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The Complex World of Rail Travel

Exploring the Relationship Between Railroad Infrastructure,
Operating Constraints, and Public Schedules

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MTA Metro-North Railroad

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Today's (Quick) Lessons

- 1 What factors are behind determination of published public timetable trip times between station pairs?
- 2 How operating documents can be utilized to reconstruct reasons for journey time changes?
- 3 How to properly construct a schedule that accounts for these factors?
- 4 **New Haven Line Case Study**
Changes in public timetable running times alone is insufficient evidence to infer events in:
 - rail industry investment
 - maintenance management
 - infrastructure stewardship, etc.

1 Factors Affecting Published Running Times

- A. **Right of Way:** Environment, Geographic Features
- B. **Ownership:** Shared Use of Track
- C. **Track:** Geometry, Maintenance, Special Work, Layout
- D. **Non-Track Infrastructure:** Structures, Signal Braking Distances, Cab Signal Systems, Grade Crossings, Electrical Supply Infrastructure
- E. **Vehicle:** Cant Deficiency (Underbalance), Prime Mover Rating, Acceleration and Braking Rates
- F. **Operating Practices:** Rules, Staffing, Working Limits (Slow Zones), Single Tracking, Approach Control, Train Slots
- *All factors work both ways—a constraint can always be eliminated with a suitable investment project*

1

C. Track Factors Increasing Trip Times

- **Geometry:** sharp curves, short curve spirals, low superelevation
- **Maintenance:** “class of track” maintenance limits
- **Special Trackwork:**
 - Shorter/smaller turnouts
 - Diamond crossings, mitre rails, etc.
 - Higher speed designs (e.g. curved switch points, movable point frogs) not utilized
 - Improperly adjusted/worn turnouts
- **Track Layout:**
 - Removal of critical switches/interlockings
 - Reverse moves to access platform tracks



1

D. Non-Track Infrastructure Factors

- **Structures:** design and condition, clearances
- **Signal Issues:** inappropriate block spacing, vehicle characteristics changes, retrofit without redesign, unable to display most favourable aspects, etc.
- **Cab Signal Systems:** normally no running time impact, but if modified to protect civil speeds...
- **Grade Crossings:** type of crossing protection, unmodified approach circuits
- **Electrical Supply Infrastructure:** maximum power draw, pantograph bounce, third-rail shoe nosepiece issues...



1 E. Vehicle Factors Increasing Trip Times

- **Cant Deficiency (Underbalance):** substitute equipment not equipped with tilting systems
- **Installed Power:** power-to-weight ratio, traction type
- **Wheel-Rail Interface:** adhesion limits
- **Braking Rates:** vehicles not equipped with high capacity braking systems (i.e. disc-and-tread)



F. Operating Practices

- **Rules:** e.g. requirement to hold outside of stations
- **Staffing:** e.g. hand-throws by traincrew, reduced routing flexibility due to towerman reductions, etc.
- **Working Limits (Slow Zones):** use of stop signs, temporary speed restrictions
- **Single Tracking:** delays incurred due to crossing over and waiting for opposing trains
- **Approach Control:** reduced signal speed when approaching major junctions
- **Train Slots:** congestion—waiting for other trains to clear



2

Operating Documents

- A. Operating Rule Book:** usually no impact, except for specific rule provisions (already discussed)
- B. Employee Timetable & Special Instructions:** three kinds of maximum authorized speed restrictions
 - Line Speeds, Civil Speeds, Equipment Speeds
- C. General Orders:** permanent changes to (A) & (B)
- D. Bulletin Orders:** temporary changes to (A) & (B)
 - updated daily, may be modified during the day
- E. Train Orders:** issued by dispatchers, contain immediate instructions (e.g. emergency speed restriction)



2

B. Special Instructions: Line Speeds

189

BUFFALO DIVISION

	Single Track		No. 2 Track		No. 1 Track		No. 3 Track		No. 4 Track		No. 5 Track		No. 6 Track	
	Pass.	Frt.	Pass.	Frt.	Pass.	Frt.	Pass.	Frt.	Pass.	Frt.	Pass.	Frt.	Pass.	Frt.
Miles per Hour														
Main Line Alby.-Renns. to Bay View Between;														
MP 296.5 & MP 328														
MP 328 & MP 332.6														
MP 332.6 & MP 334														
MP 334 & MP 340.4														

Rare

Relative Availability

Retention: 6 months to 3 years

Common

2

B. Special Instructions: Civil Speeds

205	
BUFFALO DIVISION	
Miles Per Hour	
Main Line: MP 296.5 to Bayview	
Bridge 636—Seneca River at MP 319.98	30
Niagara Branch:	
CP H. CP I. E-L 3, when diverting—not exceeding	10
Tuscarora Wye	15
CP E-L 3 and 59—Track 1	20
Falls Road Branch:	
Lockport—Over streets	20
West Shore Branch East:	
Between MP 347.3 and MP 347.8	10
Between MP 359.8 and MP 361	40
Between MP 361 and MP 362	30

Rare

Relative Availability

Retention: 6 months to 3 years

Common



2

B. Special Instructions: Equipment Speeds

206

TURBO TRAINS—CURVES, BRIDGES, ETC.

1157-Fla. Maximum speed, for trains consisting entirely of Turbo equipment, cars Nos. 50 to 53, inc.; Nos. 70 to 75 inc., in high-speed passenger service.

Shore Line:	Miles Per Hour
Curve between MP 74 and MP 76	60
Curve east of MP 78	60
Second curve west of MP 81	60
First curve west of Branford	50
Branford—MP 81.0 to MP 81.3	50
MP 81.9 to MP 82.3	65
Lectes Island—MP 85.6 to MP 85.9	80
MP 87.2 to MP 87.5	70
Guilford—MP 89.3	79
Madison—MP 93.0 to MP 93.2	75
MP 94.4 to MP 94.9	75
Clinton—MP 96.1 to MP 96.4	85
Westbrook—MP 99.6 to MP 100.9	75
MP 101.9 to MP 102.1	70
Old Saybrook—MP 106.2 to MP 106.4	45

Rare

Relative Availability

Retention: 6 months to 3 years

Common

2

C. General Orders: Permanent Change

PENN CENTRAL TRANSPORTATION COMPANY
 NORTHEASTERN REGION
 New Haven, Conn., December 18, 1972
 General Order No. 604
 Effective 12.01 A.M., Tuesday, December 26, 1972

Applies in Buffalo Division

CURVES, BRIDGES, ETC.
 MAXIMUM SPEEDS
 TEMPORARY SPEED RESTRICTIONS (MPH) in
 effect as follows:

I. Belt Line Branch

Between	No. 1 Track	No. 2 Track	Single Track
CP I and East Ferry St. ...	10	10	
East Ferry St. and Dewey Ave.		10	
Elmwood Ave. and CP I		10	
CP I and 55			5

Special Instructions 1157-F1, page 205 and 1157-H1, pages 210 and 211, changed.

Rare

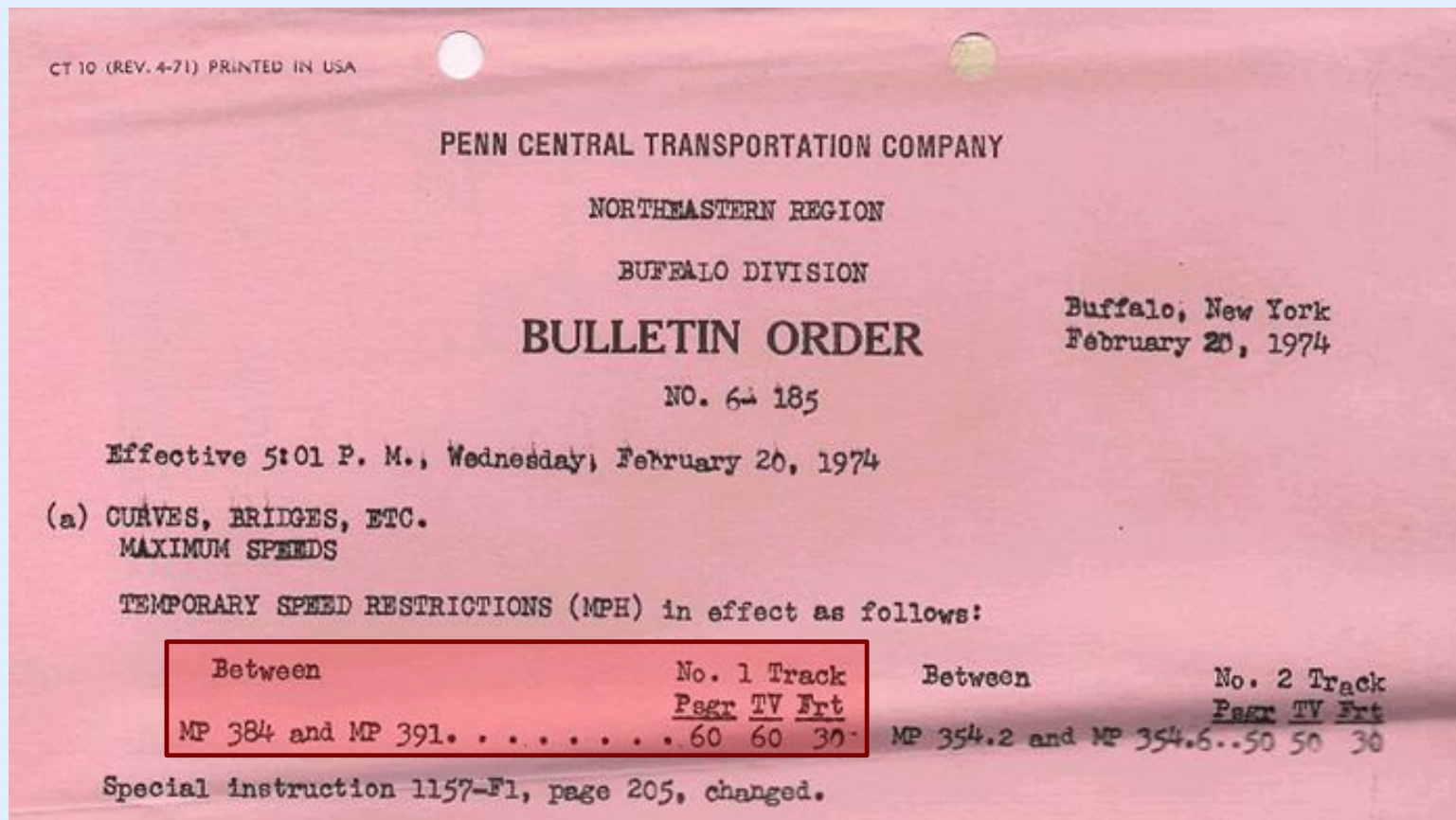
Relative Availability

Retention: until end of timetable period

Common

2

D. Bulletin Orders: Temporary Change



Rare

Retention: until G.O. or summary B.O. issued

Relative Availability



Common



2

E. Train Orders: Immediate Change

FORM 19 PENN CENTRAL CO. FORM 19
 TRAIN ORDER No. 22
 Oct - 26 1972
 To C & E Southward Trains and Foreman M. Sanchez
 At Wrenona
 Single track obstructed for maintenance between MP 113 and MP 114 from 957 nine fifty seven AM to 430 four thirty PM Approach the stop signs prepared to stop and stop
 R P M 39
 You & Foreman M. Sanchez
 Order no 22 is cancelled
 R P M
 Con 339 PM Cisiekis

To:
 Conductors and Engineers of Southward Trains and (Track) Foreman M. Sanchez

“Single track obstructed for maintenance between Milepost 113 and M.P. 114 from 957 AM to 430 PM approach the stop signs prepared to stop and stop.”

