Using Automated Transit Data to Manage Operations and Improve System Performance

Presented by:

Jordan Holt, Washington Metropolitan Area Transit Authority

Laurel Paget-Seekins, Massachusetts Bay Transportation Authority & MassDOT

Alla Reddy, New York City Transit

Moderator:

Michael Shiffer, MTA Metro-North Railroad

May, 2017

Introduction

Transit agencies are collecting rapidly increasing amounts of data using a variety of technologies.

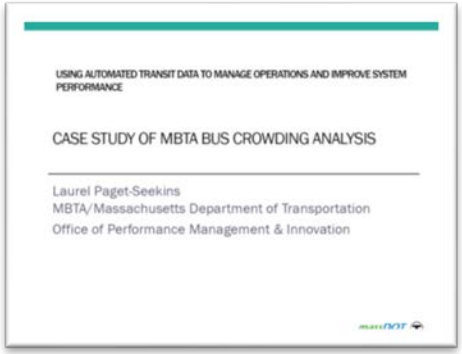
What are they doing to put this data to productive use?

This webinar highlights several case studies that demonstrate the benefits of:

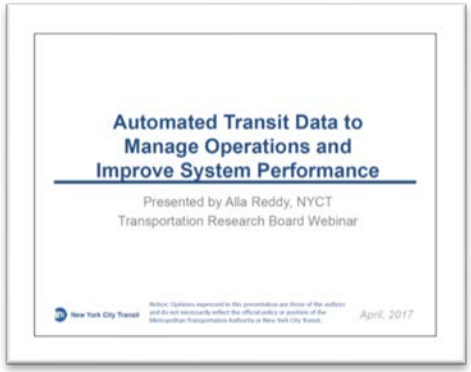
- Integrating high quality data management practices across departments;
- sharing important system information internally within the agency and externally for the riding public; and
- turning performance measures into realistic, usable operational practices and strategies for improving performance, particularly under abnormal scenarios or incidents.

Presenters

- Jordan Holt, Washington Metropolitan Area Transit Authority



- Laurel Paget-Seekins, Massachusetts Bay Transportation Authority & MassDOT



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METRORAIL AUTOMATED TRANSIT DATA

KPI: Rail Customer On-Time Performance (Pilot)

QUALITY SERVICE

Why did performance change?

- Rail customer on-time performance (OTP) was highest in March and April, at 78 and 80%, as mild weather translated into fewer railcar malfunctions and track-related delays. Midday, evening, and weekend track work was also suspended during parts of these months to meet the demands of Cherry Blossom tourists.
- In June, the aggressive, 24/7 SafeTrack emergency repair program began. SafeTrack touched about 16% of the system from June to December 2016, affecting customers on all lines and lowering monthly OTP by up to six percentage points as service was severely scaled back or parts of the system were shutdown for extended periods.
- While railcars accounted for the bulk of unplanned service disruptions (65% in 2016, either because railcars failed in service or were not available for service), total railcar-related delays and offloads were down by over 13% compared to 2015 thanks to the more reliable 7000-Series trains. After railcars, the most common sources of customer delays are: transit police responses, sick customers, or unattended bags (14%); and rail infrastructure defects (7%).
- To improve safety, Metro enhanced its track inspection procedures, leading to speed restrictions (5% of all 2016 delays) that slowed train travel times and caused more customers to be late.

Key actions to improve performance

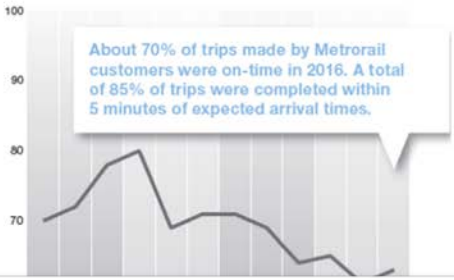
- Execute a "Get Well" plan for railcars to further reduce offloads and cut delays by 25%
- Complete SafeTrack and implement new, aggressive preventive maintenance efforts designed to cut infrastructure-related delays in half by the end of 2018
- Repair escalators, elevators and fare gates to enable smooth flow of passengers through station

ANNUAL PERFORMANCE

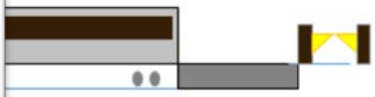
Rail Customer On-Time Performance

KPI Pilot

1-YEAR TREND IN PERFORMANCE



V PERFORMANCE



Travel to fare

Washington Metropolitan Area Transit Authority

Accessibility | Getting Around | Fares | Rider Tools | About Metro

Metrorail 3 month Travel Summary
9/15/15 – 12/15/15

Your On-time Score:	**89%**
Number of trips made:	117 (avg. 9 trips/week)
Total miles traveled on Metro:	523
Number of stations visited:	17

On-time performance by trip

Information is displayed for trips that you've made 5 or more times during the past 3 months

Where you travel	When you travel	On-time Score	# Trips	Fastest time	Average time	Slowest time	WMATA expected travel time range
Cleveland Park to Judiciary Square		**88%**	**50**	**12** *(11/27/15)*	**15**	**28** *(10/2/15)*	
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Presenters

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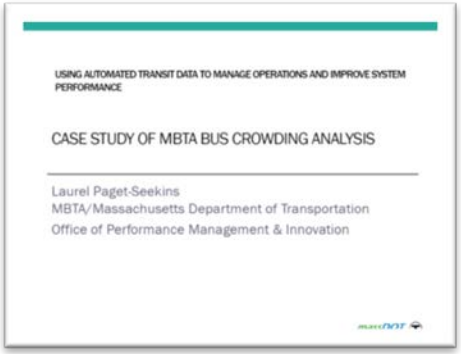

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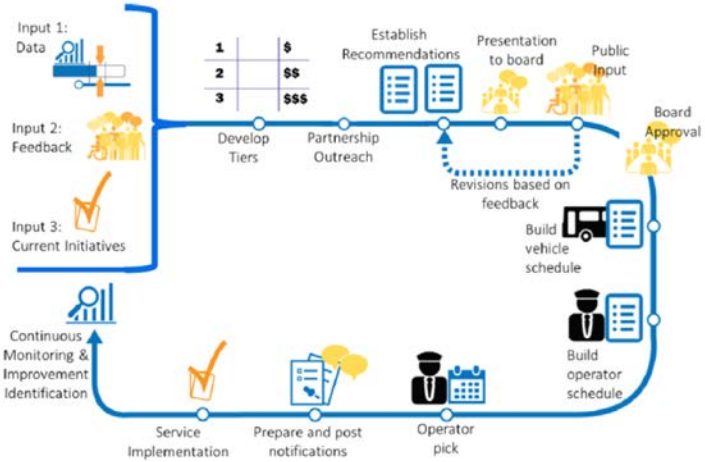
- Alla Reddy, New York City Transit

Implementation Steps

- New Service Planning process includes analyzing all of the tools together
- Focus on municipal partnerships
- Pilots projects
  - Bus lanes
  - All-door boarding
  - New dispatching tools



6 Implement

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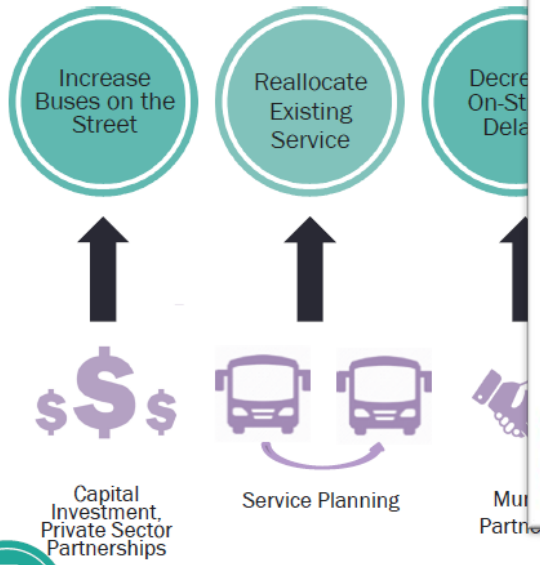
What tools can we use



5 Tools

11

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3 Baseline

Data reflects an average weekday in Fall 2015. Routes SL1, SL2, SLW, 71, and some Limited Service routes are excluded due to insufficient data

94%

of passenger hours spent on MBTA buses are comfortable (Fall 2015, average weekday)

9

acity

154% of seated capacity

Definition

Above 140% of seated capacity, all passengers are considered uncomfortable

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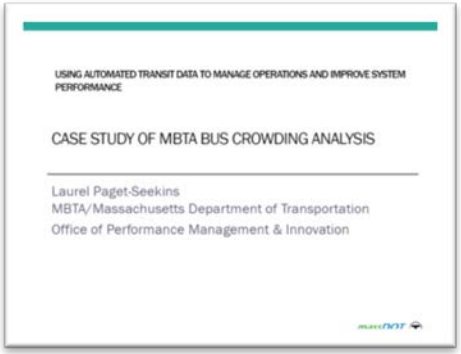

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Uncertainty about what the solution looks like

Phase III: Simple display of real-time recommended actions

DRAFT

Lines

1 2 3 4 5 6 All

Can filter by line

Territories

1 2 3 4 5 6 7 8 9 10 11 All

Can filter by job assignment

Last Updated:
Thu Sep 15 2016 17:13:26

Recommendations are color coded by priority, based on passenger time savings

Splitting recommendations by direction was an idea from dispatchers

Northbound

Line	Direction	Train ID	Next Stop	Hold Duration (Mins)	Stops to Skip	Gap Before (Mins)	Gap After (Mins)
6X	N	06 1702+ BBR/	26ST LEX	1		2.1	4.6

Southbound

Line	Direction	Train ID	Next Stop	Hold Duration (Mins)	Stops to Skip	Gap Before (Mins)	Gap After (Mins)
6	S	06 1658 PEL/BBR	WLCK AVE		E149 ST,143 ST	7.6	3.4
6	S	06 1654+ 177/BBR	125 ST	1.5		2.1	5.8
6	S	06 1700 177/BBR	BRK.AVE.	1.5		5.8	9.1
6	S	06 1630 PEL/BBR	68 ST	1.5		1.6	5.3

Estimated total passenger time savings: **2000 passenger-minutes** (or more). Th ... senger-minutes.

