

Real-Time Data for Operational Monitoring and Control

Alla Reddy

Senior Director

*System Data & Research
Operations Planning*



New York City Transit

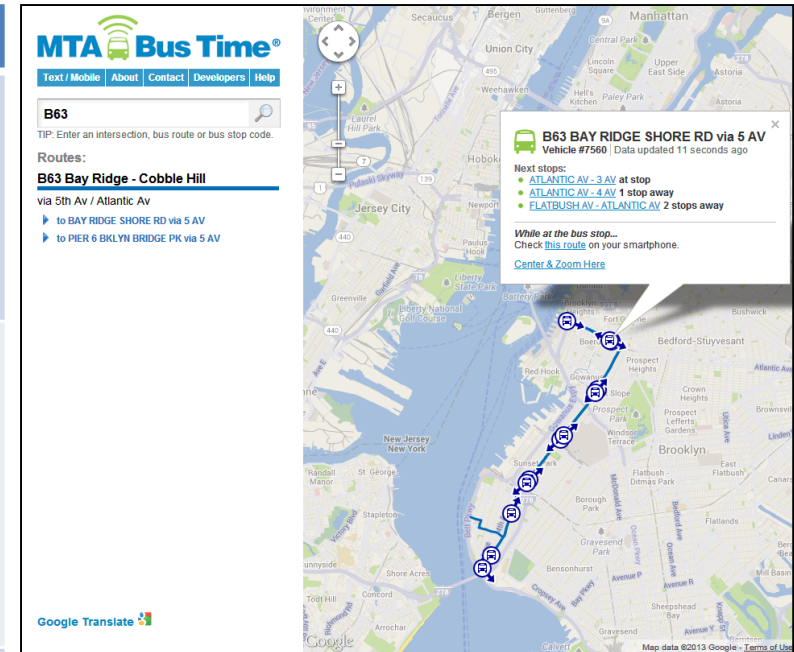
**APTA ITS TRANSIT BEST PRACTICES WORKSHOP
2014**

Today's Presentation

- Overview: Big Data at New York City Transit
- Buses
 - Real time service monitoring with Bus Time
 - Daily reviews for better service: hot spots, data visualization
 - Longer-term studies: better service planning and community response
- Subways
 - Real time data with GTFS-RT: service monitoring with stringline charts and the gap table
 - Next day reports and service evaluation: headway regularity, dwell time, OTP
 - Long term: running time analysis and scheduling improvements
- Summary

Big Data at New York City Transit

	Bus	Subway
System Statistics	2.6M weekday riders 300 routes 6,000 buses 6M daily Bus Time data records	5.5M weekday riders 22 lines 6,325 subway cars 468 stations 100,000 daily ATS-A records
Data Sources	- MTA Bus Time: Real-time Automatic Vehicle Location (AVL) for all MTA buses - System based on open source OneBusAway project	- Countdown Clocks (1-6, Grand Central Shuttle, L) - Integrated Train Register Activity Console (I-TRAC) and Programmable Logic Controller (PLC) data (sections of 7 and lettered lines)
Customer Applications	Live bus tracking: http://bustime.mta.info	Public Announcement/ Customer Information System (PA/CIS)
Internal Performance Monitoring	- Performance Indicators - Planning and scheduling - Bus Ridership Model: Bus Time linked to MetroCard swipe data	- Performance Indicators - Planning and scheduling - Subway Network Model (under development): Countdown clock data linked to MetroCard swipe data