(signed by Dispatcher)

Rare

Relative Availability

Retention: 24 hours to 7 days

Common

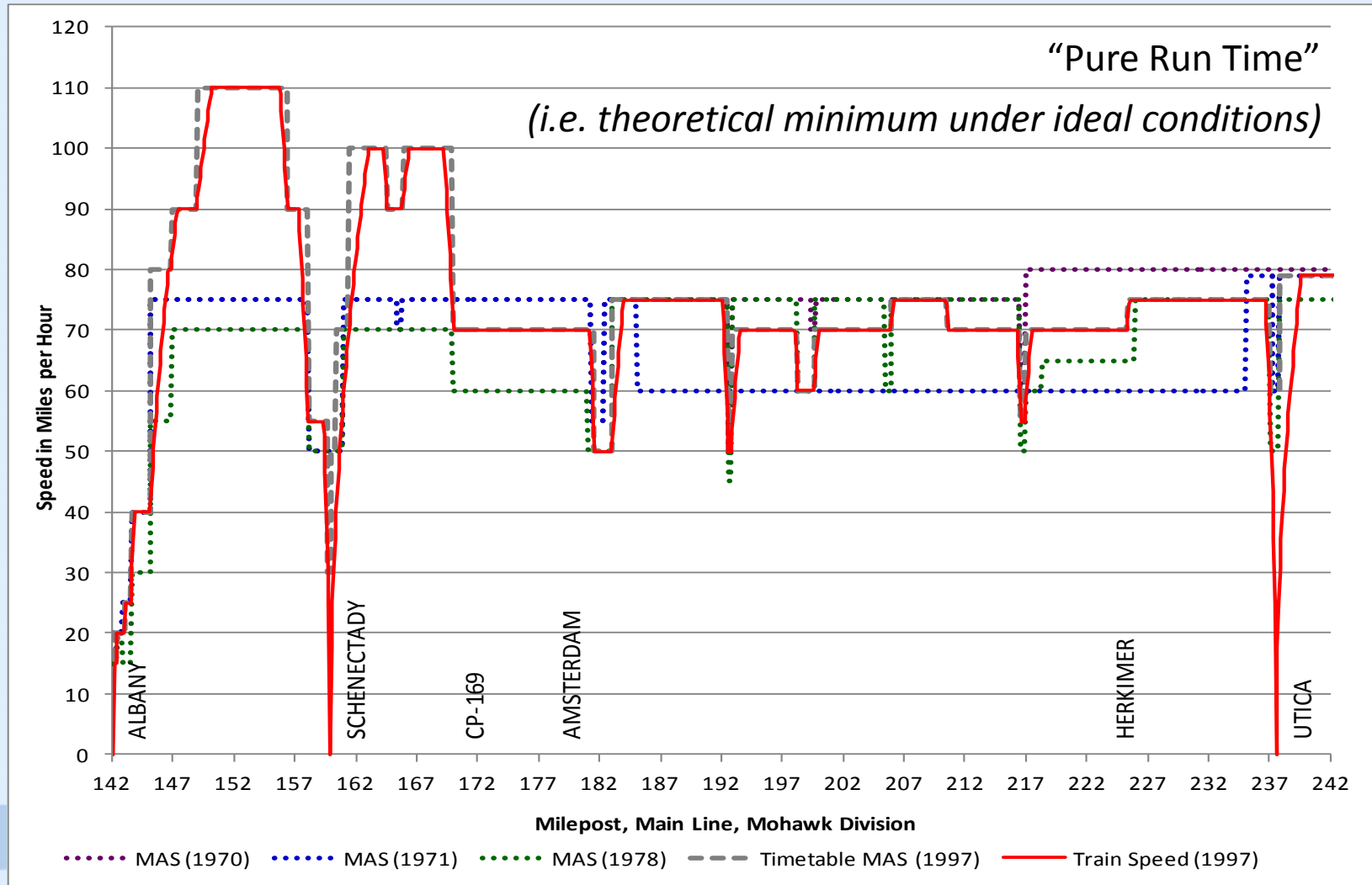
3

Building an Operating Schedule

- A. **Train Performance Calculator:** Calibrate, then simulate “ideal” point-to-point pure running time
- B. **Station Dwell Times:** passenger transfer, train servicing, crew relief, change of host railroad, etc...
- C. **Engineering Adjustment** (*‘Square Time’*): planned track work, temporary speed restrictions, etc.
- D. **Routing Time** (*‘Circle Time’*): waiting for train slots, congestion delays at key interlockings, etc.
- E. **Performance Allowance** (*‘Triangle Time’*): individual variations in locomotive engineer performance



A. Train Performance Calculator (TPC)



C. [Engineering Adjustment]

GC26 CARSTAIRS, MILLERHILL & EDINBURGH TO NORTH BERWICK, BERWICK & BRANCHES													Railtrack Scotland Zone (2000)		UP
													WEEKDAYS		
Train ID		2Y94	5Y94	9O84	9O84	1E02	2Y06	2Y60	5Y33	1E05	1E05	5S99	2Y82		
Departs From			07:38 Haymarket	07:30 Glasgow Central	07:30 Glasgow Central			07:10 Glasgow Central	08:38 Haymarket	08:00 Glasgow Central	08:00 Glasgow Central				
To				Paris Nord	Paris Nord	London Kings Cross				London Kings Cross	London Kings Cross				
Timing Type		EMU	EMU	E110/373	E110/373	HST/2+9	EMU	DMU(S)	EMU	91/410	91/410	D595	DMU(S)		
Days Run		SX	SX	SX	SO	SO	SO	SX	SX	SO	SX	TThO	SO		
Operating Chars									Y	EP	EP	Q			
CARSTAIRS	Arr	1													
	Dep	2		07/56	07/56					08/28½	08/28½	4 JUN			
	mgn	3										22 SEP			
	mgn	4													
Carstairs East Jn	Arr	5		07/58½	07/58½					08/31½	08/31½				
	Dep	6													
Benhar Jn	Arr	7						07/57							
Fauldhouse	Arr	8						07/59							
Breich	Arr	9						08/02½							
Addiewell	Arr							08/06½							
WEST CALDER	Arr							08/09½							
	Dep							08p10½					08.41		
Livingston South	Arr							08p15					08.46		
Midcalder Goods Loop	Dep														
	mgn							[2] (1)					[2]		
Midcalder Jn	Arr							08/X21		08/44	08/44		08/X51		
Kirknewton	Arr							08p23					08.53		
Curriehill	Arr							08p28½					08.58½		
Wester Hailes	Arr							08.32					09.02		
Kingsknowe	Arr							08.34½					09.04½		
Slateford	Arr	23	08.14					08.37					09.07		
	mgn	24	[2]			[2] <1>		[2]		[2] <1>	[2] <1>		[2]		
Slateford Jn	Arr	25													
	Dep	26	08/16½		08/21	08/21		08/40	08RM46	08/53	08/53		09/10		
	mgn	27						(1)	(1)				(1)		
Haymarket	Arr	28	08.19½					08.43					09.13		
Haymarket	Dep	29	08.20½		08/23	08/23		08.44	08/50	08/55	08/55		09p14		
Princes St Gardens	mgn	30													
	Arr	31	08/X22½						08/X52						
EDINBURGH	mgn	32													
	Arr	33	08.24		08U26	08U26		08.47	08+56	08.57½	08.57½		09.17		
EDINBURGH	Dep	34	08.37		08pU31	08pU31	08.35	08p38	13F	NLS	09q02	09q02	09+15		
Craigenlinny T & RSM	pl	35	19		20	20	19	7			11	11	10		
Powderhall Refuse Siding	Dep	36											13		
Leith South	Dep	37													
	mgn	38													
	Arr	39													
Portobello Jn	Arr	40	08/41		08/35	08/35	08/39	08/42				09/06	09/20½		
Musselburgh	Arr	41	08.43½					08p44½							

Due to maintenance activity in this section, all trains traversing it are given two [2] extra minutes on approach to critical junction.

D. (Routing Time)

GC26 CARSTAIRS, MILLERHILL & EDINBURGH TO NORTH BERWICK, BERWICK & BRANCHES													Railtrack Scotland Zone (2000)		UP
													WEEKDAYS		
Train ID		2Y94	5Y94	9O84	9O84	1E02	2Y06	2Y60	5Y33	1E05	1E05	5S99	2Y82		
Departs From			07:38 Haymarket	07:30 Glasgow Central	07:30 Glasgow Central			07:10 Glasgow Central	08:38 Haymarket	08:00 Glasgow Central	08:00 Glasgow Central				
To				Paris Nord	Paris Nord	London Kings Cross				London Kings Cross	London Kings Cross				
Timing Type		EMU	EMU	E110/373	E110/373	HST/2+9	EMU	DMU(S)	EMU	91/410	91/410	D595	DMU(S)		
Days Run		SX	SX	SX	SO	SO	SO	SX	SX	SO	SX	TThO	SO		
Operating Chars									Y	EP	EP	Q			
CARSTAIRS	Arr	1													
	Dep	2		07/56	07/56					08/28½	08/28½	4 JUN			
	mgn	3										22 SEP			
	mgn	4													
Carstairs East Jn	Arr	5		07/58½	07/58½					08/31½	08/31½				
	Dep	6													
Benhar Jn	Arr	7						07/57							
Fauldhouse	Arr	8						07.59							
Breich	Arr	9						08.02½							
Addiewell	Arr	10						08.06½							
WEST CALDER	Arr	11						08.09½							
	Dep	12						08p10½					08.41		
	mgn	13													
Livingston South	Arr	14						08p15					08.46		
Midcalder Goods Loop	Dep	15													
	mgn	16			(2)			[2](1)					[2]		
Midcalder Jn	Arr	17													
	Dep	18								08/44	08/44		08/45½		
Kirknewton	Arr	19	07.59	07RM56	08/10	08/12		08/X21					08.53		
Curriehill	Arr	20	08.06	07+58				08p23					08.58½		
Wester Hailes	Arr	21	08.09					08p28½					09.02		
Kingsknowe	Arr	22						08.32					09.04½		
Stateford	Arr	23						08.34½					09.07		
	Dep	24						08.37					[2]		
	mgn	25						[2]		[2]<1>	[2]<1>		[2]		
Stateford Jn	Arr	26													
	Dep	27													
	mgn	28													
Haymarket	Arr	29						08/40	08RM46	08/53	08/53		09/10		
	Dep	30						(1)	(1)				(1)		
	mgn	31						08.43					09.13		
Haymarket	Arr	32													
	Dep	33						08.44	08/50	08/55	08/55		09p14		
Princes St Gardens	Arr	34							08/X52						
	Dep	35													
EDINBURGH	Arr	36						08.47	08+56	08.57½	08.57½		09.17		
	Dep	37													
	mgn	38													
EDINBURGH	Arr	39													
	Dep	40	08.37		08pU31	08pU31	08.35	08p38	13F	NLS	09q02	09q02	09+15		
	pl	41	19		20	20	19	7			11	11	10		
Craigenlinny T & RSMD	Arr	42											13		
Powderhall Refuse Siding	Arr	43													
Leith South	Arr	44													
	Dep	45													
	mgn	46													
Portobello Jn	Arr	47	08/41		08/35	08/35	08/39	08/42							
Musselburgh	Arr	48	08.43½					08p44½							
	Dep	49													
	mgn	50													
	mgn	51													
	mgn	52													
	mgn	53													
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	mgn	93													
	mgn	94													
	mgn	95													
	mgn	96													
	mgn	97													
	mgn	98													
	mgn	99													
	mgn	100													

Trains switching from express to local tracks ahead of main interchange station are allotted one (1) minute to make the move.

E. <Performance Allowance>

GC26 CARSTAIRS, MILLERHILL & EDINBURGH TO NORTH BERWICK, BERWICK & BRANCHES													Railtrack Scotland Zone (2000)		UP
													WEEKDAYS		
Train ID		2Y94	5Y94	9O84	9O84	1E02	2Y06	2Y60	5Y33	1E05	1E05	5S99	2Y82		
Departs From			07:38 Haymarket	07:30 Glasgow Central	07:30 Glasgow Central			07:10 Glasgow Central	08:38 Haymarket	08:00 Glasgow Central	08:00 Glasgow Central				
To				Paris Nord	Paris Nord	London Kings Cross				London Kings Cross	London Kings Cross				
Timing Type		EMU	EMU	E110/373	E110/373	HST/2+9	EMU	DMU(S)	EMU	91/410	91/410	D595	DMU(S)		
Days Run		SX	SX	SX	SO	SO	SO	SX	SX	SO	SX	TThO	SO		
Operating Chars									Y	EP	EP	Q			
CARSTAIRS	Arr	1													
	Dep	2		07:56	07:56					08:28½	08:28½	4 JUN			
	mgn	3										22 SEP			
	mgn	4													
Carstairs East Jn	Arr	5		07:58½	07:58½					08:31½	08:31½				
	Dep	6						07:57							
Berhar Jn	Arr	7						07:59							
Fauldhouse	Arr	8						08:02½							
Breich	Arr	9						08:06½							
Addiewell	Arr	10						08:09½							
WEST CALDER	Arr	11						08p10½					08.41		
	Dep	12													
Livingston South	Arr	13						08p15					08.46		
Midcalder Goods Loop	Arr	14													
	Dep	15													
Midcalder Jn	mgn	16			(2)			[2](1)					[2]		
	Arr	17								08/44	08/44				
	Dep	18		08/10	08/12			08/X21					08/X51		
Kirkcaldy	Arr	19						08p23					08.53		
Curry	Arr	20						08p28½					08.58½		
West	Arr	21						08.32					09.02		
King	Arr	22						08.34½					09.04½		
Stair	Arr	23						08.37					09.07		
Stair	Arr	24						[2]		[2]<1>	[2]<1>		[2]		
Stair	Arr	25		08/21	08/21			08/40	08RM46	08/53	08/53		09/10		
Haymarket	Arr	26						(1)	(1)				(1)		
Haymarket	Arr	27						08.43					09.13		
Haymarket	Arr	28		08/23	08/23			08.44	08/50	08/55	08/55		09p14		
Princes St Gardens	Arr	29													
	mgn	30	08/X22½						08/X52						
EDINBURGH	Arr	31	08.24		08U26	08U26		08.47	08+56	08.57½	08.57½		09.17		
EDINBURGH	Dep	32			08pU31	08pU31	08.35	08p38	13F	NLS	09q02	09q02	09+15		
	pl	33	08.37		20	20	19	7			11	11	10		
Craigentinny T & RSMD	Dep	34	19										13		
Powderhall Refuse Siding	Dep	35													
Leith South	Dep	36													
	mgn	37													
Portobello Jn	Arr	38	08/41		08/35	08/35	08/39	08/42		09/06	09/06	09/20½			
Musselburgh	Arr	39	08.43½					08p44½							

Non-stop trains are given one <1> extra minute for performance in case they lose time en-route.