Recommended holds give durations while skips list stops

11

Why

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want to be

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4

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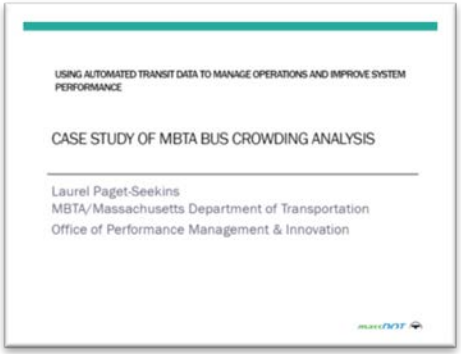

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Summary

The common elements of each of these presentations was that they typically combined several data and information sources to provide new insight into the overall performance of their transit services from a customer perspective.

- Jordan described WMATAs innovative approach of integrating train movement and farecard data to provide a more comprehensive picture of a person's total transit experience.

- Laurel described how bus performance measures such as crowding feeds into MBTA's multi-step service planning process.

- Alla described a process of innovative development and partnership to put appropriate tools into the hands of dispatchers who can positively affect millions of passenger movements a day with the right tools.

Conclusion

- The hope is that these cases will inspire other transit agencies to leverage their data streams to improve not only vehicle performance, but total customer experience.

- Of particular interest moving forward will be learning how various agencies have assembled the talent and facilitated the collaboration necessary to develop these tools systematize their use, and sustain them over time.

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May, 2017

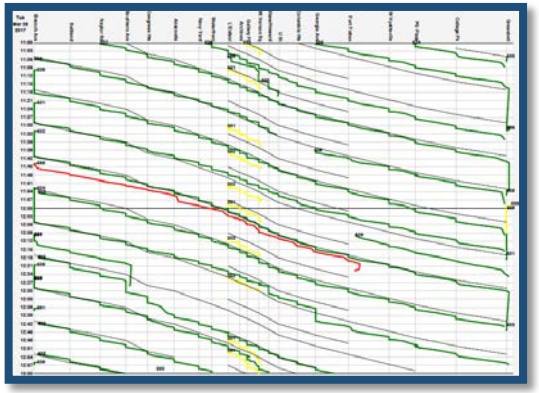
Washington Metropolitan Area Transit Authority

Using Automated Transit Data to Manage Operations and Improve System Performance

Jordan Holt
Senior Performance Analyst

METRORAIL AUTOMATED TRANSIT DATA

Train Movement Data



- Record movement of trains via track circuits
- Data collected for each train includes:
  - Time enters each station
  - Time opens doors
  - Time closes doors
  - Time leaves each station
- Over 21,000 trains stops per day

Farecard Data

- Fare charged depends on how far customers travel
- Customers must “tap in” to enter the system and “tap out” to exit
- Data collected includes:
  - Entry and exit location (station, entrance, and faregate)
  - Entry and exit date/time
- About 700,000 trips per day

MOVING FROM TRAIN TO CUSTOMER FOCUS

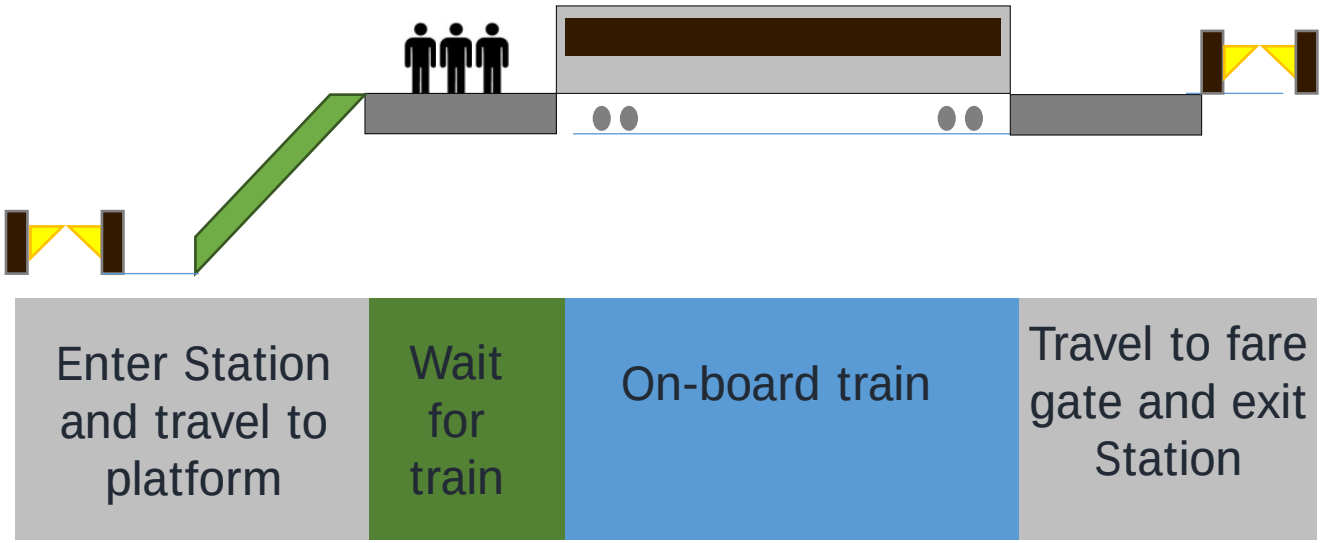
vs.

79%

Average On-Time Performance for month

6…

STEP 1: DEVELOP NEW PERFORMANCE MEASURE



1-3 minutes + 1 headway +scheduled run time+ 1-3 minutes

% Customer On-Time

- % Customers delayed by <5 min
- % Customers delayed by 5-10 min
- % Customers delayed by >10 min

“On-time” defined based on service standards

STEP 2: USE TO COMMUNICATE PERFORMANCE

KPI: Rail Customer On-Time Performance (Pilot)

QUALITY SERVICE

Why did performance change?

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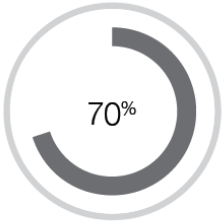
Rail Customer On-Time Performance



KPI Pilot

1-YEAR TREND IN PERFORMANCE

Chief Performance Officer 6

Washington Metropolitan Area Transit Authority

Bus | Accessibility | Getting Around | Fares | Rider Tools | About Metro

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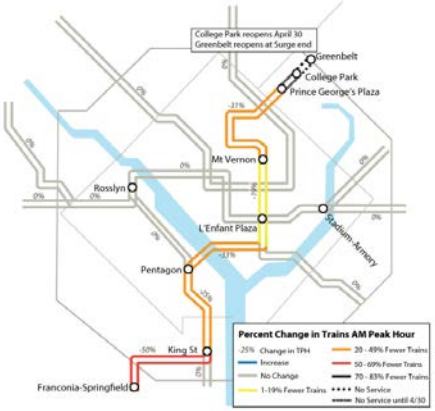
STEP 3: ANALYZE DRIVERS TO MANAGE OPERATIONS/ IMPROVE PERFORMANCE

How does track work during revenue hours impact customers?

- Planned track work lowers on-time performance (OTP) by 4-6% each month
- Single-tracking has 1.5 - 2x more impact on OTP than shutting down both tracks
- Action: adjust plans



How does interlining impact customer on-time performance?