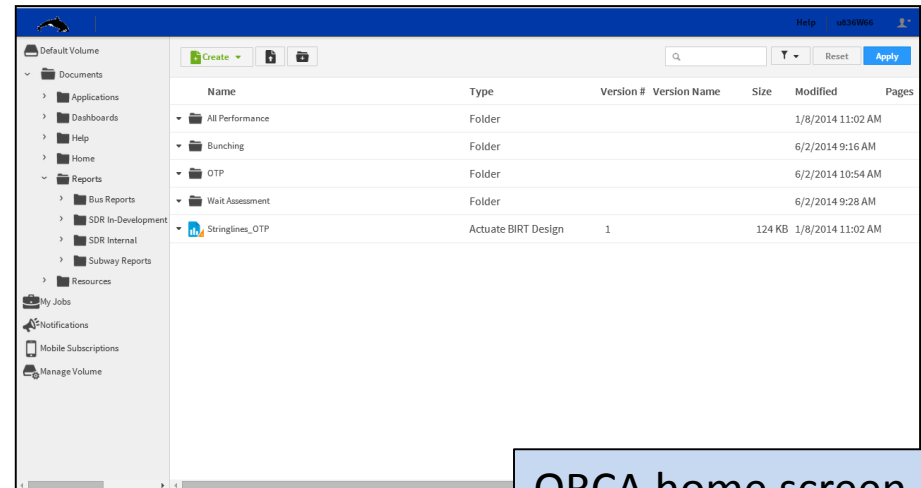


Buses

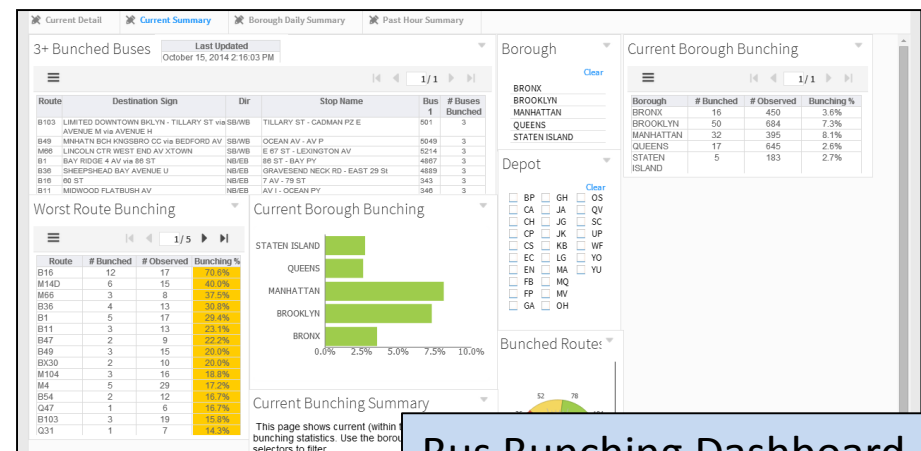


Real Time Service Monitoring with BusTime

- Rollout for NYC done in early 2014
- Provides GPS data every 30 sec
- Bus CIS data used starting in 2012 for performance reporting
- BusTrek: Department of Buses project for mapping bus location and status (in development)
 - OP has partnered with DOB to develop related service management tools
- Operations Research Computational Analysis: Reporting and visualization platform
 - Bus Bunching Dashboard ([link](#))
 - Pinpoint problem routes and locations
 - Allows Road Operations to investigate and take quick action



ORCA home screen



Bus Bunching Dashboard



Next Day Data Integration

- MTA Bus Time data now allows for **next day** reporting of performance for service monitoring on any route
- For higher accuracy (up to 25% improvement in data accuracy), BusTime data is integrated with other data sources:
 - Schedules
 - Timekeeping (UTS) data
 - Roadcalls
 - EBS (Dispatcher Swaps)
 - Integrated Vehicle Network (IVN)

Data Element	Improvement
Override incorrect login information by operators on buses, which sometimes misidentifies the specific trip the bus is assigned to	10-15%
Override incorrect inferences by the Bus Time system that may momentarily incorrectly identify buses by route and trip	
Schedule matching algorithm accounts for when buses do not step exactly at stop locations due to problems at stop locations or rerouted patterns	
Identify trips that did not occur (bus did not leave the depot due to unscheduled problems)	2-3%
Buses that have broken down in the middle of trip and did not complete their trip are identified	
Buses that display “Not In Service” or “Next Bus Please” on their destination headsign at some point during their trip are separated from the raw data	5%
Identification of buses not equipped with the AVL hardware or buses with non-functional hardware	
Incorporate changes made by field dispatcher that modify planned service patterns	1-2%
TOTAL	~25%

Before automatic data:

- Manually collected data sample from traffic checkers (42 of the 224 NYCT routes only)
- Performance indicators were reported semi-annually to the NYC Transit Committee



Daily Service Reviews

- “Hot Spot” analysis: Allows Road Ops to concentrate on problematic locations, like areas with street repairs
- Visualization: Easily see Performance Indicators by location ([link](#))
- Working with Operations to include extra bus service and deadhead trips

M15 Local NB Wait Assessment

M15 Local SB Wait Assessment



New York City Transit

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Perf. Overview - ALL BOROUGHES

Weekday Only

Single Day - 6/14/2013

Preliminary

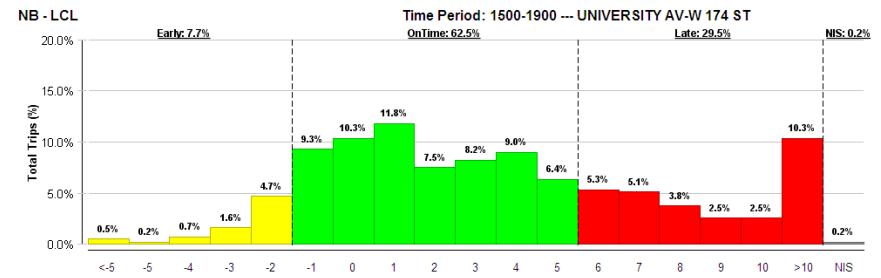
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Created on: Jun 10, 2013 11:21 AM