Hypothetical "Schedule Skeleton"

Schedule Skeleton - Spirit of Western Reserve/Train 47 (Daily)							December 17, 1982	
RR	Mileage	PRT	Recovery Minutes	Misc. Adjust.	Dwell Minutes	Arrive	Depart	Station
ANR	0.0						7:45 PM	Quaint, New England
NETA	6.2	5			3	7:50 PM	7:53 PM	R Route 20, New England
NETA	28.1	19	1		3	8:13 PM	8:16 PM	R High-Tech, New England
NETA	51.8	19	3	8	3	8:46 PM	8:49 PM	Appleseed, New England
B&O		7				8:56 PM	8:56 PM	CPF 852
B&O	122.9	69	1	5	5	10:11 PM	10:16 PM	State College, N. England
B&O	184.2	71			2	11:27 PM	11:29 PM	North Mountain, N. England
ANR	222.5	55	13	5		12:42 AM	12:42 AM	CPF 987
ANR	237.2	16				12:58 AM		Capital, Great State
ANR	237.2	0			45		1:43 AM	Capital, Great State
ANR	257.3	19	1		5	2:03 AM	2:08 AM	Factory Town, Great State
B&O	268.2	5				2:13 AM	2:13 AM	CP-169
B&O	350.5	63	1		5	3:17 AM	3:22 AM	Wheat, Great State
B&O	412.8	46	2	3	6	4:13 AM	4:19 AM	The Orange, Great State
B&O	513.1	73	2		5	5:34 AM	5:39 AM	Camera City, Great State
B&O	587.2	47	10		5	6:36 AM	6:41 AM	Snowy Lake, Great State
B&O	694.4	84	5		3	8:10 AM	8:13 AM	County Seat, Williamstate
B&O	712.0	12				8:25 AM	8:25 AM	CP-133
B&O	804.6	67				9:32 AM	9:32 AM	CP-211
PRR	805.2	6		3		9:41 AM	9:41 AM	CP-ASH
PRR	815.3	6	12		18	9:59 AM	10:17 AM	Lake City, Western Reserve
PRR	836.9	30			4	10:47 AM	10:51 AM	State Fair, W.R.
PRR	881.4	30			4	11:21 AM	11:25 AM	Beach Resort, W.R.
PRR	935.0	47	12		20	12:24 PM	12:44 PM	Port City, W.R.
PRR	1000.6	50			2	1:34 PM	1:36 PM	Middle, W.R.
PRR	1028.3	24			5	2:00 PM	2:05 PM	Flag Stop, Crossroads
PRR	1102.2	44	2		2	2:51 PM	2:53 PM	Big Yard, Crossroads
PRR	1124.9	21	4		3	3:18 PM	3:21 PM	Airport Exchange ET
PRR	1176.1	36				2:57 PM	2:57 PM	CP-LAPORTE CT
PRR	1198.7	25				3:22 PM	3:22 PM	Suburbia, Crossroads
PRR	1210.4	9				3:31 PM	3:31 PM	Tower 72
ANR	1224.0	4	31			4:06 PM	4:06 PM	Tower 21
ANR	1216.3	5	1			4:12 PM		Stockyards, Midwest CT
		Total Pure Run	Total Recovery Minutes	Total Misc. Adj.	Total Dwell	Total Schedule Time		
QNE-SYM		1014	101	24	148	1287		

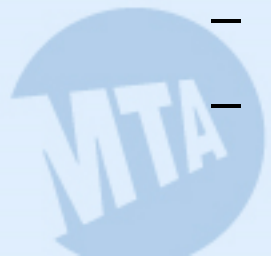
Purpose of Misc. Adjustments

- 10 mins. at CPF 987 for meet with 46 on single track.
- 5 mins. at Capital, Great State to avoid conflict with 2235.
- 3 mins. at Orange for crossover to preferred track.
- 3 mins. at CP-ASH for crossover to preferred track at Lake City.



4 What *Really* Happened to Running Times?

- **Metro-North New Haven Line:
New Haven to Grand Central Terminal**
 - Infrastructural changes accumulated over a long period
 - e.g. signalling changes, SHELL at grade, new stations, new interlockings, constant tension catenary, etc.
 - Running times adjusted, but became progressively less achievable
 - On-Time Performance (OTP) fell below 90% due to numerous events
 - Analyses carried out to identify necessary changes
- **Why did published journey times increase?**
 - Necessary safety improvement (civil speed enforcement)
 - Congestion due to higher train volumes
 - More realistic running times to improve performance and reliability
 - Revised stopping pattern, including new stations



4

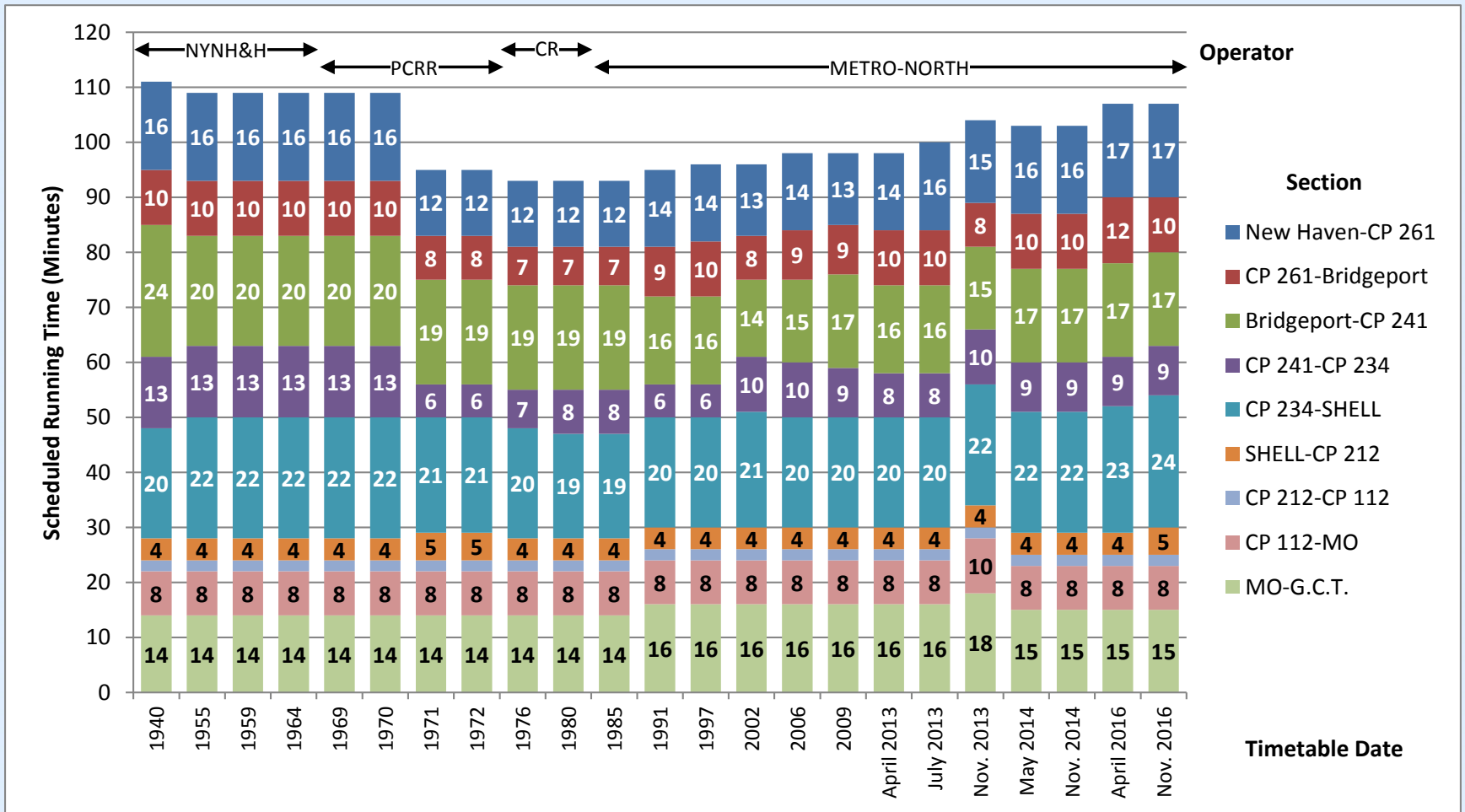
Running Time Changes

- A. **Historical Sectional Running Time Analysis:** general long-term trends augmented by knowledge of historical events, supplemented by reviewing operating documentation
- B. **On-Time Performance:** train-by-train analysis to understand extent of observed running time changes
- C. **Differential Schedule Analysis:** short-term events can often be correlated with revision-by-revision comparison of operating schedules
- D. **Maximum Authorized Speeds & Train Performance Analysis** (*see Appendix*): not required in this case because access to section schedulers and revision notes were available