- "Congestion" at merge point for 3 lines lowers OTP by 14% for customers traveling through that area
- Action: Adjust headways and run-times

POTENTIAL NEXT STEPS

Improve trip planning functionality

- Actual times vs. schedule

Integrate farecard, train movement, and service disruption databases

- Understand path choice, crowding
- Improve operational responses to service disruptions
- Understand which types of services disruptions (and where) have the biggest impact on customers

USING AUTOMATED TRANSIT DATA TO MANAGE OPERATIONS AND IMPROVE SYSTEM PERFORMANCE

CASE STUDY OF MBTA BUS CROWDING ANALYSIS

Laurel Paget-Seekins
MBTA/Massachusetts Department of Transportation
Office of Performance Management & Innovation

massDOT Massachusetts Department of Transportation

7 steps for service improvements

1. Define and prioritize **the problems and tradeoffs**
2. Set **measures** to evaluate key attributes
3. Do baseline **analysis** of how current service performs
4. Set **targets** (short-term and aspirational)
5. Determine **tactical tools** to use to improve service
6. **Implement** service and other changes
7. **Evaluate** progress toward achieving targets

Tactical toolbox for bus service improvements

Operational Changes

- All door boarding and faster fare collection
- Improved dispatching tools and procedures

Partnerships with municipalities

- Bus lanes
- Signal priority and queue jumps

Private sector partnerships

Capital Projects

- Fleet facilities
- Additional buses

Service Changes

- Route alignment and stop spacing
- Frequency and span changes

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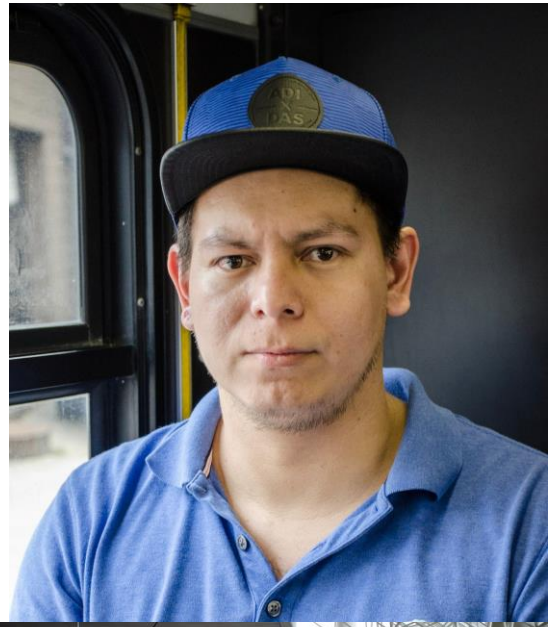
BUS CROWDING CASE STUDY

Customer Experience Interviews

Route 111

We interviewed riders on the 7, 111, 66 and 57 bus routes with high crowding, this is what they said…

"I normally take the 111 bus seven days a week and it is usually very full. Sometimes it is so full that **I have to wait for two or three buses to pass**, and will have to wait up to 10-20 minutes for another bus.
-Edwin , 111 Rider



"Yo uso este bus normalemente todos los dias, siete dias a la semana. Algunas veces si voy sentada en el bus, depende mucho de la hora y el horario. Durante la manana normalmente hay mucha gente, en un bus con capacidad de 40 personas, **esto se llena entre 60-90 personas**. -Rosa Maria, 111 Rider

1
Problem

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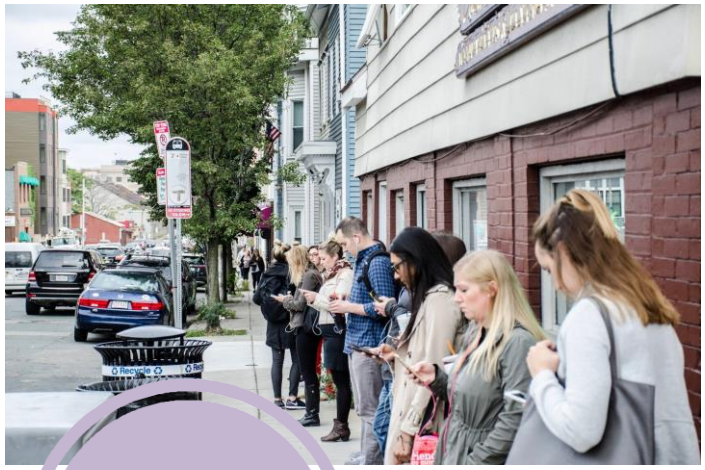
Customer Experience Interviews



Route 7

"I usually take this bus to get to work every week day. Usually it is very crowded. Usually the buses will be back to back, and sometimes there will be a bus loading people here and around the corner you would have another bus loading more people up, when they are not already full. So earlier, at like 8:45, usually the bus would be really crowded and there would be a line around the corner."

- Sean, 7 Rider

1 Problem

"I usually ride the 7 bus every day to go to work. **I am left behind every day** because the buses are too crowded. I often take other forms of transportation, Yesterday I took Uber, because I didn't feel like waiting for 3 buses until I could get on. - Kate, 7 Rider

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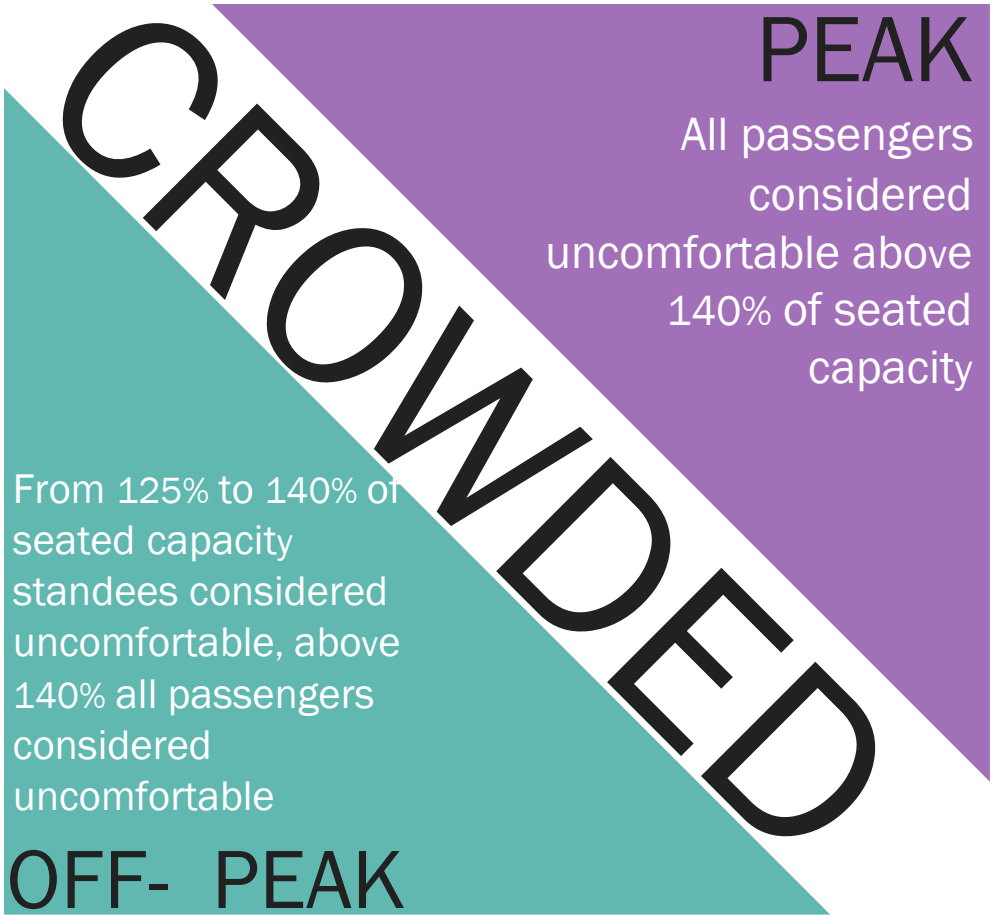
How do we define crowded?



MAGNITUDE

Measure amount of passenger time that is uncomfortable.

PROPORTION

Percent of passenger time that is comfortable

2
Definition

The target is for bus routes to have over 96% of passenger minutes in comfortable conditions.

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What does crowded look like?