Route	On-Time Performance				Obs (est) NIS	Headway Analysis			Bunching % Miss [30 sec]	% No HW Installed	Data Availability			Sch
	% O [-1]	% L [1 to +5]	% NIS	% WA [+3 to +5]		Bunched	Spaced	% Bunch [30 sec]			% Miss NoObs	% Total NoObs		
BRONX	7.7%	68.7%	22.6%	1.1%	41810	80.9%	8.4%	8.9%	38848	5.8%	0.5%	8.8%	9.2%	46053
BK1	7.5%	77.2%	15.3%	0.0%	372	85.2%	3.2%	5.1%	311	1.6%	0.0%	5.1%	5.1%	362
BK1-LTD	5.7%	67.0%	25.4%	1.3%	1195	78.4%	10.9%	11.5%	1002	7.3%	1.1%	13.3%	14.4%	1490
BK2	6.0%	61.2%	31.7%	1.0%	1178	73.1%	15.4%	16.0%	1042	9.9%	2.0%	17.6%	20.4%	1485
BK3	8.5%	72.0%	16.0%	2.9%	1148	81.8%	9.3%	9.9%	1100	8.1%	0.0%	3.3%	3.3%	1167
BK4	6.4%	66.7%	24.4%	2.6%	468	75.3%	2.6%	4.0%	348	0.7%	0.0%	22.6%	22.6%	605
BK4A	6.5%	40.3%	42.2%	1.9%	307	67.0%	6.0%	8.2%	279	1.7%	0.0%	25.7%	26.7%	501
BK5	7.2%	64.5%	24.4%	3.9%	944	75.7%	12.0%	12.2%	804	7.0%	0.0%	15.3%	15.3%	1134
BK6	9.2%	75.0%	14.9%	0.1%	1903	87.0%	10.9%	9.7%	1882	10.0%	0.2%	0.0%	0.0%	1918
BK7	3.9%	63.7%	31.3%	1.1%	1217	73.4%	15.4%	18.0%	1055	11.2%	0.0%	17.9%	17.9%	1482
BK8	11.3%	72.7%	15.9%	0.2%	1185	62.0%	6.7%	4.1%	1141	2.9%	0.0%	3.3%	3.3%	1226
BK9	10.7%	76.8%	12.1%	0.4%	1643	86.4%	9.1%	7.1%	1595	7.8%	0.0%	4.4%	4.4%	1718
BK10	11.7%	72.4%	15.1%	0.8%	1061	84.4%	7.3%	6.1%	979	3.8%	0.0%	6.7%	6.7%	1137
BK11	5.9%	68.7%	25.0%	0.6%	1024	62.6%	8.3%	8.3%	998	8.1%	0.0%	1.5%	1.5%	1049
BK12	10.1%	72.3%	14.4%	3.2%	1170	65.0%	6.5%	6.3%	1049	3.4%	0.0%	10.5%	10.5%	1307
BK13	17.8%	72.9%	9.0%	0.3%	1000	88.5%	7.0%	5.6%	913	4.3%	0.0%	10.7%	10.7%	1120
BK15	7.0%	49.0%	40.7%	2.8%	1729	70.0%	13.4%	19.0%	1475	9.9%	0.0%	22.8%	22.8%	2240
BK16	10.0%	74.8%	14.0%	0.0%	941	83.2%	1.2%	1.7%	803	0.5%	0.0%	3.2%	3.2%	972
BK17	4.0%	50.2%	43.3%	1.9%	1023	71.1%	15.1%	17.1%	973	10.0%	1.4%	8.9%	10.3%	1140
BK18	11.5%	51.7%	34.2%	2.3%	87	72.6%	3.0%	7.1%	84	3.5%	0.0%	3.3%	3.3%	90
BK19	5.4%	69.5%	23.9%	1.2%	2077	78.4%	11.2%	11.2%	1976	7.0%	0.0%	5.0%	5.0%	2186
BK20	0.0%	56.3%	43.7%	0.0%	71	80.3%	13.8%	6.9%	58	8.0%	0.0%	15.5%	15.5%	84
BK21	4.0%	75.0%	19.7%	0.7%	1459	79.2%	7.0%	9.1%	1324	4.9%	1.0%	10.9%	12.7%	1614
BK22	8.4%	67.3%	23.0%	1.3%	1779	81.1%	9.0%	7.5%	1777	6.0%	0.0%	3.6%	3.6%	1846
BK23	7.9%	72.0%	19.5%	0.0%	303	77.9%	7.5%	6.4%	281	0.0%	0.0%	1.9%	1.9%	309
BK24	4.5%	78.8%	16.7%	0.0%	66	80.2%	0.0%	1.6%	61	0.0%	0.0%	2.9%	2.9%	68
BK25	3.5%	67.6%	29.1%	2.6%	1029	62.2%	6.1%	10.4%	964	4.5%	0.0%	6.9%	6.9%	1104
BK27	8.1%	81.1%	10.7%	0.1%	819	87.9%	6.0%	4.0%	784	3.5%	0.0%	4.3%	4.3%	856
BK28	7.2%	77.4%	14.8%	0.6%	824	87.0%	2.0%	2.4%	788	0.7%	0.0%	3.3%	3.3%	852
BK29	2.1%	70.4%	27.5%	0.0%	169	78.7%	3.0%	3.6%	169	0.5%	0.0%	12.5%	12.5%	216
BK30	6.3%	68.7%	24.3%	0.7%	1070	80.8%	6.0%	6.2%	1021	4.2%	0.0%	3.6%	3.6%	1110

Report excludes school trips, express bus drop off locations, and shows enroute timestamps only. See OTP, WA, or Bunching reports for further details.