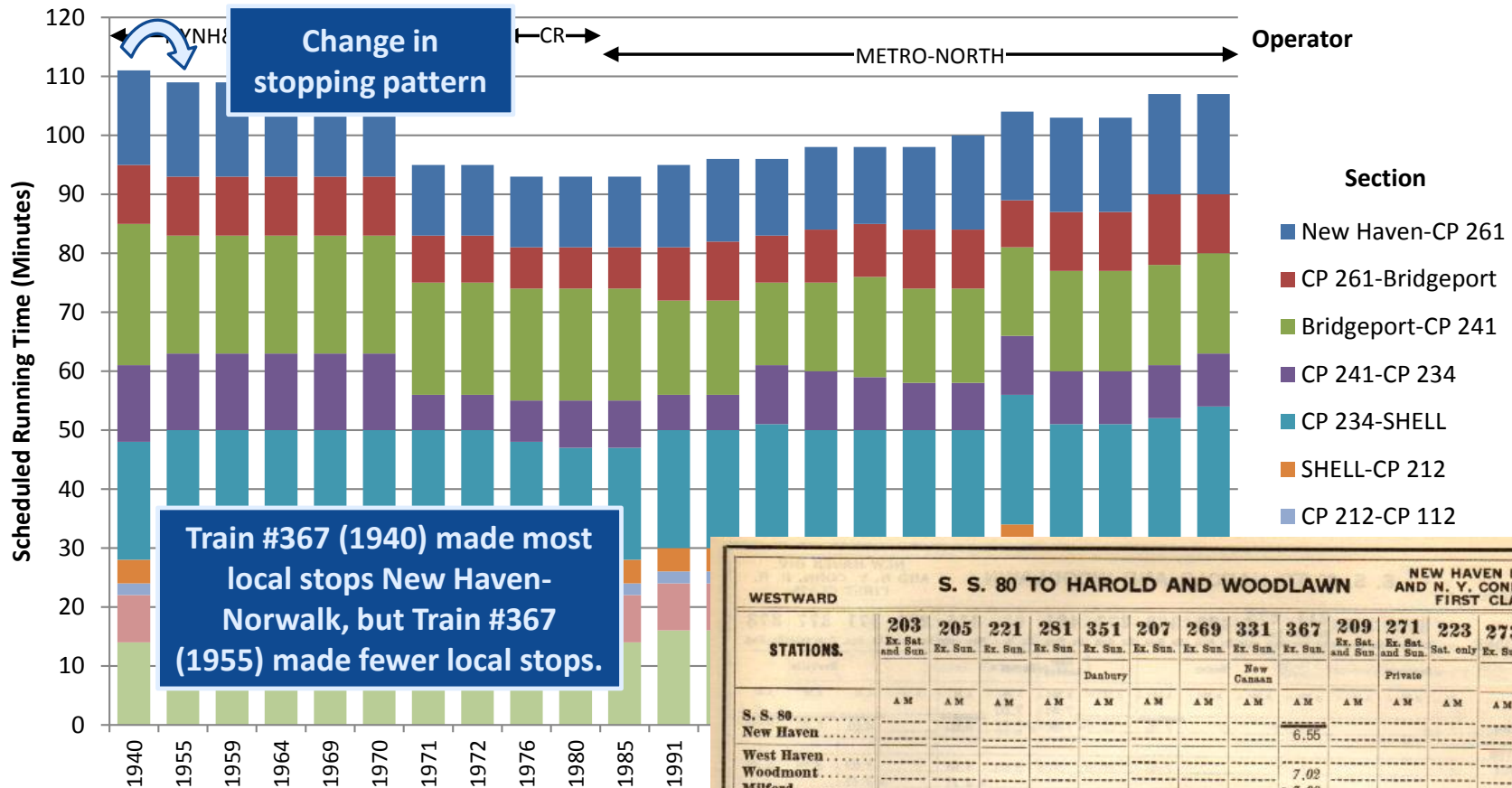


4

A. Express Run Times (1940-2016)



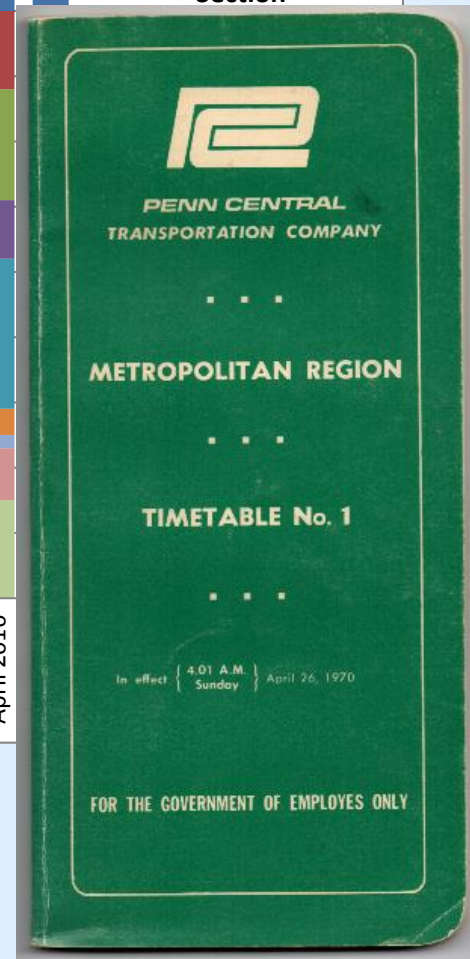
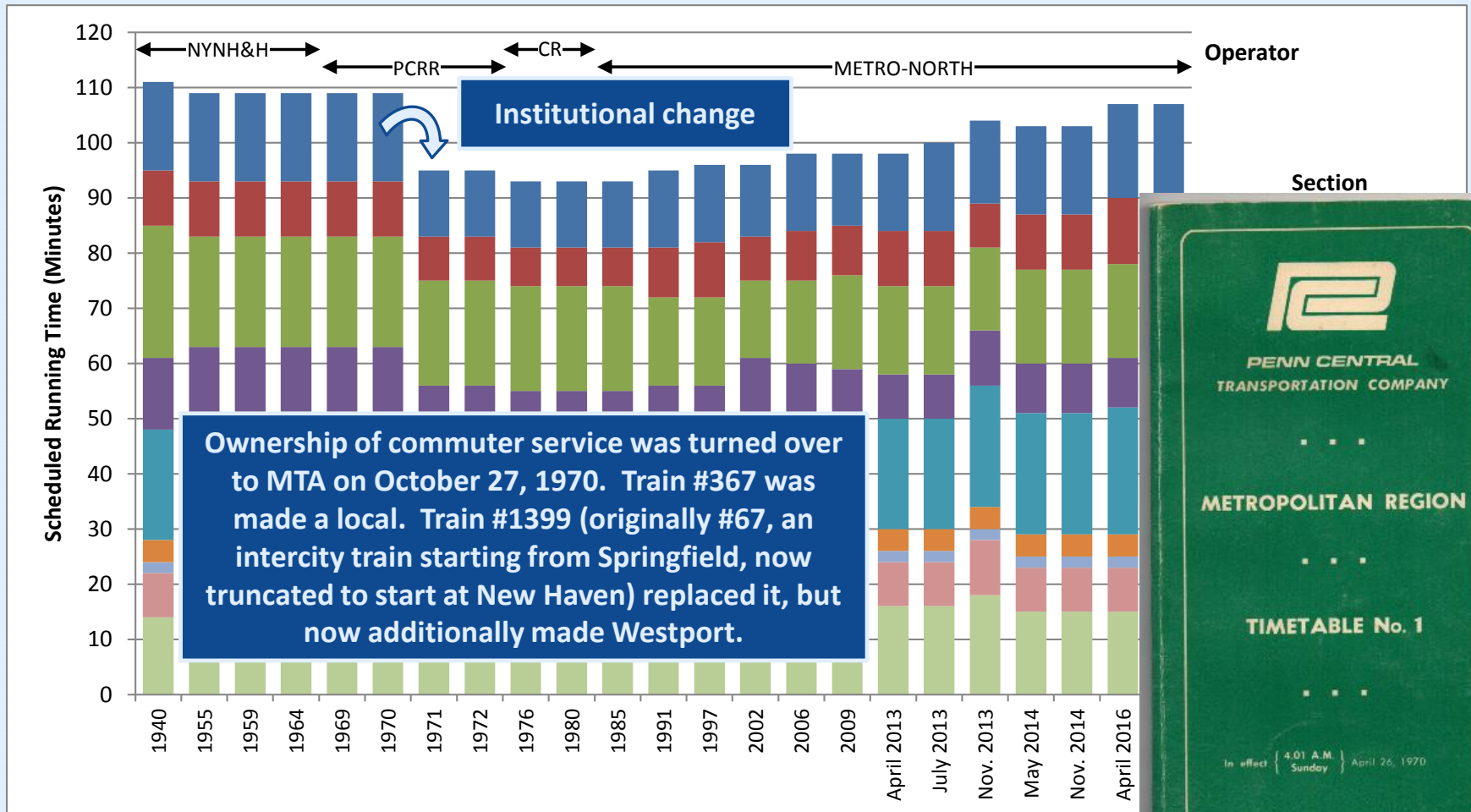
Routine Service Revisions



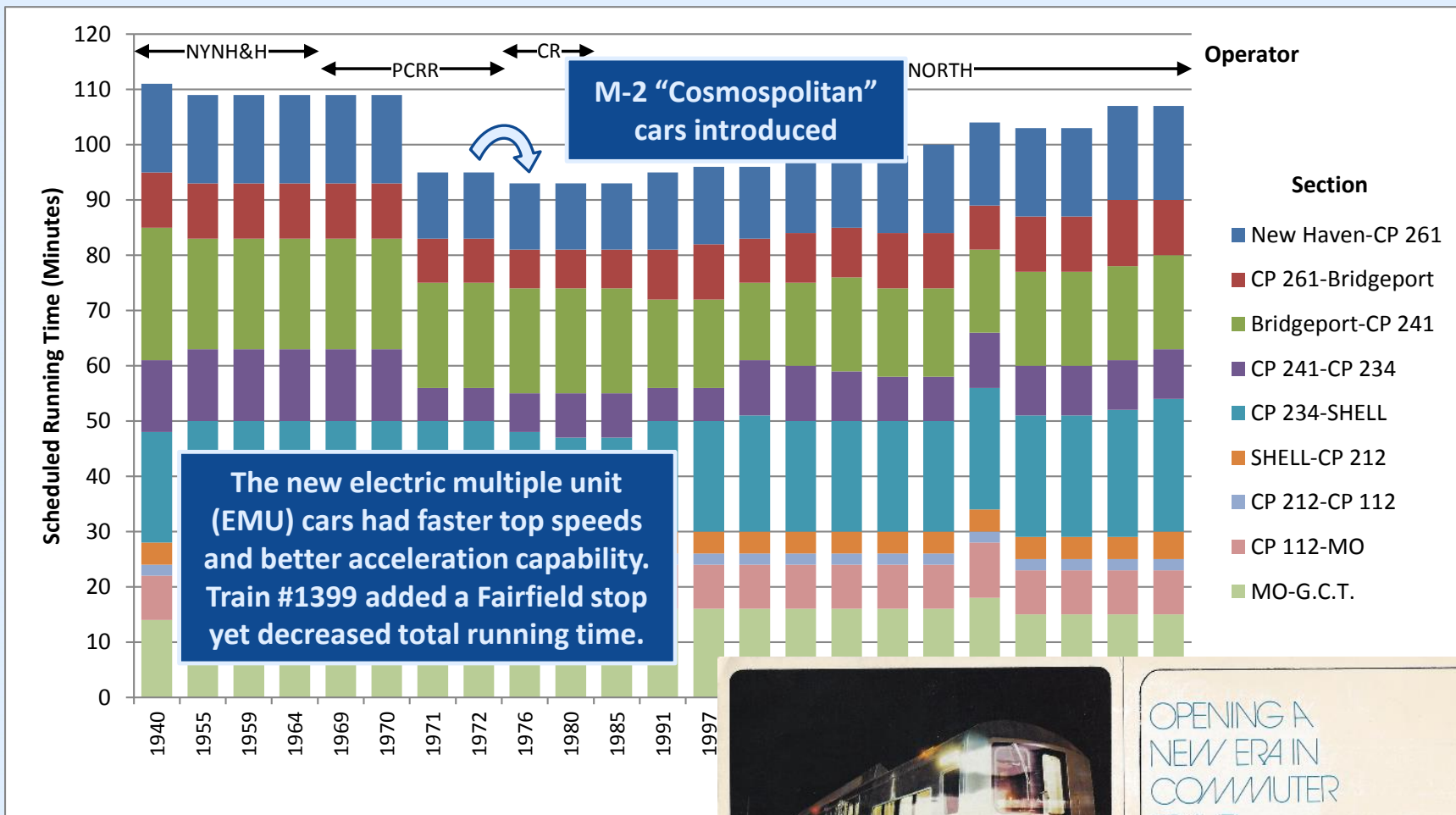
S. S. 80 TO HAROLD AND WOODLAWN												NEW HAVEN DIV. 3 AND N. Y. CONN. R. R. FIRST CLASS			
WESTWARD															
STATIONS.	203 Ex. Sat. and Sun.	205 Ex. Sun.	221 Ex. Sun.	281 Ex. Sun.	351 Ex. Sun.	207 Ex. Sun.	269 Ex. Sun.	331 Ex. Sun.	367 Ex. Sun.	209 Ex. Sat. and Sun.	271 Ex. Sat. and Sun.	223 Sat. only	273 Ex. Sun.	285 Ex. Sun.	
	Danbury											New Canaan			
	New Canaan											Private			
S. S. 80	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	
New Haven									6.55						
West Haven															
Woodmont									7.02						
Milford									7.08						
Devon									7.11						
Stratford									7.14						
Bridgeport									7.20						
Fairfield									7.27						
Southport									7.31						
Green's Farms									7.34						
Westport									7.40						
East Norwalk									7.43						
So. Norwalk					7.17				7.47						
Rowayton					7.28										
Darien					7.32				7.54						
Noroton					7.35										
Glenbrook					7.38										
Stamford					7.36	7.41			7.49	7.58	8.00		8.03	8.08 8.17	



Private to Public Transition (1970)



New M-2 Car Equipment (1973)

