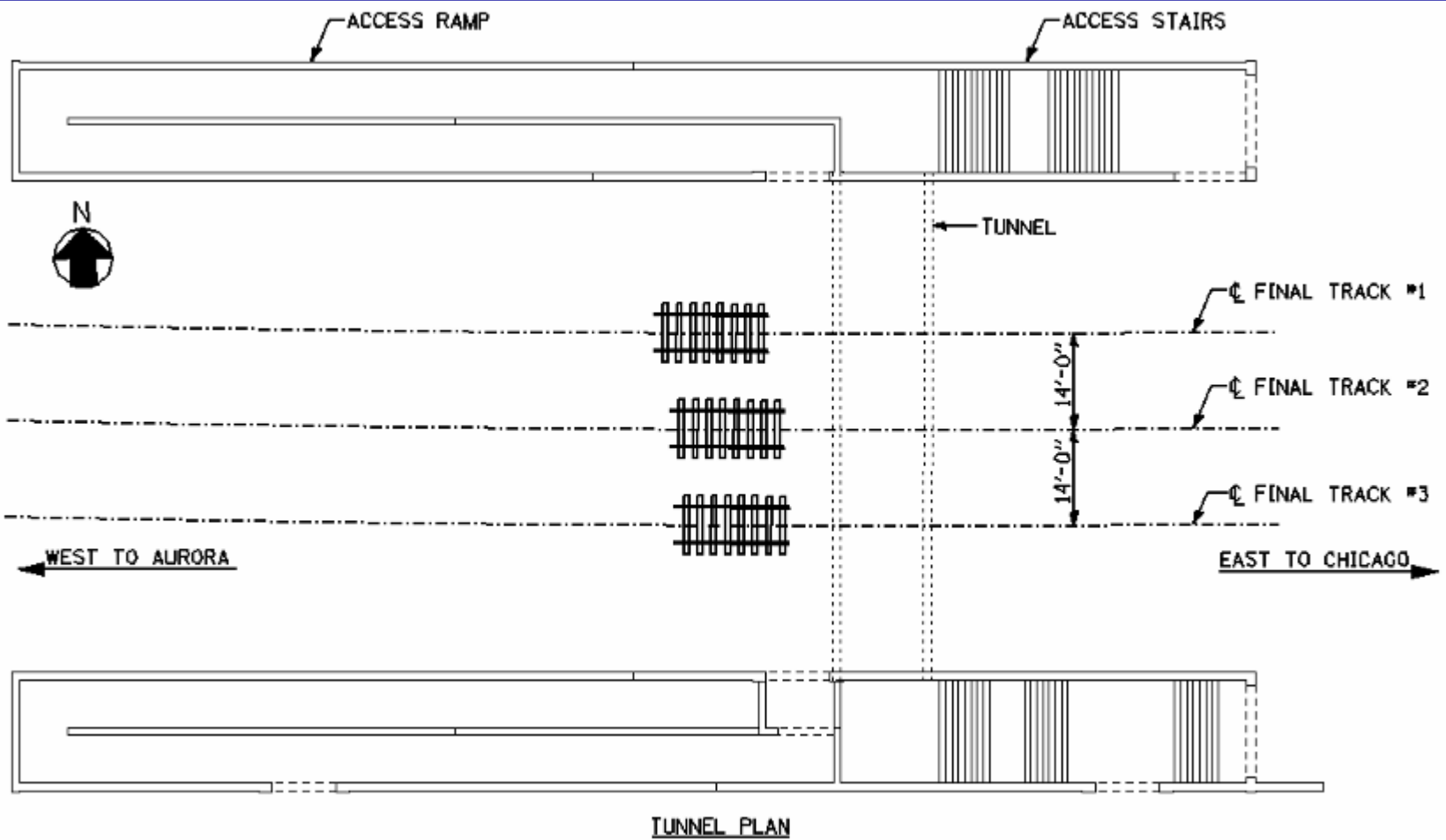
08/07/2010 09:13



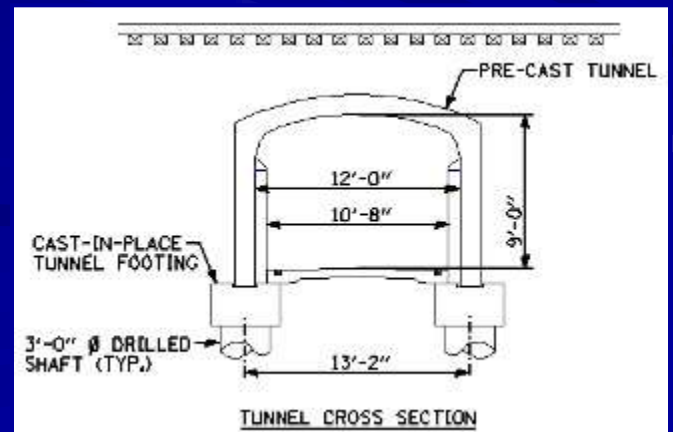
10/07/2010 07:48



09/14/2010 09:50



Pedestrian Tunnel







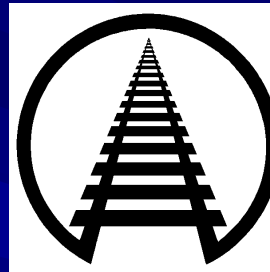
Metra

CREATE P-1

Englewood Flyover

Grade separation of Metra
Rock Island District and NS
Main Line

CREATE Partners





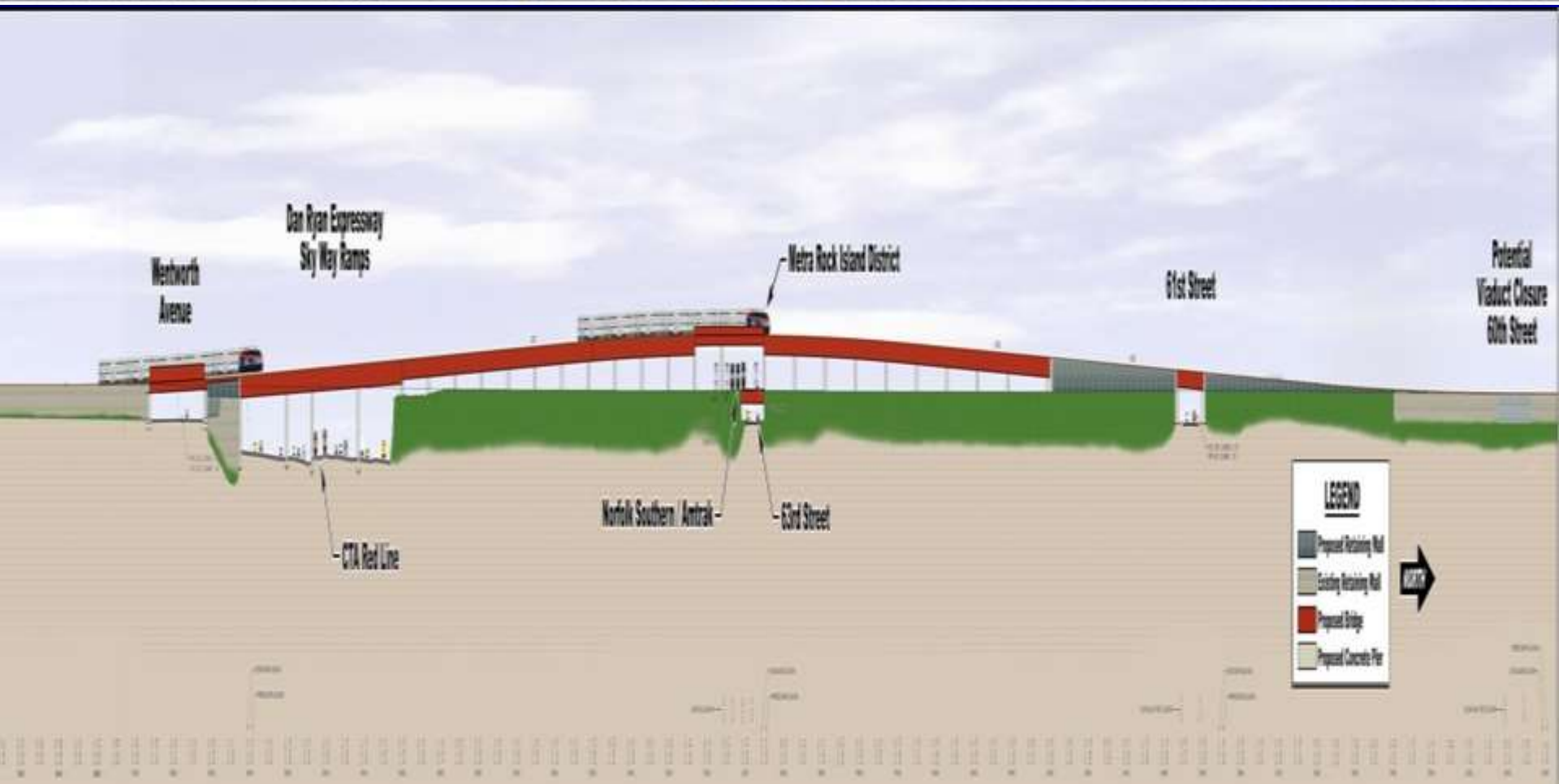
NS / Amtrak

Metra Rock Island District









Riverdale Bridge Fire

















06/30/2003



2003 11 21

State of Good Repair

- State of Good Repair: SGR is the condition where all assets perform their assigned function without limitation
- Essential if public transportation systems are to provide safe and reliable service to millions of daily riders
- Includes sharing ideas on recapitalization and maintenance issues, asset management practices, and innovative financing strategies
- Includes issues related to measuring the condition of transit capital assets, prioritizing local transit re-investment decisions and preventive maintenance practices