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Improved Service Planning and Community Response

- Continuous improvement: plan to automatically identify worst routes as candidates for review
 - Ridership changes
 - Running time changes
- New ability to address community concerns
 - Now possible to address details: overall performance may look good, but certain time periods are not good
 - Can perform detailed studies requested by community boards and elected officials, as well as better internal reviews
 - Co-Op City study (2013)
 - Northeast Queens study (In progress)
 - East Side Bus Service analysis (Internal)
 - Reviews of new bus service
 - Ridership-based performance indicators

Before automatic data:

- Each bus route reviewed only once every 2 years (weekend service once every 4 years)
- Origin-destination surveys required in-person studies with large staffing requirements

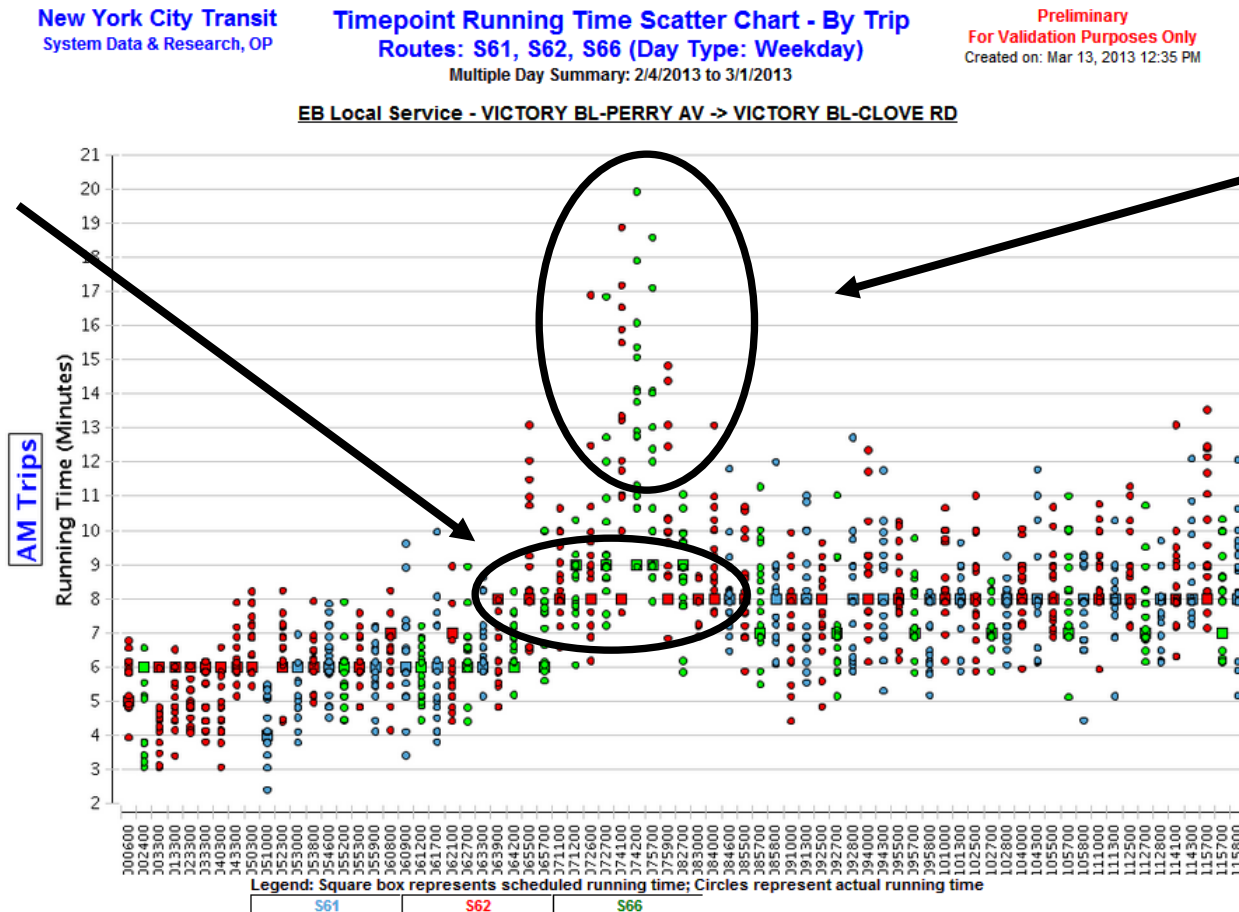


Tools for Service & Schedule Improvement: Corridor Analysis

- Schedules department can analyze segment run times
 - Multiple routes sharing same corridor

Different
schedule
times by
route over
the same
path

(corridor
analysis)