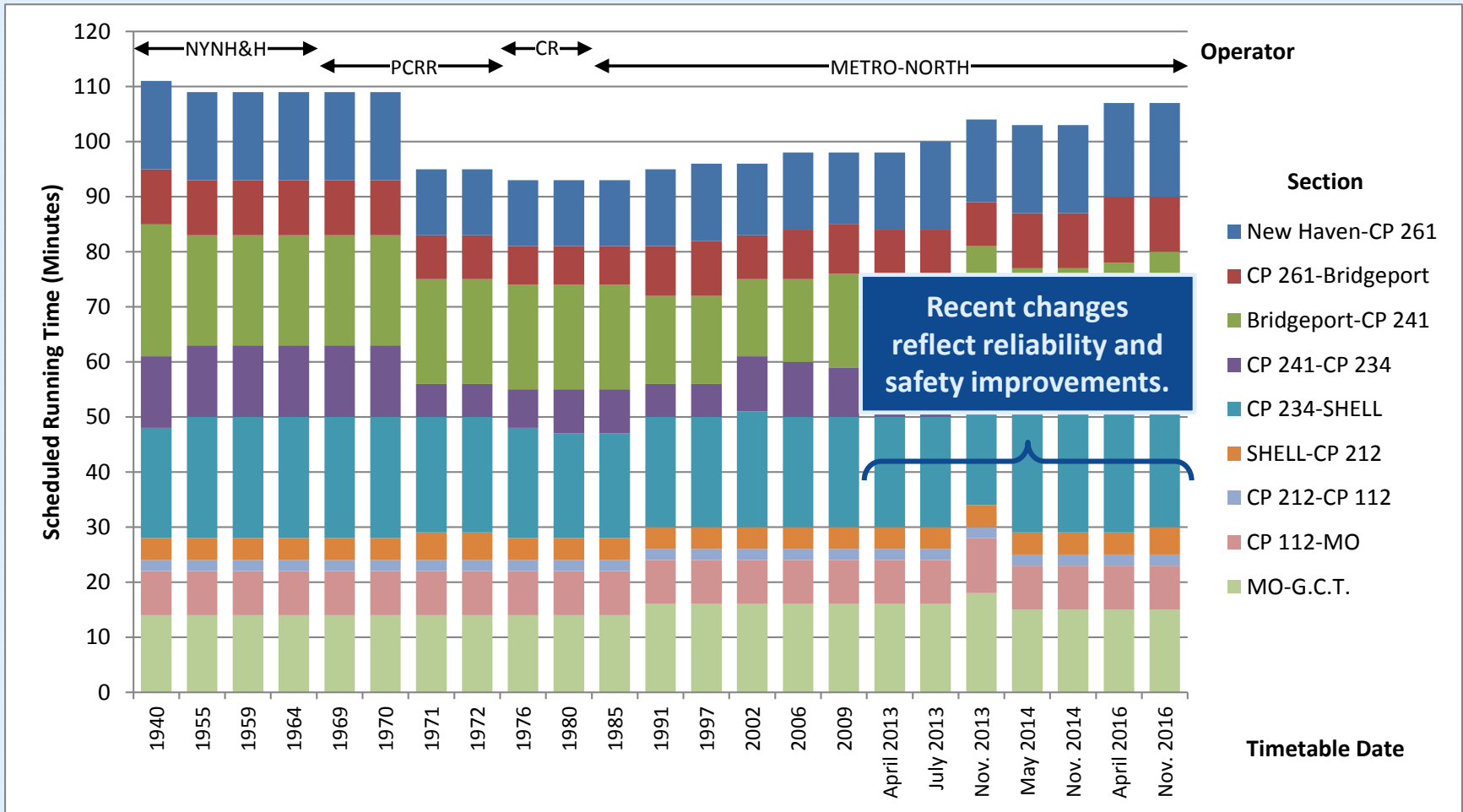


OPENING A
NEW ERA IN
COMMUTER
TRAVEL...

THE COSMOPOLITAN

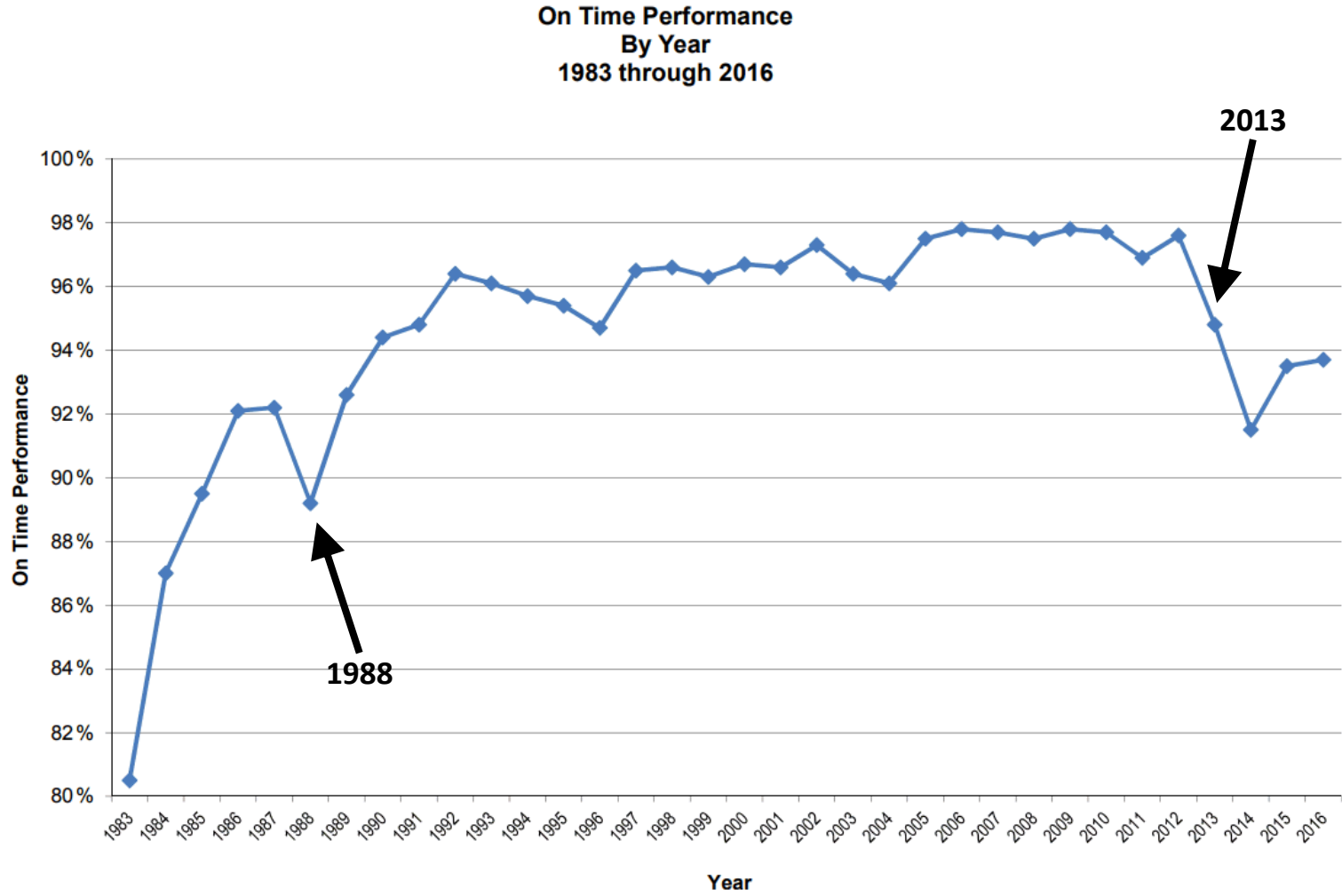


Recent Adjustments



4

B. On-Time Performance (1983-2016)

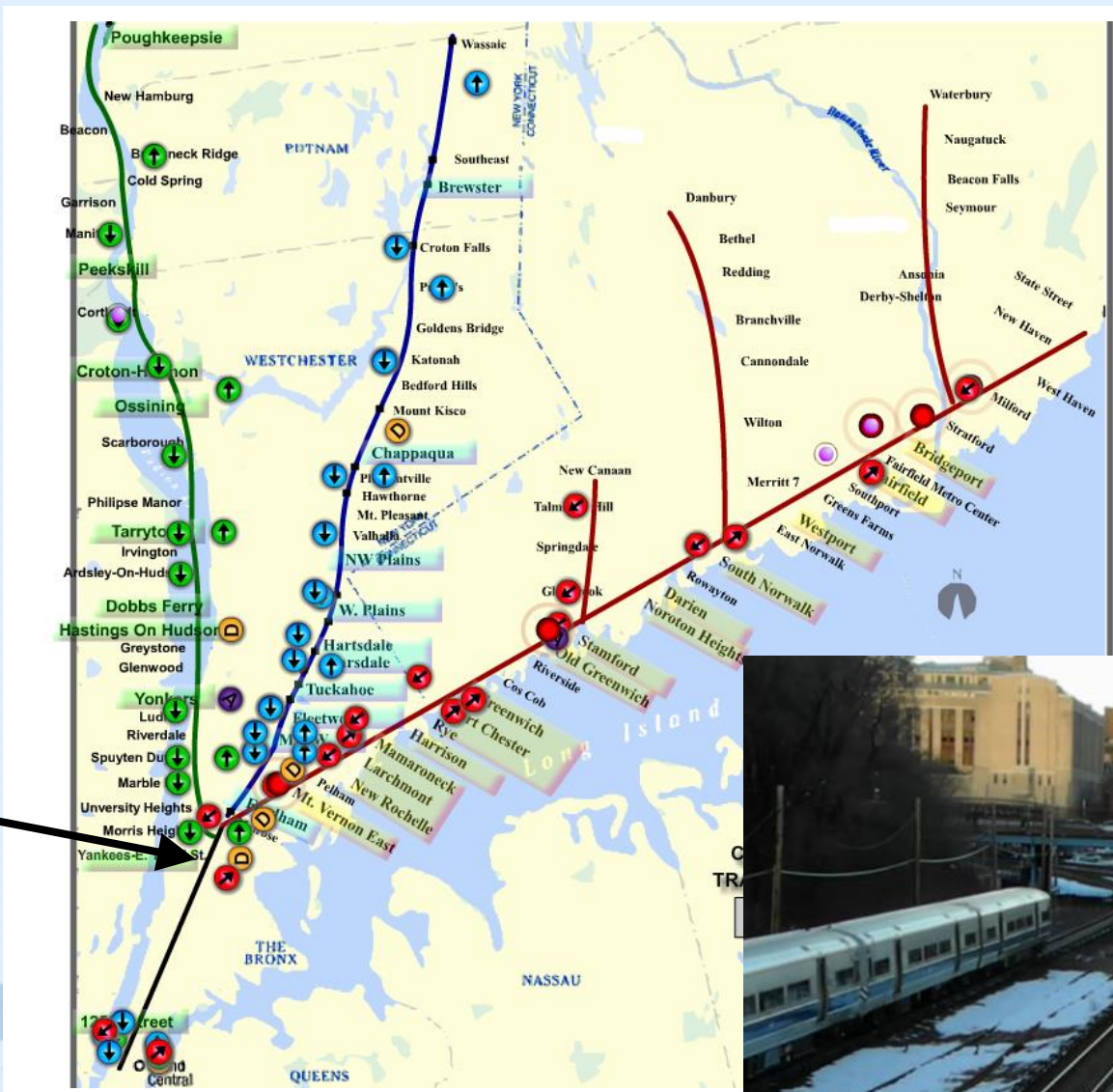


Off-Peak Train Tracker (1:30 PM)



4

Peak Train Tracker (7:45 AM)