150% of seated capacity

154% of seated capacity

Above 140% of seated capacity, all passengers are considered uncomfortable

2
Definition

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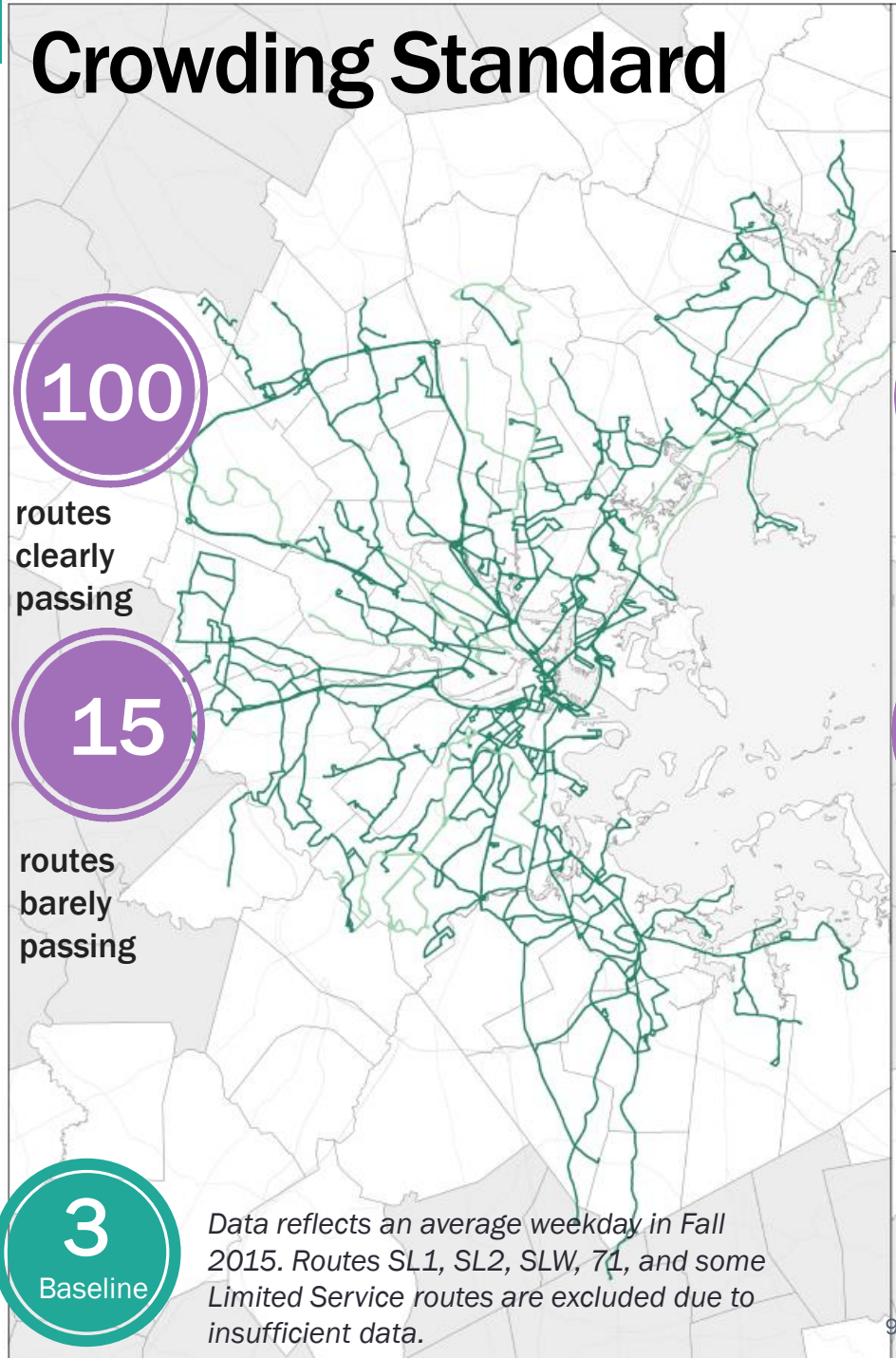
Crowding Standard



100

routes clearly passing

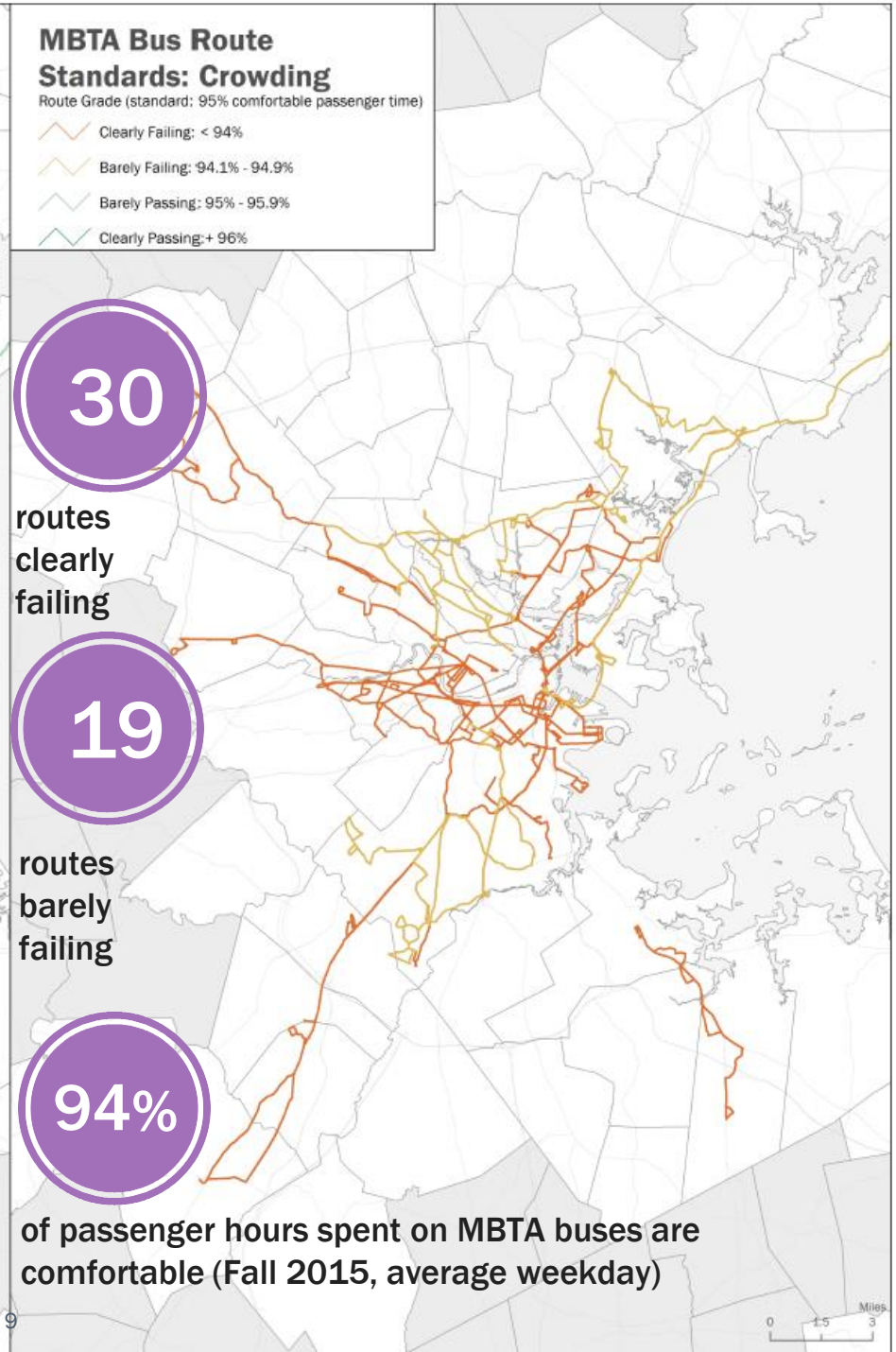
15

routes barely passing

3

Baseline

Data reflects an average weekday in Fall 2015. Routes SL1, SL2, SLW, 71, and some Limited Service routes are excluded due to insufficient data.



30

routes clearly failing

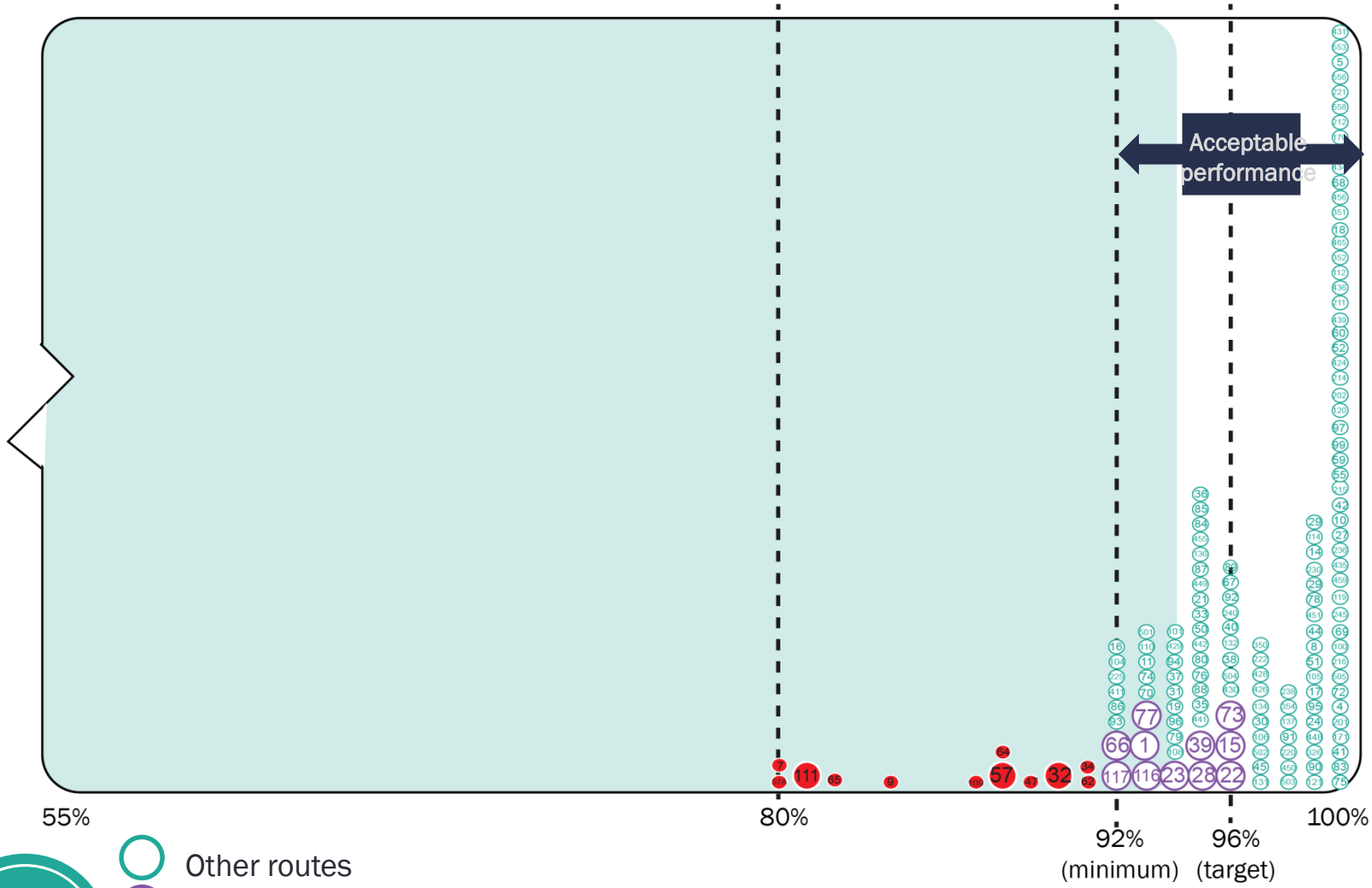
19

routes barely failing

94%

of passenger hours spent on MBTA buses are comfortable (Fall 2015, average weekday)

Current Performance by Route



Other routes

Key bus routes

Current average performance

4
Target

Note: this diagram represents most (not all) bus routes with average weekday crowding, 9/1/2015 – 12/14/2015.