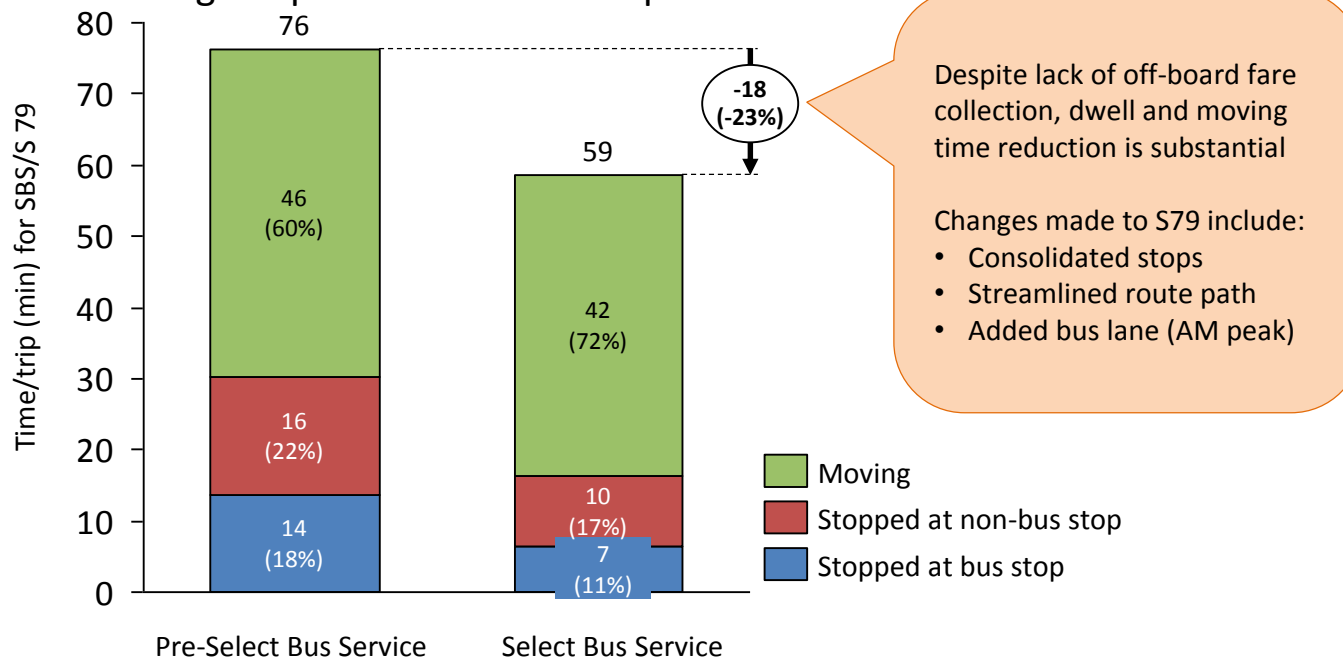


Widely
varying
running
times



Tools for Service & Schedule Improvement: IVN Data Analysis

- Integrated Vehicle Network data can be used to examine dwell and running times
 - Large sample sizes with IVN will allow us to produce finer-grained analysis
 - Detailed data on dwell locations enables detection of map errors
 - Service change improvements can be quantified

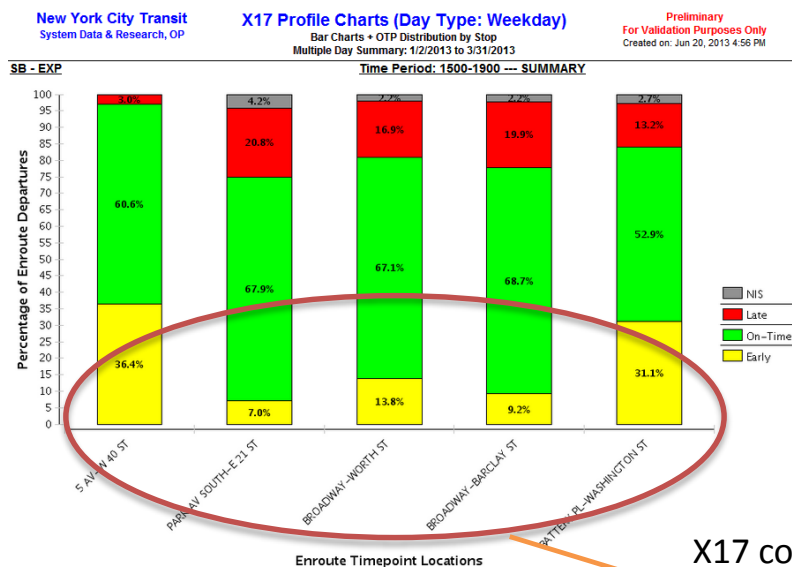
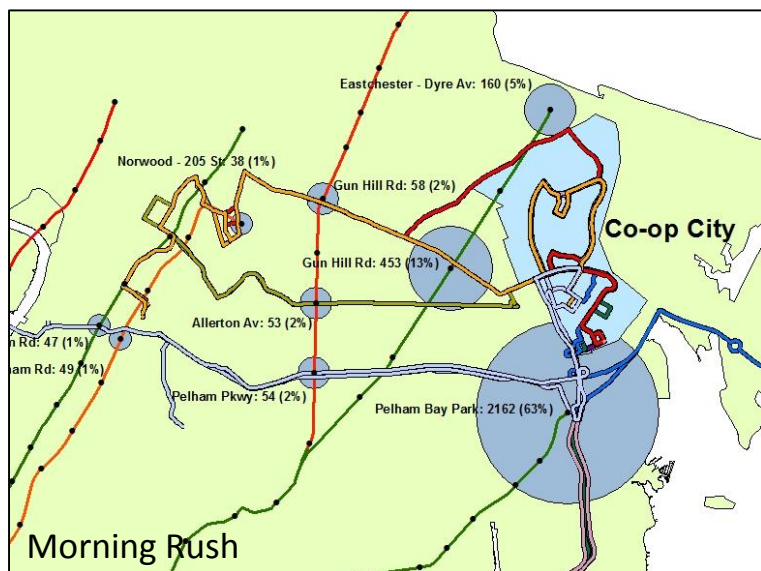


IVN data examined: 39 sample trips on Oct 28, Oct 30, Nov 01 2013, between 6:30AM & 7:30PM. Bus assumed to be at bus stop if doors open. Manual macro data: 30 weekday sample trips in Nov 2010 – Mar 2011, during same time interval



Service Planning Tools

- Profile Charts
- Bus to Subway Transfer Analysis and O-D Estimation
- Ridership Estimation
- IVN Dwell Time Analysis
- Before/after Comparisons