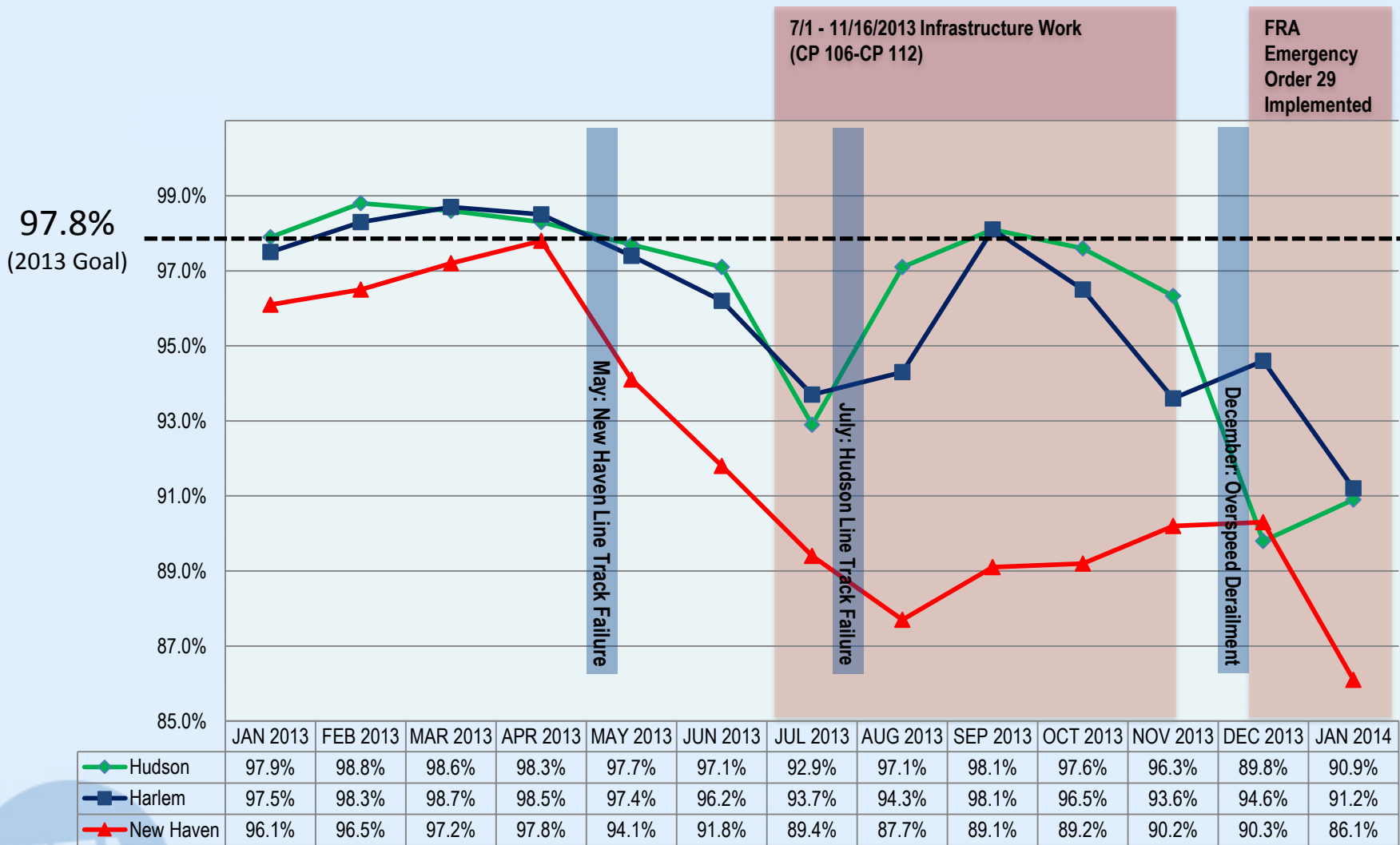
Mott
Haven
(MO) Jct.



Photo: The Transport Net/YouTube

4

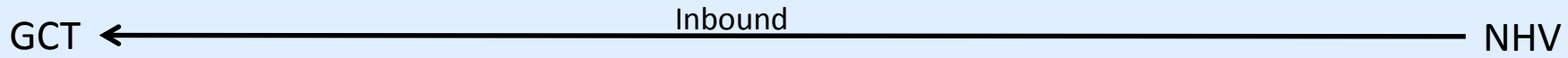
On-Time Performance (2013)



4 OTP Charts (2013)



Timeline represents study period during 2013.



REAL_DIR	TIME_NAME	CP 1	CP 3	CP 4	CP 5	CP 106	CP 112	CP 212	CP 215	CP 216	CP 217	CP 223	CP 229	CP 230	CP 232	CP 233	CP 234	CP 235	CP 240	CP 241	CP 244	CP 248	CP 255	CP 257	CP 261	CP 264	CP 271	CP 272	CP 273
W	0003 # 1597			-419	-392	-401	-266	-217	-221		-195	-130	-81	-28	36		49		58	82	-4	148	56	78	74	15	-23		
	0041 # 1497	0	0	0	0	0	0	0	0	0	0	-37	51	-27	13		50	0	0	0	0	0	99	142	74	-1	-35	0	
	0120 # 1599																												
	0148 # 1399	-645	-450	-391	-364	-431	-218	-190	-71		-204	-16	76	17	73	-598													
	0541 # 1301	-77	123	44	66	41	-90	-53	19		34	45	118	39	33														
	0544 # 1503	-197	-8	-113	-87	-159	-107	-117	-114		-154	-95	-48	-57	8				41	14	-37		-7	41	53	7	-16		
	0614 # 1303	-229	-29	-100	-78	-98	-62	-20	51	49	40	-37	76	-16	9														
	0620 # 1507	-115	70	-9	10	8	81	93	86		103	94	126	115	151	172			106	79	69	211	108	138	44	3	-26	0	
	0634 # 1305	-43	116	27	47	-79	-96	-52	26		25	-14	138	55	70	-183													

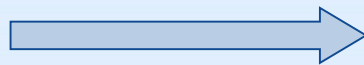
Chart shows cumulative delay (in seconds) by location and by train (color coded), e.g. train 1507 was at least 151 seconds late at CP 232.



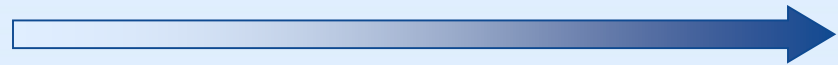
4

C. Differential Causal Analysis

Effective Date	10/27/02	10/01/06	10/18/09	04/07/13	07/01/13	11/17/13	05/11/14	11/09/14	04/03/16	10/02/16
Train #	1527	1527	1527	1527	1527	1527	1523	1523	1523	1523
N.H.-CP 271	3	3	3	3	3	3	3	3	3	3
CP 271-CP 266	5	5	5	5	(+2) 7	(-1) 6	(+1) 7	7	7	7
CP 266-CP 261	5	(+1) 6	(-1) 5	(+1) 6	6	6	6	6	(+1) 7	7
CP 261-CP 257	5	(+1) 6	6	(+1) 7	7	(-2) 5	(+2) 7	7	(+2) 9	(-2) 7
CP 257-CP 255	4	4	4	(+1) 5	5	(-1) 4	4	4	4	4
CP 255-CP 248	6	6	6	(+1) 7	7	7	7	7	7	7
CP 248-CP 244	4	4	4	4	4	4	(+1) 5	5	5	5
CP 244-CP 241	3	(+1) 4	(+2) 6	(-3) 3	3	3	(+1) 4	4	4	4
CP 241-CP 234	10	10	(-1) 9	(-1) 8	8	(+2) 10	(-1) 9	9	9	9
CP 234-CP 229	8	(-1) 7	7	7	7	(+1) 8	8	8	(+1) 9	9
CP 229-CP 223	6	6	6	6	6	6	(+1) 7	7	7	7
CP 223-CP 217	7	(-1) 6	6	6	6	(+1) 7	(-1) 6	6	6	(+1) 7
CP 217-CP 215	1	(+1) 2	2	2	2	2	2	2	2	2
CP 215-CP 212	3	3	3	3	3	3	3	3	3	(+1) 4
CP 212-CP 112	2	2	2	2	2	2	2	2	2	2
CP 112-MO	8	8	8	8	8	(+2) 10	(-2) 8	8	8	8
MO-G.C.T.	16	16	16	16	16	(+2) 18	(-3) 15	15	15	15
Total Trip Time	96	98	98	98	100	104	103	103	107	107



stable operating environment
*(programmed engineering adjustments
 move with work location)*



fast-changing operating environment
*(additional repair work occurring in
 many locations simultaneously)*

4

New Stations

Effective Date	10/27/02	10/01/06	10/18/09	04/07/13	07/01/13	11/17/13	05/11/14	11/09/14	04/03/16	10/02/16
Train #	1527	1527	1527	1527	1527	1527	1523	1523	1523	1523
N.H.-CP 271	3	3	3	3	3	3	3	3	3	3
CP 271-CP 266	5	5	5	5	(+2) 7	(-1) 6	(+1) 7	7	7	7
CP 266-CP 261	5	(+1) 6	(-1) 5	(+1) 6	6	6	6	6	(+1) 7	7
CP 261-CP 257	5	(+1) 6	6	(+1) 7	7	(-2) 5	(+2) 7	7	(+2) 9	(-2) 7
CP 257-CP 255	4	4	4	(+1) 5					4	4
CP 255-CP 248	6	6	6	(+1) 7					7	7
CP 248-CP 244	4	4	4	4					5	5
CP 244-CP 241	3	(+1) 4	(+2) 6	(-3) 3					4	4
CP 241-CP 234									9	9
CP 234-CP 229					7	(+1) 8	8	8	(+1) 9	9
CP 229-CP 223					6	6	(+1) 7	7	7	7
CP 223-CP 217	7	(-1) 6	6	6	6	(+1) 7	(-1) 6	6	6	(+1) 7
CP 217-CP 215	1	(+1) 2	2	2	2	2	2	2	2	2
CP 215-CP 212	3	3	3	3	3	3	3	3	3	(+1) 4
CP 212-CP 112	2	2	2	2	2	2	2	2	2	2
CP 112-MO	8	8	8	8						
MO-G.C.T.	16	16	16	16						
Total Trip Time	96	98	98	98						

Fairfield Metro passenger station opened December 5, 2011.

West Haven passenger station opened August 18, 2013. Continuing adjustments reflect fine-tuning based on practical experience.



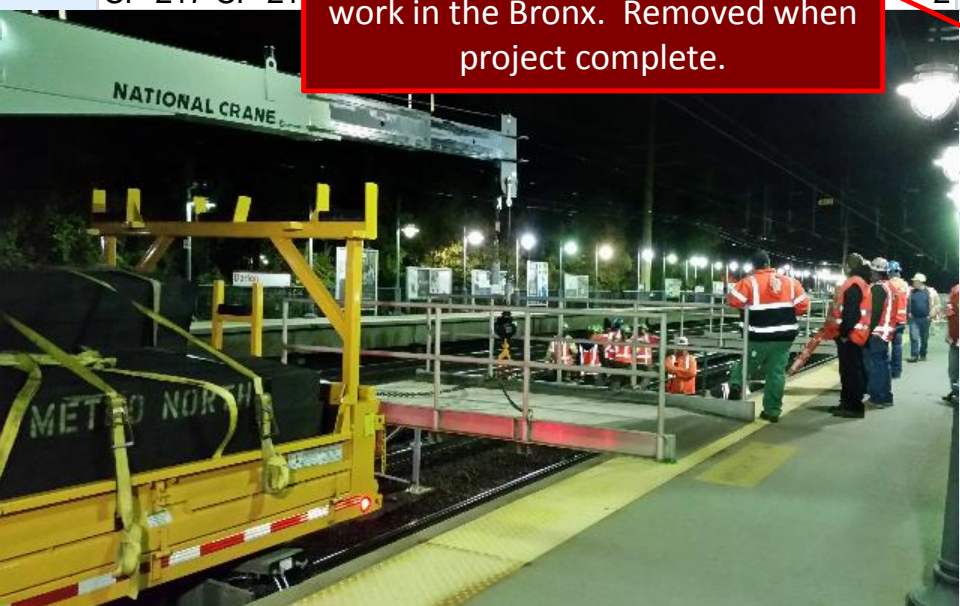
4

Project Work

Effective Date	10/27/02	10/01/06	10/18/09	04/07/13	07/01/13	11/17/13	05/11/14	11/09/14	04/03/16	10/02/16
Train #	1527	1527	1527	1527	1527	1527	1523	1523	1523	1523
N.H.-CP 271	3	3	3	3	3	3	3	3	3	3
CP 271-CP 266	5	5	Additional two minutes needed to accommodate Devon Transfer project. Upon project completion, extra time was removed.				(+1) 7	7	7	7
CP 266-CP 261	5	(+1) 6					6	6	(+1) 7	7
CP 261-CP 257	5	(+1) 6	(+2) 7	7	7	7	(+2) 9	(-2) 7	7	
CP 257-CP 255	4	4	4	4	4	4	4	4	4	
CP 255-CP 248	6	6	6	6	6	6	7	7	7	
CP 248-CP 244	4	4	4	4	4	4	(+1) 5	5	5	
CP 244-CP 241	3	(+1) 4	(+2) 6	(-3) 3	3	3	(+1) 4	4	4	
CP 241-CP 234	10	10	(-1) 9	(-1) 8	8	(+2) 10	(-1) 9	9	9	
CP 234-CP 229	8	(-1) 7	7	7	7	(+1) 8	8	(+1) 9	9	
CP 229-CP 22	6	6	6	6	6	(+1) 7	7	7	7	
CP 223-CP 21	6	6	6	6	(+1) 7	(-1) 6	6	6	(+1) 7	
CP 217-CP 21	2	2	2	2	2	2	2	2	2	
					3	3	3	3	3	(+1) 4
					2	2	2	2	2	2
					8	(+2) 10	(-2) 8	8	8	8
					16	(+2) 18	(-3) 15	15	15	15
					100	104	103	103	107	107

Additional time provided to accommodate track remediation work in the Bronx. Removed when project complete.