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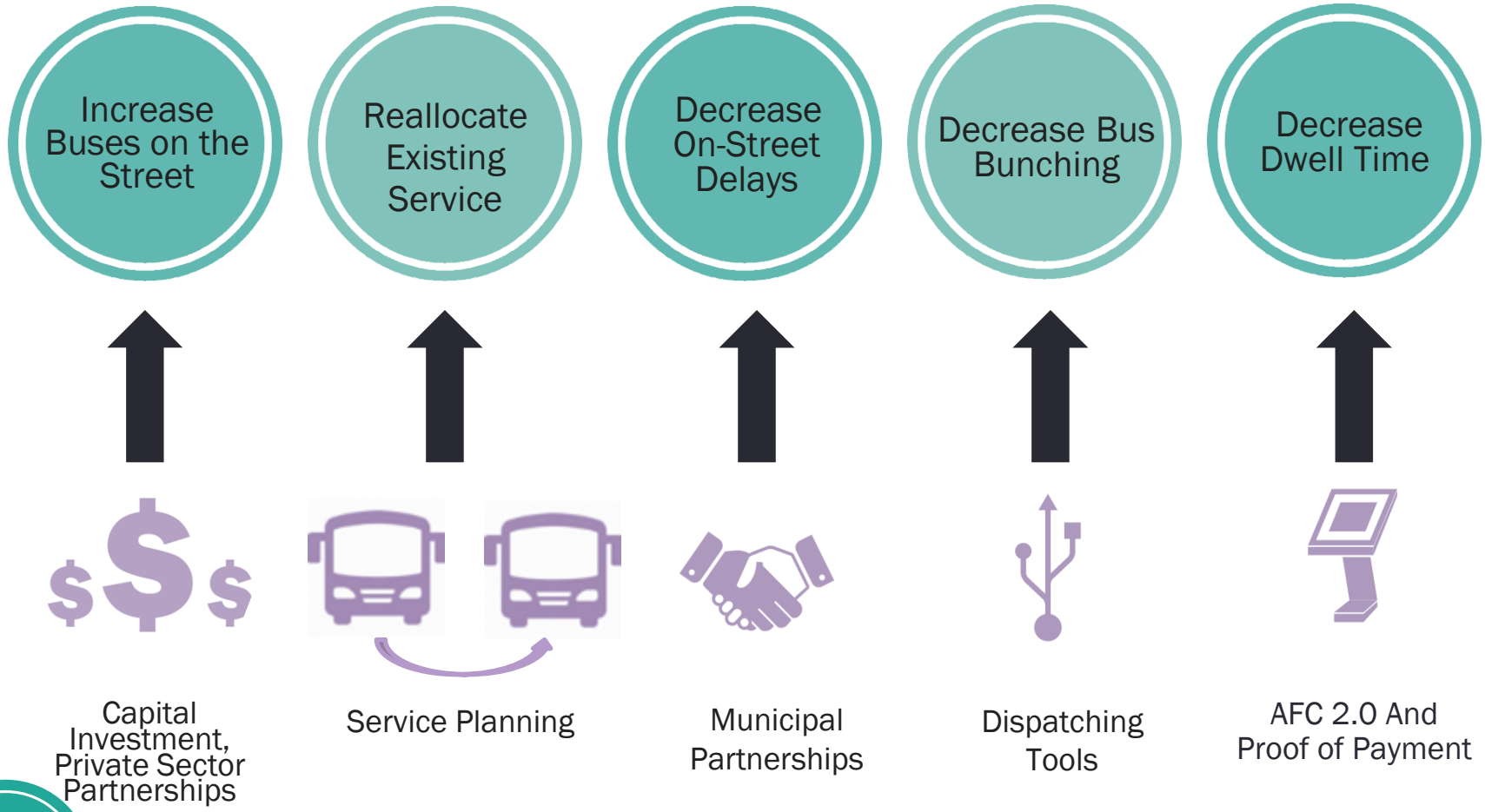
What tools can we use to address crowding?



5
Tools

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Multiple types of analysis needed to determine which tools to use

Temporal

When is crowding occurring by route

Spatial

Where is crowding occurring by route

Where is crowding occurring by street segment (for municipal partners)

Causes of crowding

By route by time of day

5
Tools

Research conducted in partnership with the MIT Transit Lab

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Route by Route Tool

1 Route # 1 UPT Route CF: 93% UPT: 185.8 h

Inbound Outbound Direction CF: 93% UPT: 87.6 h

Daily sum 1/2 h period Period CF: n/a% UPT: n/a h

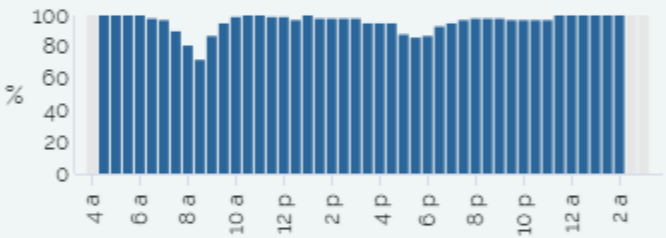
Segment CF: 82% UPT: 30.8 h

Beg. Stop 84 Massachusetts Ave (ID: 75)

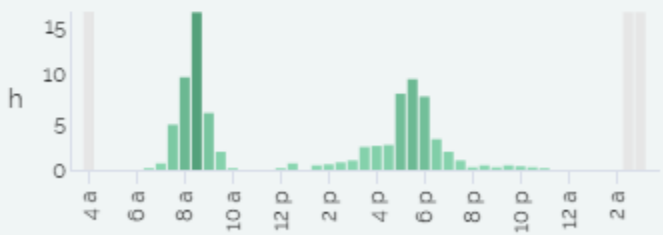
Showing values for ***inbound*** passengers.
All periods selected.

Uncomfortable passenger time by ***segment*** for inbound trips and ***all periods.*** Select a single period using the slider or bar chart.

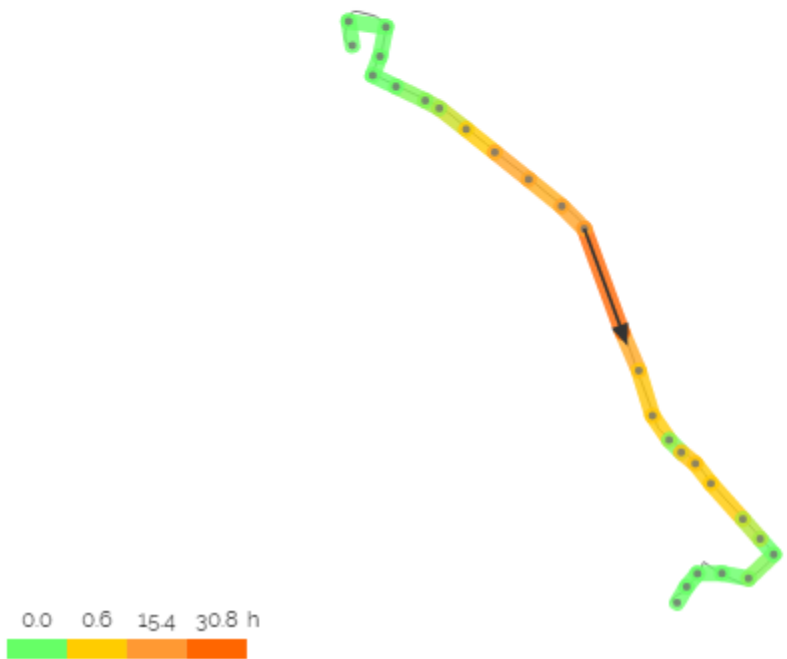
Comfort Fraction (CF)