X17 consistently runs early in the PM Peak



Subways



Real Time Subway Data: GTFS-RT

- GTFS-RT: Real-time feed specification that allows public transit agencies to provide updates about their fleet to developers
 - Currently available on the 1-6, Grand Central Shuttle, and L line
 - Rest of system uses I-TRAC for manual train booking at key locations
- Stringlines ([link](#))
 - A stringline chart represents each train trip by a “string” plotted with time on the horizontal axis and distance on the vertical axis
 - NYCT OP developed a tool for analysis of subway train movements
- Gap Table ([link](#))
 - Identifies the largest gap in service by line, direction, and console dispatcher’s territory
 - Allows immediate action for improving Wait Assessment, NYCT’s headway regularity metric

Before automatic data:

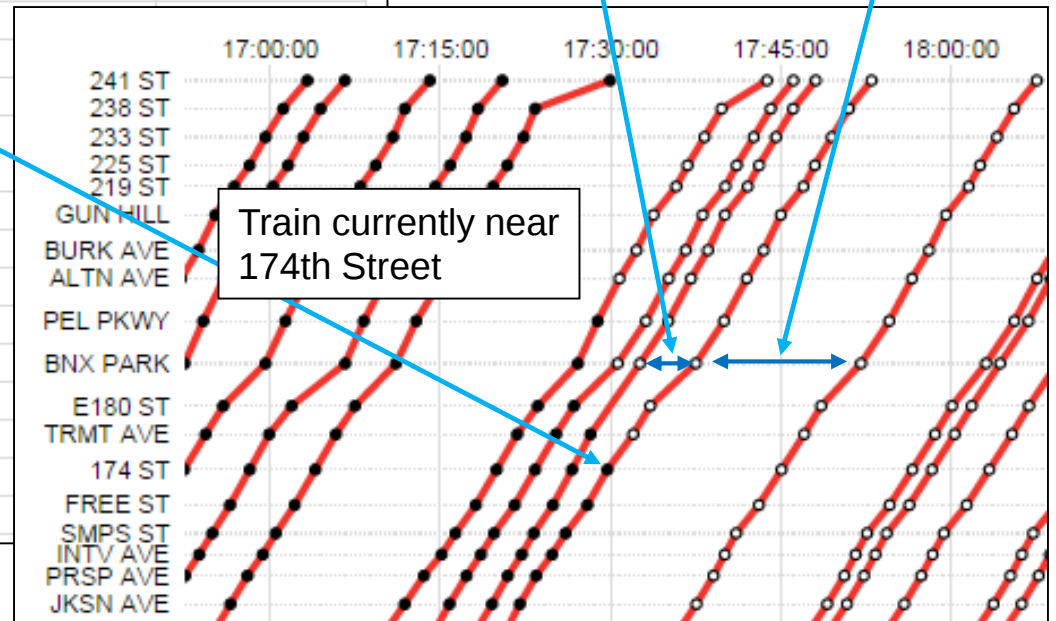
- Manually collected data sample from traffic checkers (Still needed on the B Division)
- No capability to do analysis on 100% of service



Gap Table Example

- Gap table computes all gaps in the system in real time and sorts them by largest gap after.

STATION	Train ID	Gap After	Gap Before	Territory
174 ST	02 1615 FLA/241	15	4	11
WEST SQ	06 1623 BBR/PEL	14	5	10
MORRPARK	05 1618 FLA/DYR	13	7	11
STGA AVE	03 1622 148/NLT	10	8	1
WLCK AVE	06 1718+ PEL/BBR	9	4	10
176 ST	04 1634 UTI/WDL	8	2	9
FKLN AVE	03 1714 NLT/148	8	2	
110 ST	02 1644 241/FLA	8	2	
181 ST	01 1642 SFY/242	7	6	
UTCA AVE	03 1720 NLT/148	7	8	
138 3RD	06 1706 PEL/BBR	7	0	
225 ST	01 1637 SFY/242	6	6	
161 ST	04 1711+ WDL/UTI	6	5	
176 ST	04 1719+ WDL/UTI	6	6	
72 ST	01 1703 SFY/242	6	4	
PEL PKWY	02 1718 241/FLA	6	2	
CLRK ST	02 1619 241/FLA	6	5	
NEVN ST	04 1625 BPK/UTI	6	1	
145 ST	03 1729 148/NLT	6	0	
145 ST	01 1715+ 238/SFY	6	3	



Subway Service Analysis

- Performance Indicators (Wait Assessment and On Time Performance)
- Dwell Time at key stations
- Terminal On Time Performance
- Service delays