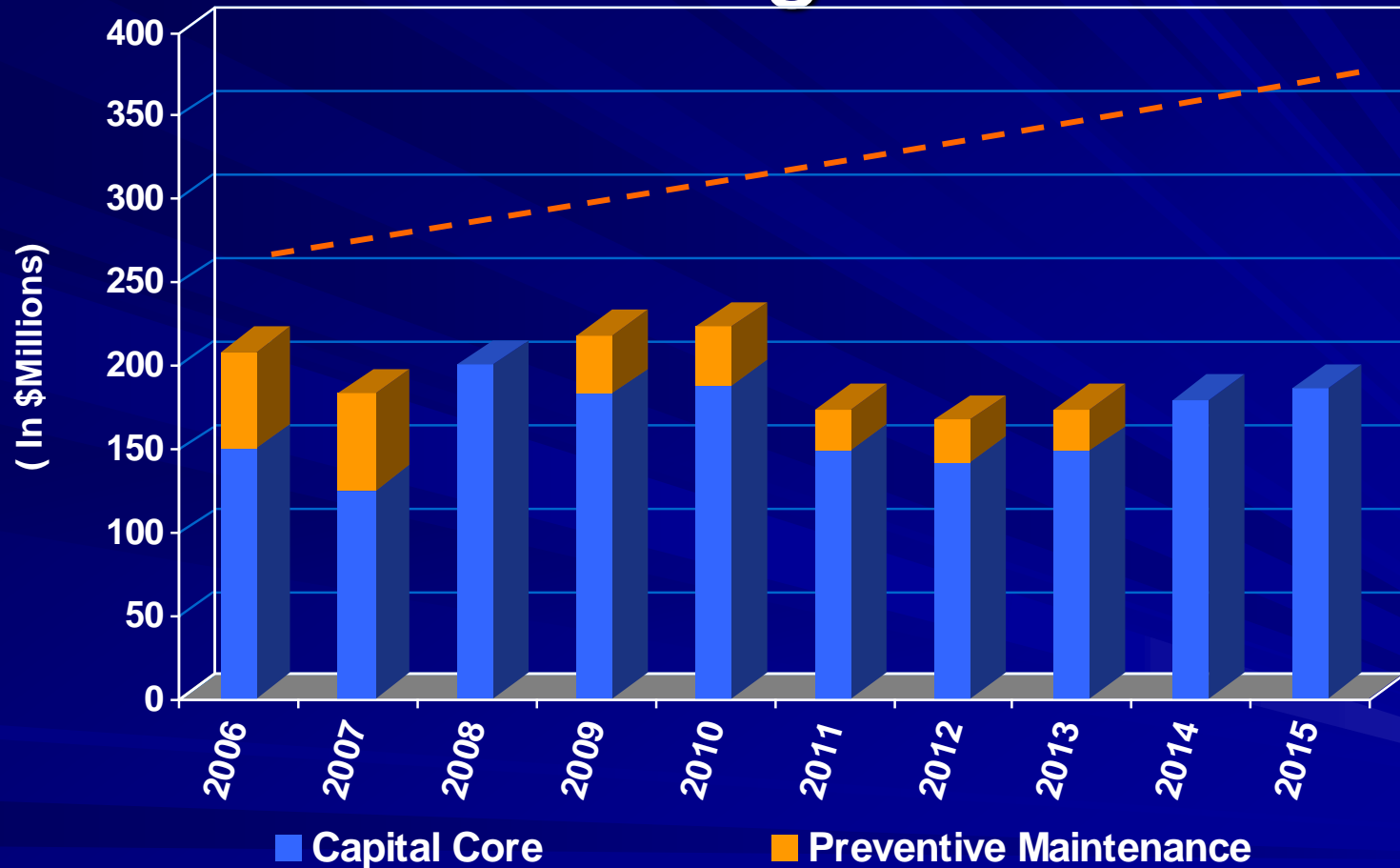
Metra Capital Investment History

1985 – Present * (in \$Millions)

Assets	<u>MED</u>	<u>RID</u>	<u>SWS</u>	<u>MHC</u>	<u>BNSF</u>	<u>UP-W</u>	<u>MWD-W</u>	<u>UP-NW</u>	<u>MWD-N</u>	<u>NCS</u>	<u>UP-N</u>	<u>Total</u>
Rolling Stock	\$850.0	\$195.5	\$57.5	\$10.9	\$307.1	\$159.5	\$163.5	\$177.1	\$142.5	\$23.4	\$145.2	\$2,232.2
Track & Structure	72.4	264.8	25.6	9.9	113.3	56.5	90.6	159.1	63.0	32.1	106.8	994.2
Signal, Elec, & Comm	105.8	48.6	18.1	3.5	103.3	54.0	58.0	34.1	56.0	7.7	29.7	518.9
Facilities & Equipment	91.6	76.5	17.2	9.1	63.3	17.8	56.5	35.1	54.6	18.0	21.8	461.6
Stations & Parking	188.0	134.2	35.3	12.9	52.5	110.1	59.7	150.6	60.2	12.9	99.4	915.6
Acq, Ext, Expansions	15.8	1.3	158.6	0.6	1.4	123.0	55.8	3.7	1.2	234.1	2.8	598.4
Support Activities	44.6	25.9	14.0	11.4	28.4	22.4	21.5	30.7	26.5	14.7	25.7	266.0
Total	\$1,368.2	\$746.8	\$326.4	\$58.3	\$669.4	\$543.4	\$505.7	\$590.5	\$404.1	\$342.9	\$431.4	\$5,986.9
Percentages	22.9%	12.5%	5.5%	1.0%	11.2%	9.1%	8.4%	9.9%	6.7%	5.7%	7.2%	100.0%

* Excludes South Shore, Preventive Maintenance, and pending FY 2010 grants

State of Good Repair – Capital Budget*



--- Funding needed to achieve a State of Good Repair

* 2012 – 2015 amounts are projected estimates

† Not inclusive of State of Illinois Bond funding

RTA Capital Asset Condition Assessment

- 18-month effort to identify and characterize the condition of all existing RTA, CTA, Metra, & Pace capital assets
- RTA Region needs \$24.6B in Capital Investment over the next 10 years. **Metra needs 30% of this.**

Metra 10-year Capital Needs	Amount
Backlog	\$3.70 B
Normal Replacement	\$1.70 B
Capital Maintenance	\$1.97 B
Total	\$7.37 B

Engineering Department

J. L. Lorenzini, P.E.
Chief Engineering Officer

It takes over 1,000 things done right for your train to run on time, but only one error to make it late.