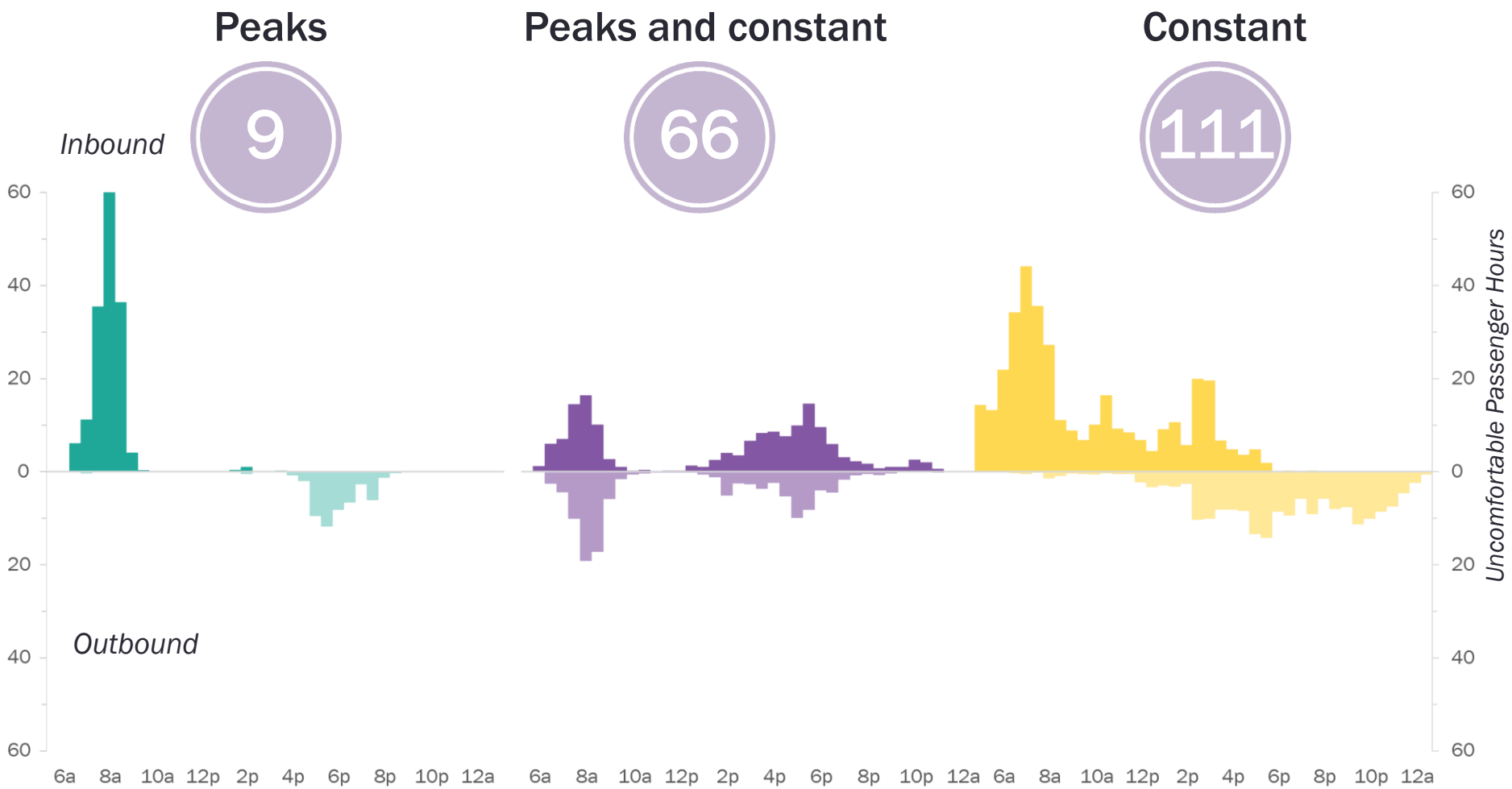
Uncomfortable Passenger Time (UPT)



best in system — worst in system

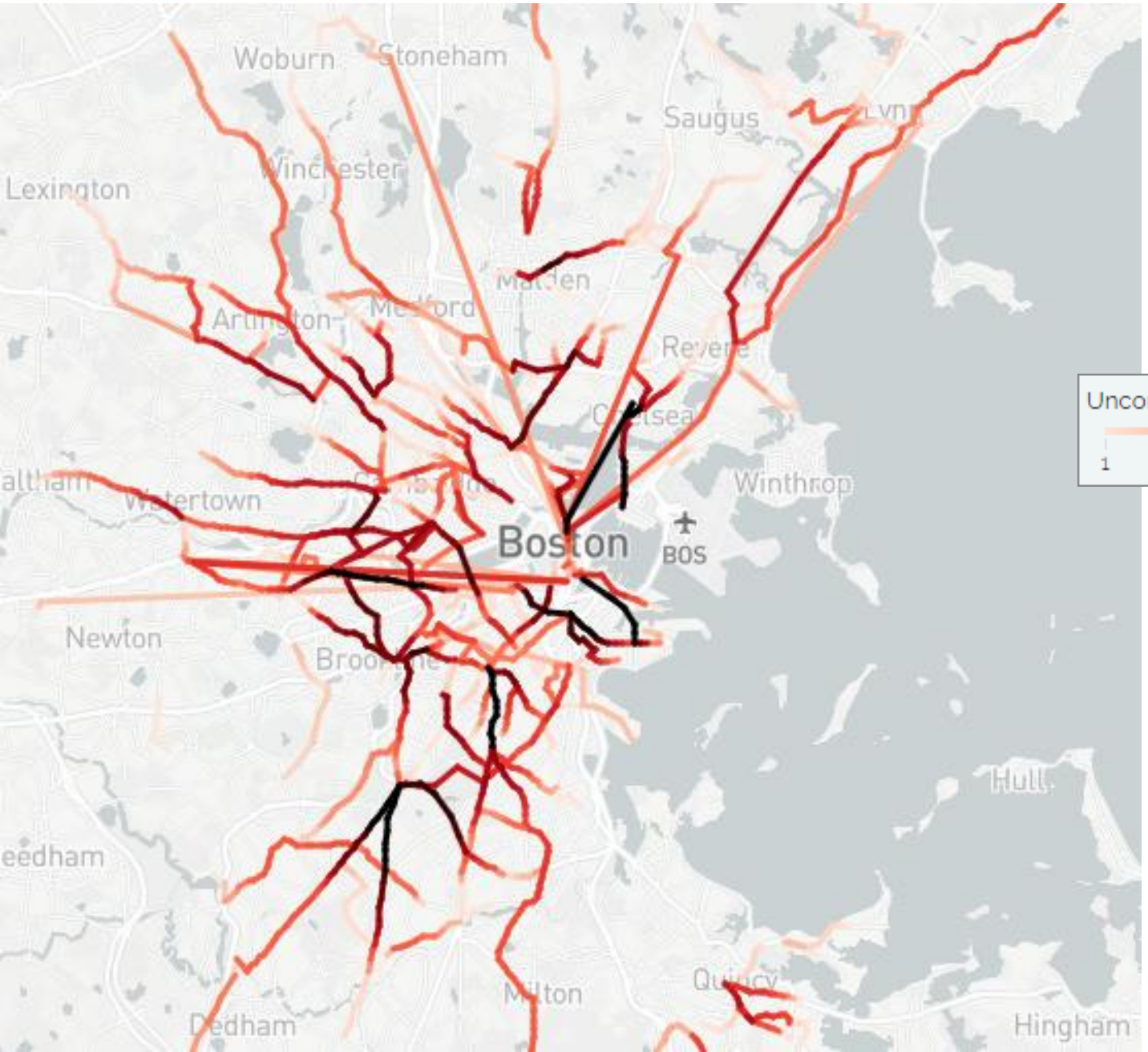


Temporal Patterns



Data reflects an average weekday in Fall 2015.

Most crowded street segments



This map shows how many passengers experience crowding on inbound trips, totaled across all bus routes that use each street.

Uncomfortable passengers/weekday:

1 10 50 200 1291

Long straight lines represent express buses that use highways without stopping.

Data reflects an average weekday in Fall 2015. Routes SL1, SL2, SLW, 71, and some Limited Service routes are excluded due to insufficient data.

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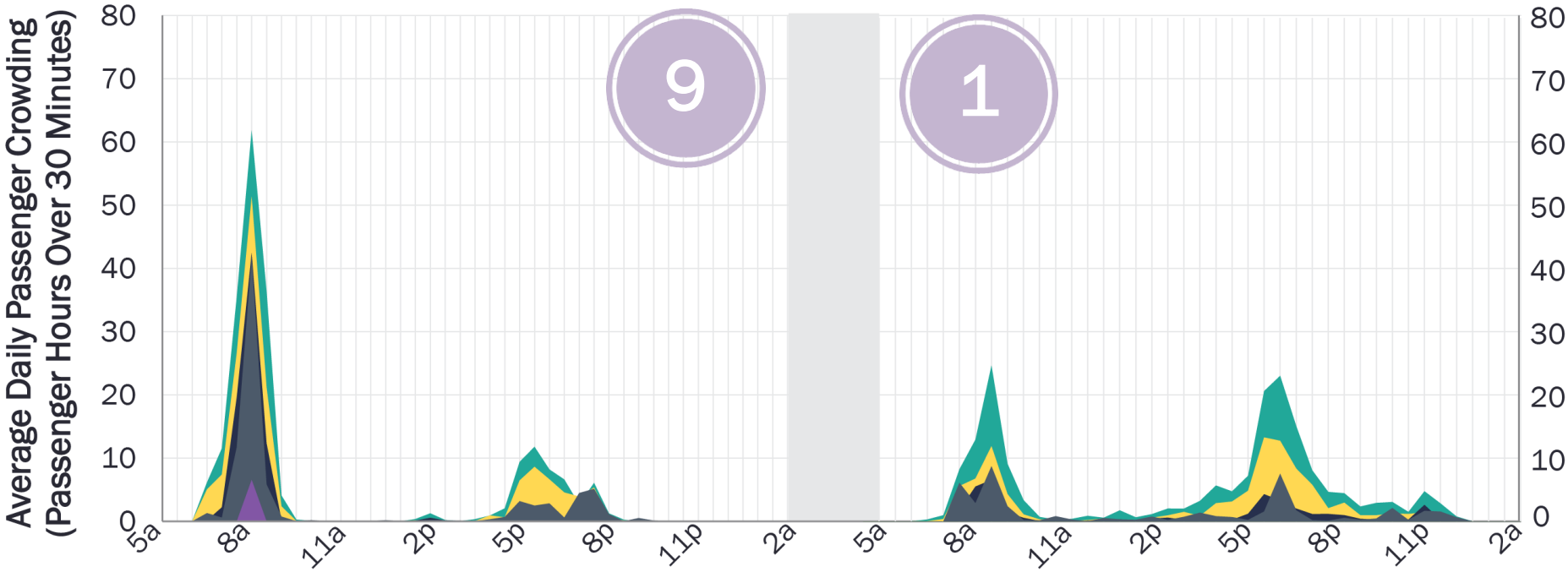
Causes of bus crowding