Time needed for crossing moves due to bridgeplates being needed at local stations to support track and catenary renewal projects requiring continuous track outages.



4

Civil Speed Protection (FRA EO 29)

Effective Date	10/27/02	10/01/06	10/18/09	04/07/13	07/01/13	11/17/13	05/11/14	11/09/14	04/03/16	10/02/16
Train #	1527	1527	1527	1527	1527	1527	1523	1523	1523	1523
N.H.-CP 271	3	3	3	3	3	3	3	3	3	3
CP 271-CP 266	5	5	5	5	(+2) 7	(-1) 6	(+1) 7	7	7	7
CP 266-CP 261	5	(+1) 6	(-1) 5	(+1) 6	6	6	6	6	(+1) 7	7
CP 261-CP 257	5	(+1) 6	6	(+1) 7	7	(-2) 5	(+2) 7	7	(+2) 9	(-2) 7
CP 257-CP 255	4	4	4	(+1) 5	5	(-1) 4	4	4	4	4
CP 255-CP 248	6	6	6	(+1) 7	7	7	7	7	7	7
CP 248-CP 244	4	4	4	4	4	4	(+1) 5	5	5	5
CP 244-CP 241	3	(+1) 4	(+2) 6	(-3) 3	3	3	(+1) 4	4	4	4
CP 241-CP 234	10	10	(-1) 9	(-1) 8	8	(+2) 10	(-1) 9	9	9	9
CP 234-CP 229	8	(-1) 7	7	7	7	(+1) 8	8	8	(+1) 9	9
CP 229-CP 223	6	6	6	6	6	6	(+1) 7	7	7	7
CP 223-CP 217	7	(-1) 6	6	6	6	6	(-1) 6	6	6	(+1) 7
CP 217-CP 215	1	(+1) 2	2	2	2	2	2	2	2	2
CP 215-CP 212	3	3	3	3	3	3	3	3	3	(+1) 4
CP 212-CP 112	2	2	2	2	2	2	2	2	2	2
CP 112-MO	8	8	8	8	8	8	8	8	8	8
MO-G.C.T.	16	16	16	16	16	16	16	16	16	16
Total Trip Time	96	98	98	98	98	98	98	98	98	98

Cab signal dropdowns provided for MAS reductions of more than 20 mph. Running time added to reflect new infrastructural constraint.



Photo: Paul Pesante/Metro-North



4

Service Reliability

Effective Date	10/27/02	10/01/06	10/18/09	04/07/13	07/01/13	11/17/13	05/11/14	11/09/14	04/03/16	10/02/16
Train #	1527	1527	1527	1527	1527	1527	1523	1523	1523	1523
N.H.-CP 271	3	3	3	3	3	3	3	3	3	3
CP 271-CP 266	5	5					(+1) 7	7	7	7
CP 266-CP 261	5	(+1) 6					6	6	(+1) 7	7
CP 261-CP 257	5	(+1) 6					(+2) 7	7	(+2) 9	(-2) 7
CP 257-CP 255	4	4					4	4	4	4
CP 255-CP 248	6	6					7	7	7	7
CP 248-CP 244	4	4	4	4	4	4	(+1) 5	5	5	5
CP 244-CP 241	3	(+1) 4	(+2) 6	(-3) 3	3	3	(+1) 4	4	4	4
CP 241-CP 234	10	10	(-1) 9	(-1) 8	8	(+2) 10	(-1) 9	9	9	9
CP 234-CP 229	8	(-1) 7	7	7	7	(+1) 8	8	8	(+1) 9	9
CP 229-CP 223	6	6	6	6	6	6	(+1) 7	7	7	7
CP 223-CP 217	7	(-1) 6	6	6	6	(+1) 7	(-1) 6	6	6	(+1) 7
	2						2	2	2	2
	3						3	3	3	(+1) 4
	2						2	2	2	2
	8	(+2) 10					(-2) 8	8	8	8
	16	(+2) 18					(-3) 15	15	15	15
	100	104					103	103	107	107

Running time studies showed that trains are short on time in this area due to increasing congestion from additional movements in Stamford.



Photo: Wayne Koch/Metro-North

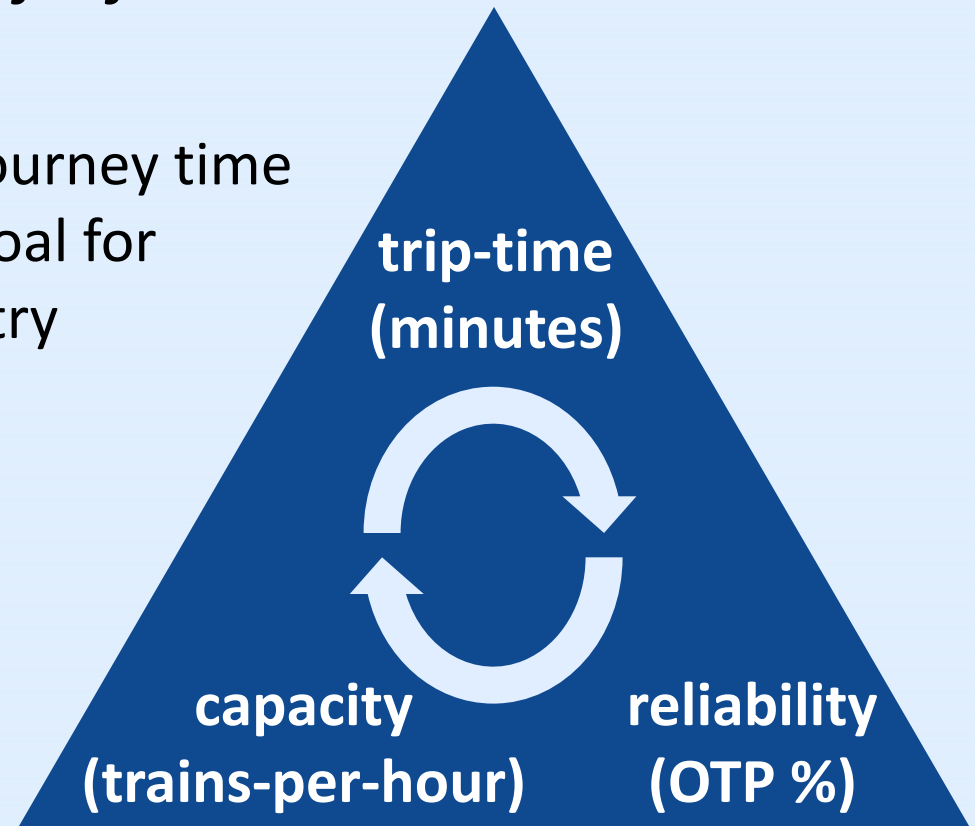
Parting Thoughts

- 1 Right-of-way, track, infrastructure, vehicle characteristics, and operating practices can all affect scheduled times.
- 2 To properly understand all speed constraints it is necessary to study timetable special instructions, general orders, bulletin orders, and potentially also specific train orders.
- 3 When constructing a timetable it is necessary to add engineering, routing, and performance allowance, and station dwell time to pure run time to arrive at a schedule.
- 4 It is impossible to infer what was happening on the railroad by reading a public timetable. ***Unless you were there, you don't know what happened.*** (Even if you were, it is still difficult to figure out exactly what was really going on.)

Corollary

- 5** *To maximize system performance, train operators must balance trip-time, capacity, and reliability subject to the overarching constraint of safe operations.*

Minimizing advertised journey time is not a higher priority goal for the passenger rail industry than maximizing trains-per-hour or on-time performance.



Thank You!



Notice: Opinions expressed or implied in this presentation are those of the authors and do not necessarily reflect the official policy or position of the Metropolitan Transportation Authority, or Metro-North Railroad.

4

Appendix:

What *Really* Happened to Running Times?

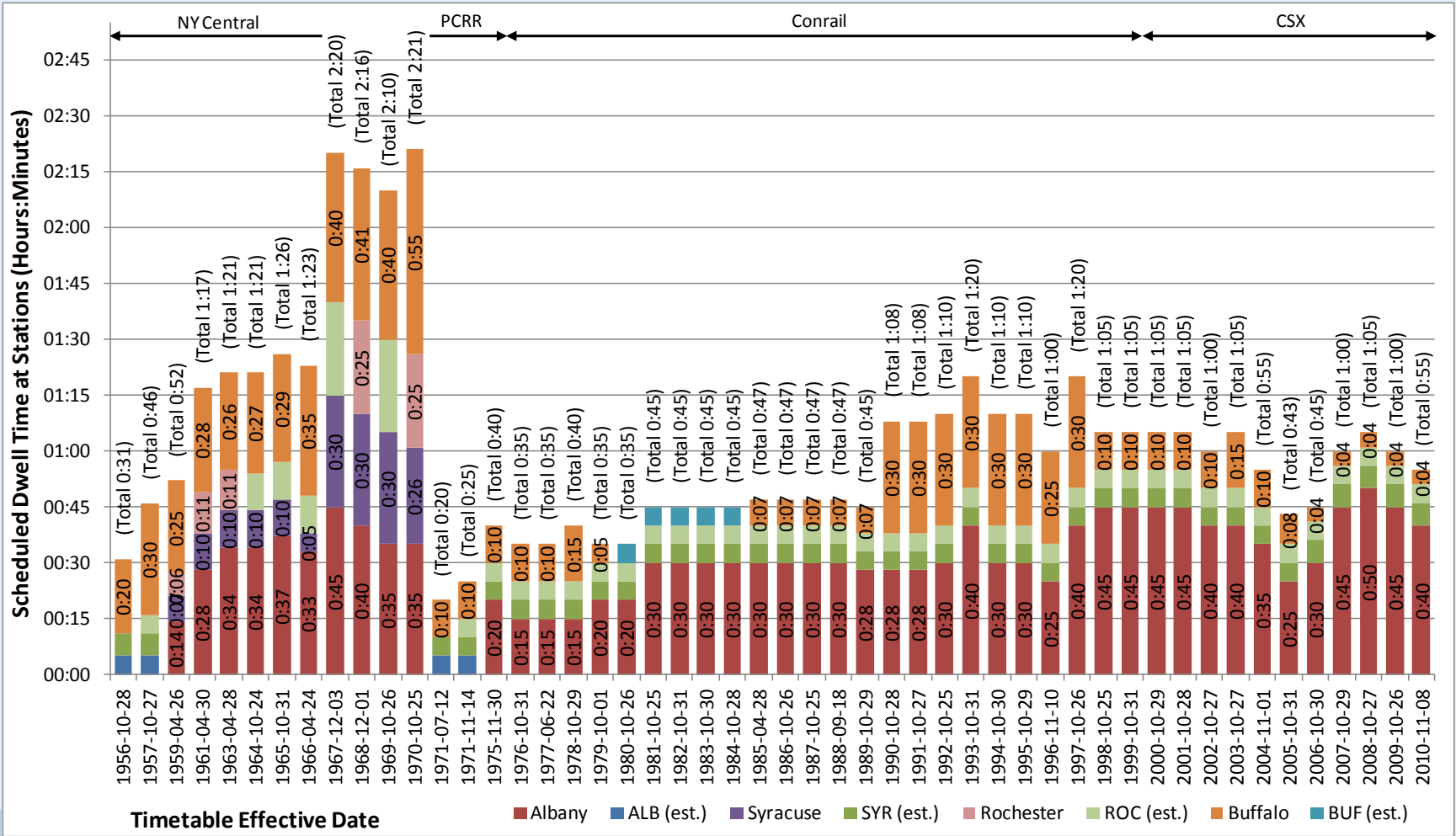
- **N.Y. Central Mohawk Division (1956-2010): Albany to Buffalo**
 - Station dwell times got long then got short again
 - Al Perlman's deliberate strategy? Mail contracts? Switching work in stations? Slotting issues? Station staffing? Infrastructure?
 - Running times fluctuated:
 - Maximum Authorized Speed (MAS) changes
 - Equipment issues
 - Industry events resulted in performance adjustments