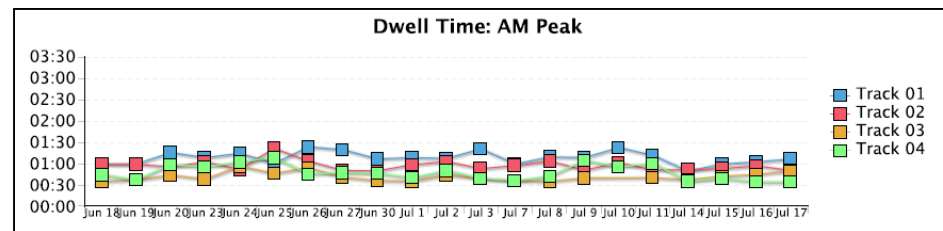
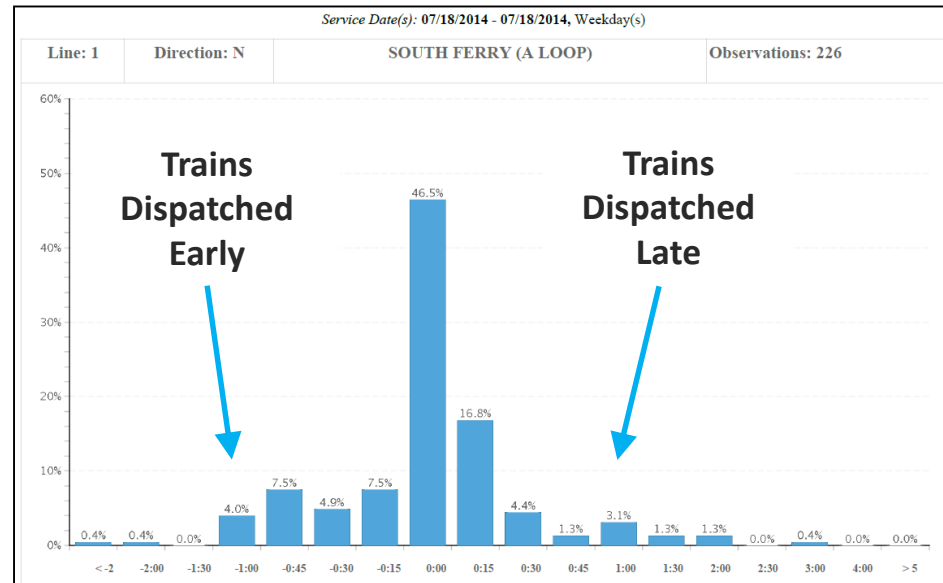
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A Division Performance Summary
Multiple Day Summary - 10/14/2014 to 10/15/2014
Weekdays (excluding Holidays) Only

Preliminary
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Created on: Oct 16, 2014 2:44 PM

Daily Overview (6:00-23:59)

	Departure OTP				Terminal OTP				Wait Assessment			
	% Early	% On Time	% Late	% ABD	% On Time	% Late	% ABD	Delays	% Pass (<+25%)	% Minor Fail (+25%+50%)	% Medium Fail (+50%+100%)	% Major Fail (>+100%)
1 Line	20%	49%	20%	11%	78%	11%	11%	182	90%	4%	3%	3%
Northbound	17%	56%	11%	15%	67%	19%	14%	135	94%	2%	2%	1%
Southbound	22%	41%	28%	8%	89%	4%	8%	47	86%	6%	3%	4%
2 Line	45%	19%	25%	11%	45%	44%	11%	295	86%	6%	3%	5%
Northbound	46%	18%	27%	9%	45%	45%	9%	145	82%	7%	3%	7%
Southbound	45%	20%	22%	13%	44%	42%	13%	150	90%	5%	2%	3%
3 Line	23%	43%	26%	8%	60%	32%	8%	213	88%	4%	3%	4%
Northbound	21%	45%	28%	6%	67%	27%	6%	87	87%	5%	3%	6%
Southbound	25%	41%	24%	11%	53%	37%	10%	126	90%	4%	4%	3%
4 Line	27%	41%	20%	11%	45%	44%	11%	359	86%	6%	3%	5%
Northbound	27%	45%	15%	13%	51%	37%	13%	161	84%	6%	4%	6%
Southbound	28%	36%	27%	10%	39%	52%	8%	198	89%	5%	3%	3%
5 Line	43%	11%	27%	18%	29%	53%	18%	410	75%	8%	8%	9%
Northbound	40%	10%	32%	18%	35%	47%	18%	186	76%	8%	8%	9%
Southbound	47%	13%	23%	18%	24%	59%	17%	224	74%	9%	8%	10%
6L Line	22%	28%	29%	22%	45%	34%	21%	445	74%	8%	7%	11%
Northbound	23%	26%	27%	25%	45%	30%	25%	217	71%	8%	8%	13%
Southbound	20%	31%	31%	18%	46%	37%	17%	228	78%	7%	6%	9%
6X Line	19%	34%	30%	16%	39%	45%	16%	123	85%	4%	6%	6%
Northbound	28%	28%	28%	17%	51%	32%	17%	55	83%	4%	8%	5%
Southbound	9%	43%	34%	15%	24%	61%	14%	68	88%	3%	2%	7%
GC Shuttle	6%	68%	25%	2%	98%	0%	2%	23	94%	3%	0%	3%
Northbound	5%	72%	22%	2%	98%	0%	2%	10	95%	3%	0%	2%
Southbound	8%	64%	27%	2%	98%	0%	2%	13	92%	4%	1%	3%
A-Div. Total	23%	41%	25%	11%	61%	28%	11%	2050	88%	5%	4%	5%