Crowding caused by:

- Headway Variability
- Demand variability within a day (uneven demand within 30 min periods)
- Dropped trips
- Demand variability between days
- Planned frequency (not enough service if demand uniform)



Data reflects an average weekday in Fall 2015.

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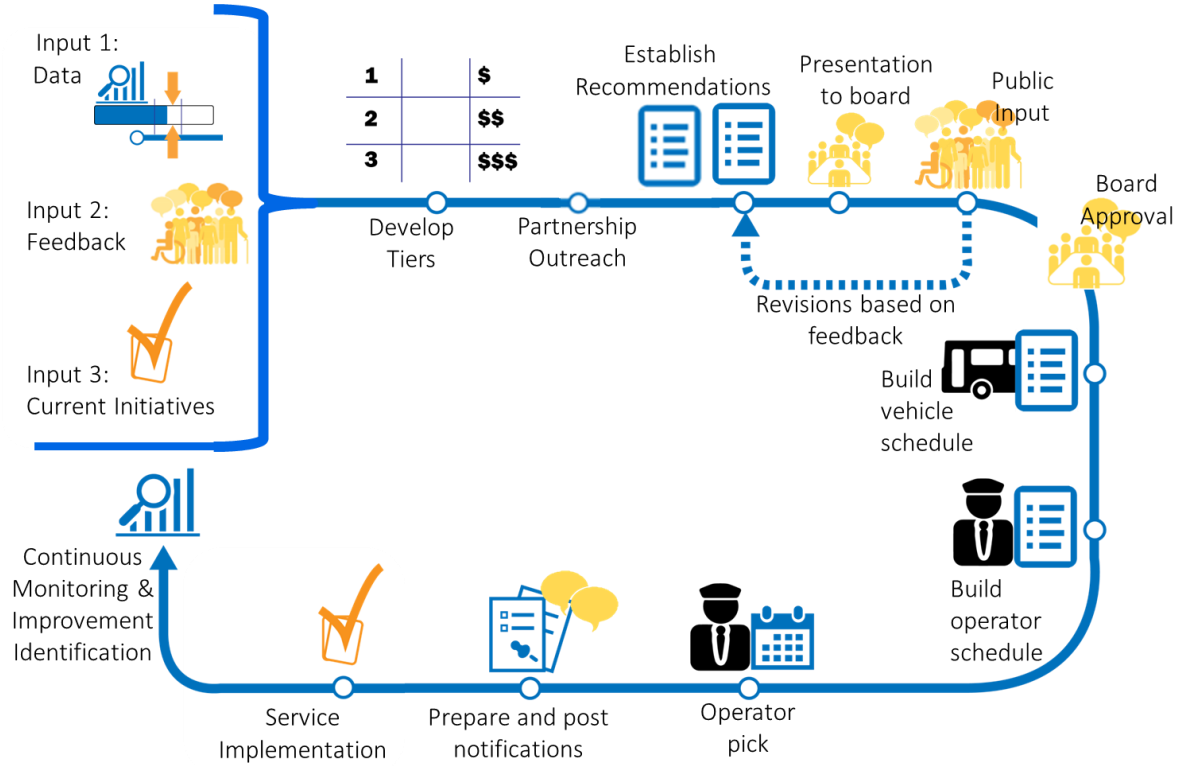
Implementation Steps

- New Service Planning process includes analyzing all of the tools together
- Focus on municipal partnerships
- Pilots projects
  - Bus lanes
  - All-door boarding
  - New dispatching tools



6
Implement

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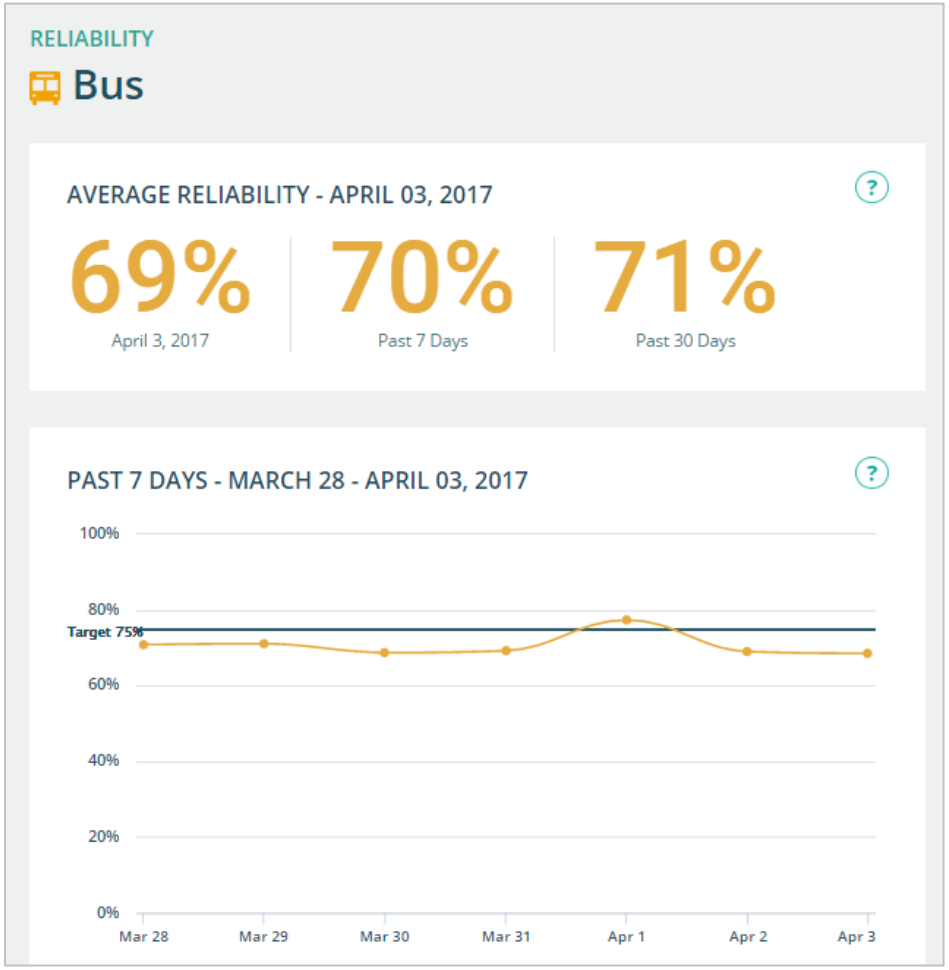
Evaluation Process

- The MBTA reports progress toward performance goals
  - Reliability on our daily dashboard
  - All measures in our annual performance report Tracker
- Annual analysis of all service performance measures
- All pilots require a research and data collection plan



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7
Evaluate

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MORE INFORMATION

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Automated Transit Data to Manage Operations and Improve System Performance