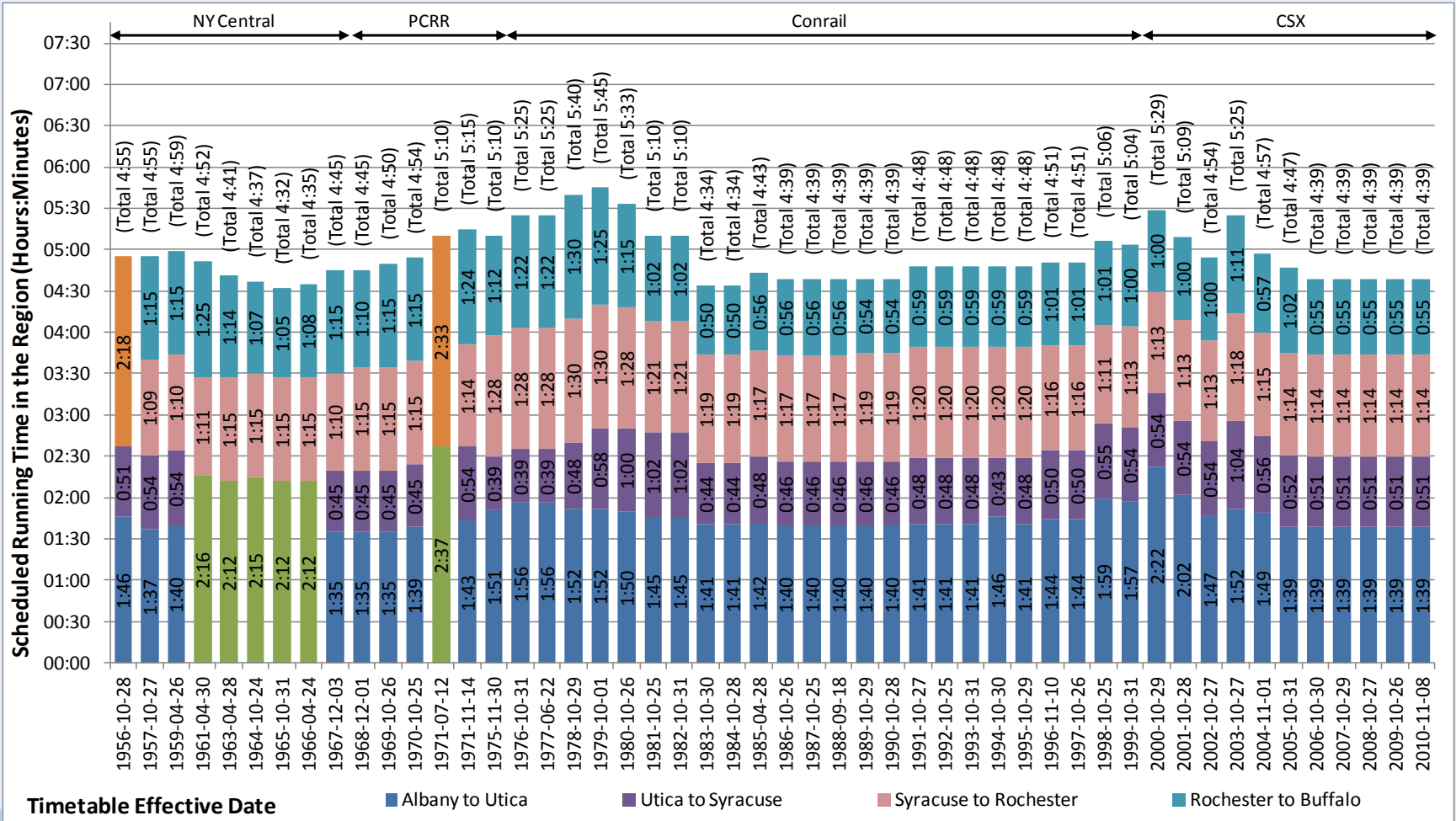
Photo: Roger Puta/Wikimedia Commons



Station Dwell Times

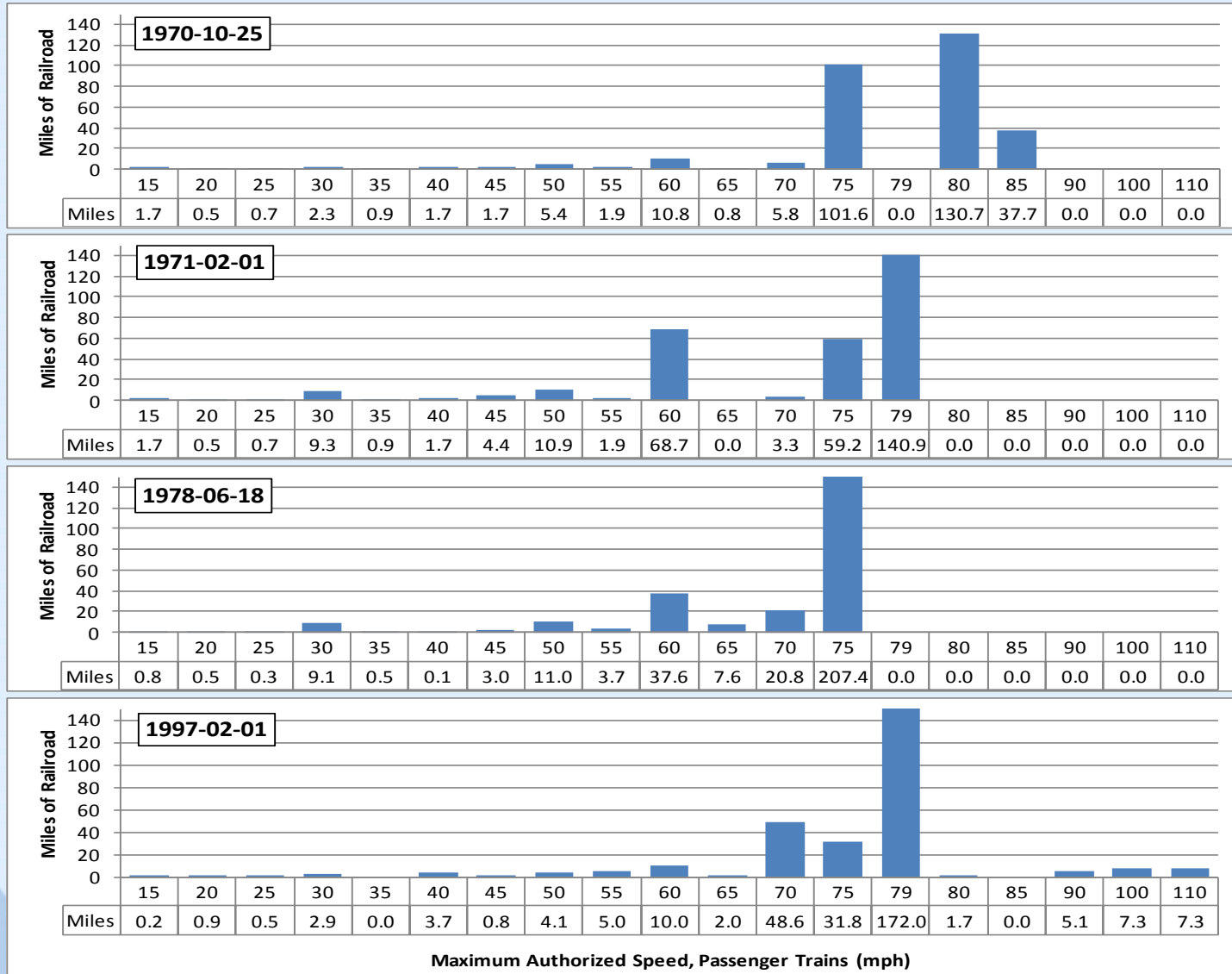


Running Times



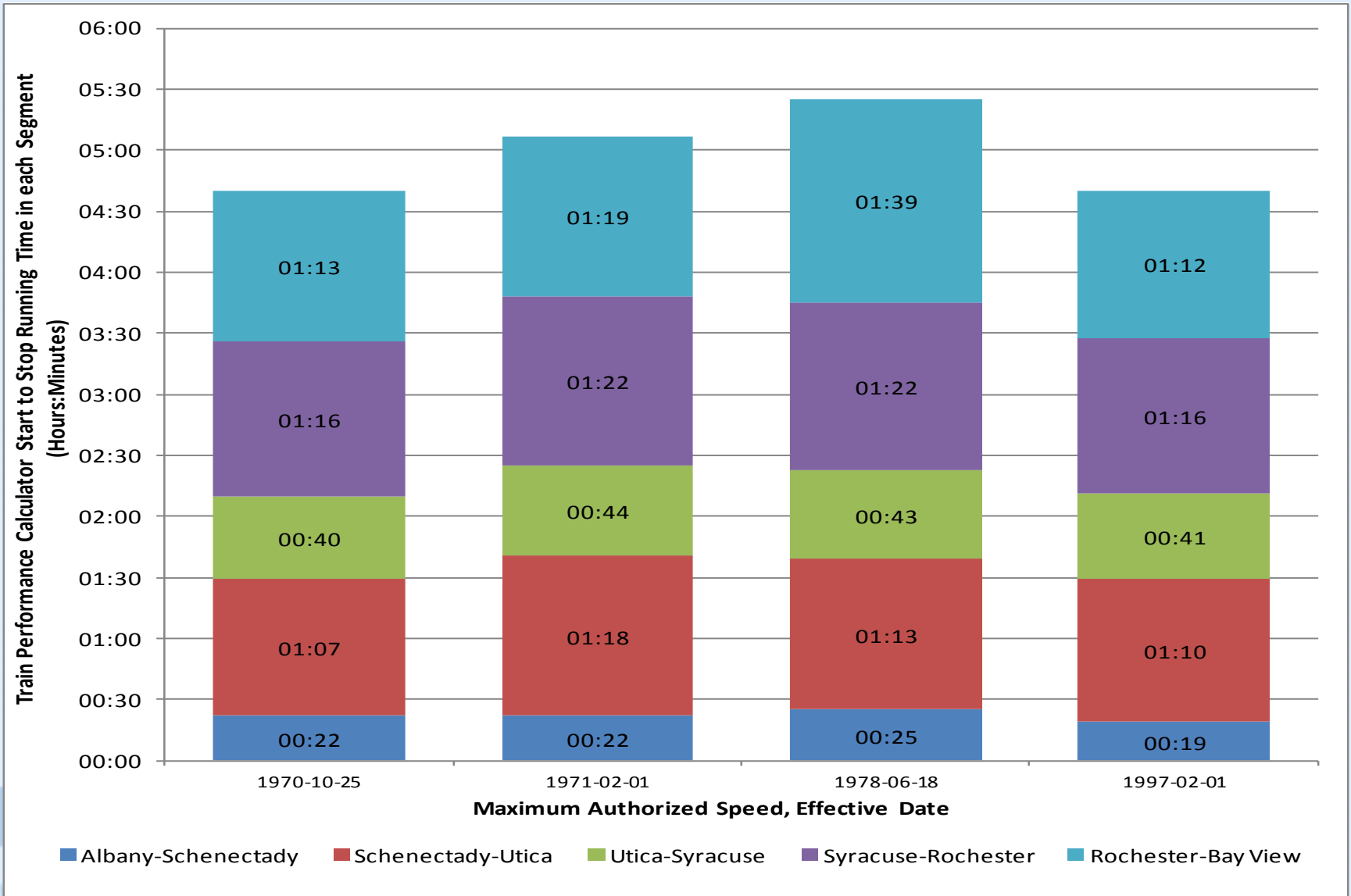
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Maximum Authorized Speeds (MAS)



4

Train Performance Calculator Results



4

G.O. Review: Other Happenings

“AMTRAK Engines, Class SDP-40F, in number series 540 to 649, are restricted as follows--trains with one SDP-40F Unit alone [...] **must not exceed 40 MPH** on curves of 1 degree 30 minutes or greater.”

Penn Central Rule 1157-G1b from Timetable No.4 (1970-10-25)

“Applies in Buffalo Division: Passenger Trains—**79 mph over the entire Division.**”

Penn Central G.O. 407 (aa)—Effective 1971-1-1

“Intermittent inductive Automatic Train Stop [ATS] System on the entire region, **out of service.**”

Penn Central G.O. 409 (a)—Effective 1971-02-01



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