For illustrative purposes only: may not reflect actual service



Schedule Review and Long-term Improvements

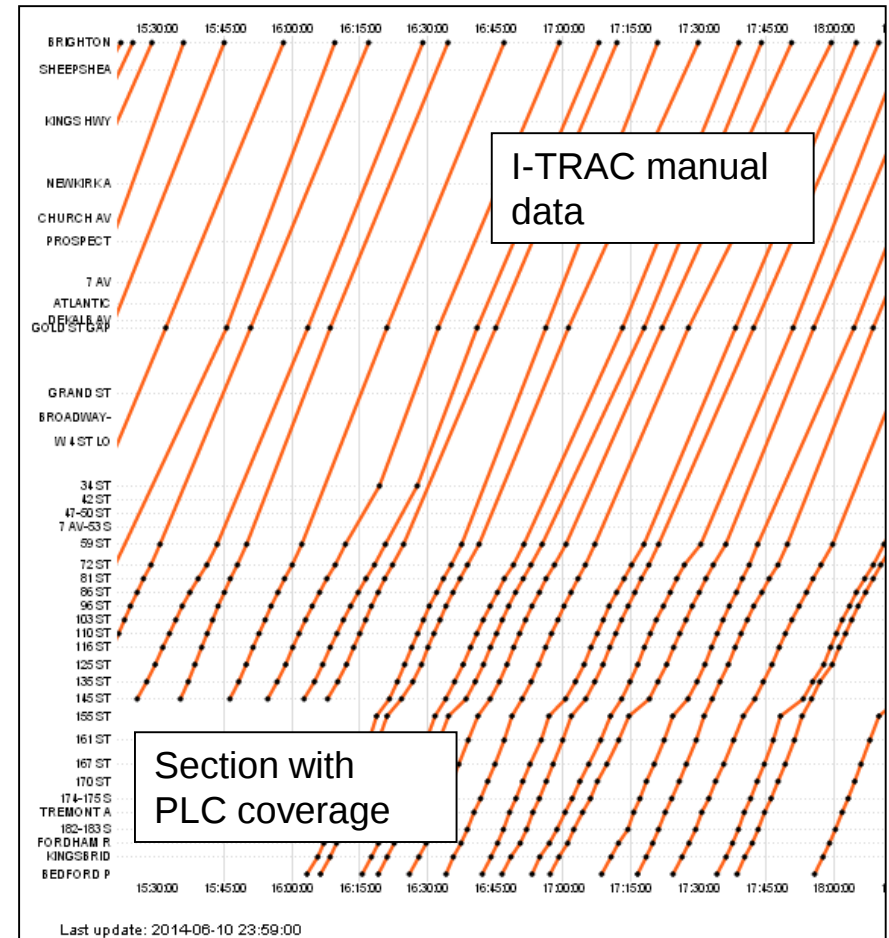
- Line studies using automatic data
 - 2/3/4/5 study (ATS-A)
 - A and B Division: additional running time (I-TRAC and PLC data)
 - A, C study (I-TRAC and PLC data)

New York City Transit
System Data & Research, OP

End to End Running Times
Multiple Day Summary - 10/12/2014 to 10/15/2014
Weekdays (excluding Holidays) Only

Preliminary
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1 Line Northbound							
SFY/137	Avg Sched Run Time	Avg Actual Run Time	Avg Actual - Sched	Std Dev (Actual)	Included Trains	Excluded (Act - Sch > 25)	Excluded (ABD)
00:00-00:29+	36.5	38.2	1.7		1	0	0
00:30-00:59+	36.5	39.0	2.5	0.6	2	0	0
01:00-01:29+	36.5	40.5	4.0	1.3	2	0	0
01:30-01:59+	36.5	42.2	5.7	1.0	2	0	0
02:00-02:29+	36.5	38.3	1.8		1	0	0
02:30-02:59+	36.5	36.9	0.4	1.1	2	0	0
03:00-03:29+	36.5	36.8	0.3		1	0	0
03:30-03:59+	36.5	33.1	-3.4	0.3	2	0	0
04:00-04:29+	36.5	37.5	1.0		1	0	0
07:30-07:59+	36.5	37.8	1.3	1.8	2	0	0
08:00-08:29+	37.0	40.1	3.1	2.9	3	0	2
08:30-08:59+	37.7	37.3	-0.3	1.3	3	0	0
09:30-09:59+	37.0	39.0	2.0		1	0	0
SFY/137 Total	36.7	38.3	1.6	2.6	23	0	2
SFY/215	Avg Sched Run Time	Avg Actual Run Time	Avg Actual - Sched	Std Dev (Actual)	Included Trains	Excluded (Act - Sch > 25)	Excluded (ABD)
08:30-08:59+	50.2	50.3	0.1	0.9	3	0	0
09:00-09:29+	49.5	49.6	0.1	1.2	4	0	0
09:30-09:59+	50.5	53.1	2.6		1	0	1
SFY/215 Total	49.9	50.3	0.4	1.5	8	0	1



For illustrative purposes only: may not reflect actual service



Summary:

Better Data – Better Service

- New York City Transit is generating and using large amounts of automatic data, for both buses and subways
 - Bus: BusTime; IVN; Timekeeping; Crews; Roadcalls; Schedules
 - Subway: Countdown clocks; PLCs; Timekeeping; Crews; Schedules
- Data is being used in a variety of contexts
 - Live operations management and service monitoring
 - Daily reviews
 - Schedule-making
 - Planning studies
- Key lesson learned: **Improve data quality by integrating multiple sources**
 - Not all data sources available in real-time; what is available is most useful for quick decision-making and short-term analysis (80-85% correct in representing actual service)
 - Special processes and algorithms are used to connect several data streams for a more complete picture; useful for long-term analysis, planning studies (95-98% correct)
 - Long-term goal: have all data available in real-time for a comprehensive picture of service