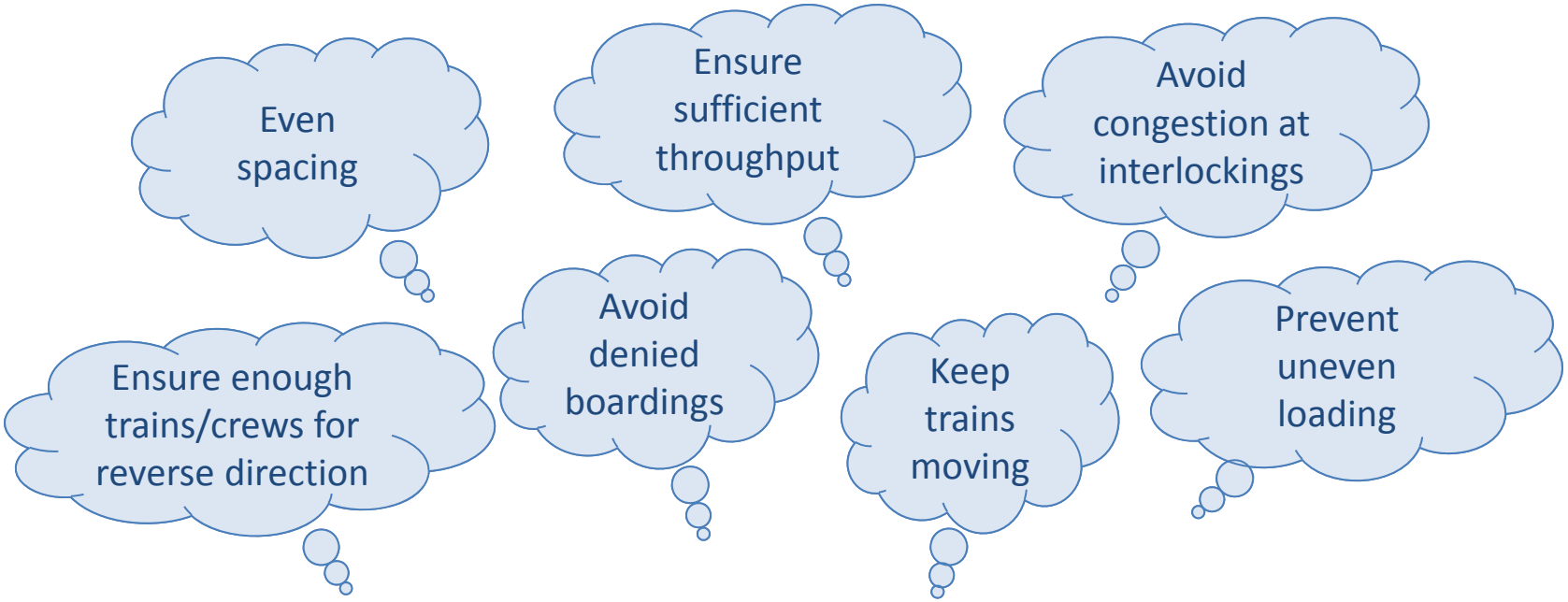
Presented by Alla Reddy, NYCT

Transportation Research Board Webinar

New York City Transit

April, 2017

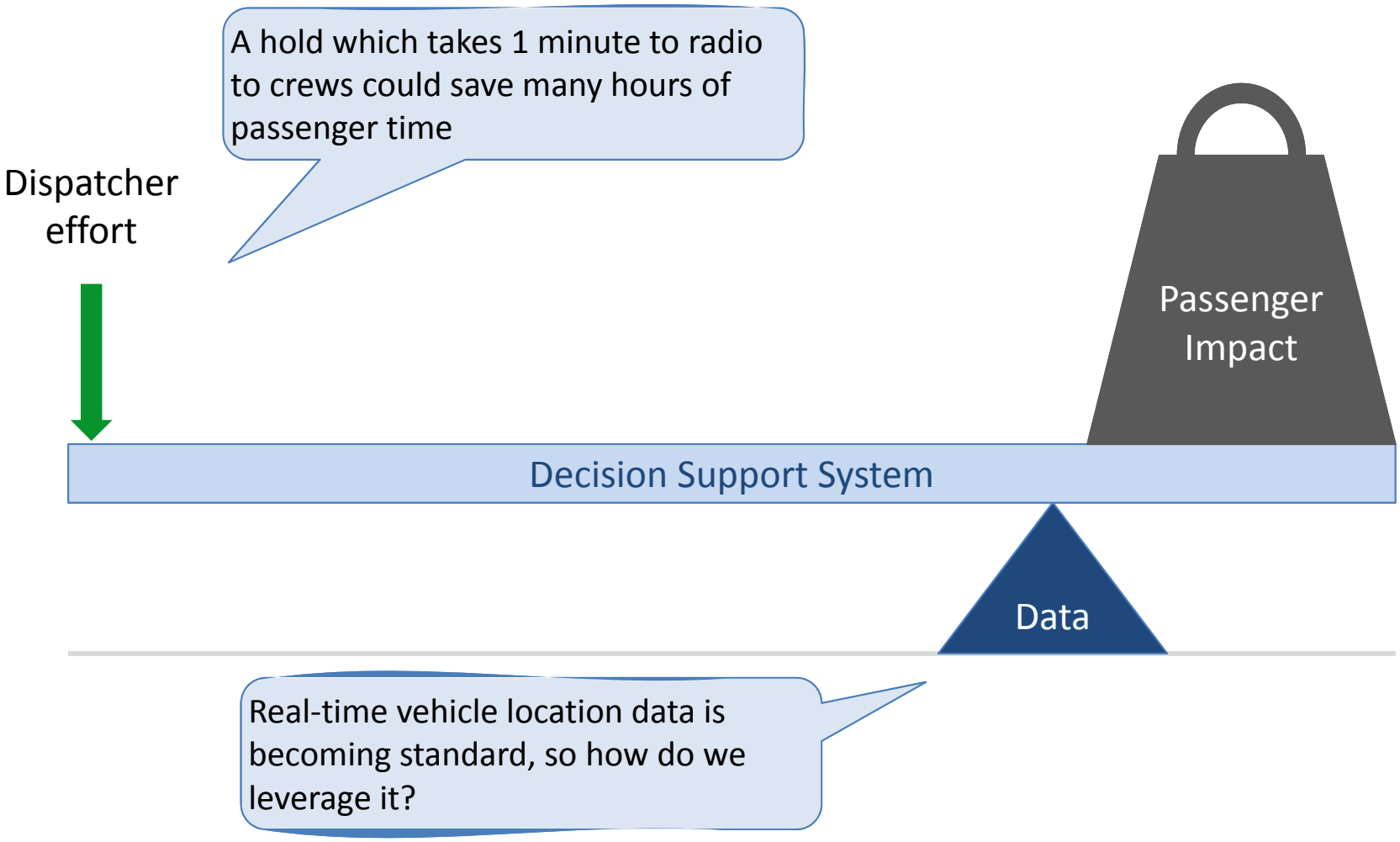
Why do we actively manage service?



All of the above are means to one end…

Get our customers safely to their destinations as quickly as possible

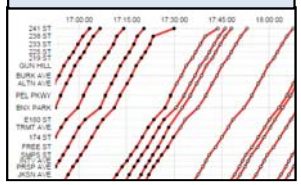
Small improvements in dispatching can have massive benefits for passengers



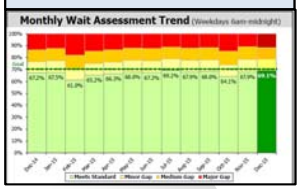
Key question: What types of outputs are most useful for service management?

Data Streams → Interpretation → Valuable Outputs

Gaps in service



Perf. Metrics



Schedules

ADA stops

Ridership

Crowding

Real-time data processing

Should the focus be on:

- ❑Visualizations?
- ❑Broad, searchable data?
- ❑Key pieces of info?
- ❑Suggested actions?

?

Because we are innovating, the ideal product is not clear, even to end-users

Uncertainty about what the solution looks like means an iterative approach is best

Traditional development

1. Plan product in meetings
2. Develop/code in isolation
3. Reveal and test product

Best when specs required are clear & known

Iterative development

- Plan and execute on short term deliverables
- Test deliverables and redirect plan after each iteration/sprint

Best when specs required are uncertain/changing

An iterative approach requires collaboration, with defined roles

	Rail Operations	Development team
Mgmt.	▪ Provide mandate to collaborate ▪ Track progress & prioritize	▪ Provide necessary resources (e.g., time, computing power) ▪ Track progress & prioritize
Analyst/ Dispatcher	▪ Test software ▪ Share feedback on utility of information and functionality of interface	▪ Research policy, and academic theory ▪ Translate research and feedback into actionable refinements ▪ Code software

Cross department collaboration needed most frequently at low levels

Heavy Rail Operations involvement is key both to building the best product and to building product ownership

Analyst/Dispatcher collaboration: What worked

- Rotate a diverse team of dispatchers & analysts to get the most complete picture
- Look for dispatchers who are active & effective, then observe them in action 1-on-1 to learn techniques
- Be humble and prepared to change your assumptions – odds are there are a few things you don’t get yet
- Periodically hold group feedback sessions so everyone can be in the loop and be heard
- Tie the project to helping to capture the knowledge/skills of more experienced (often retiring) dispatchers

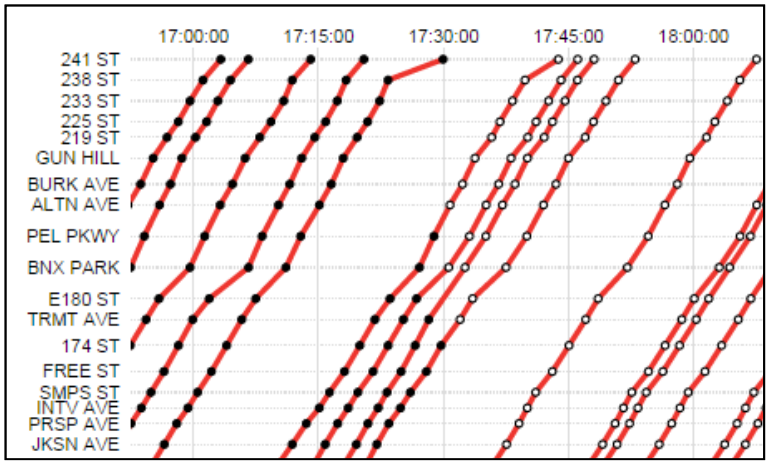
Phase I: Visualizations

Why would new visualizations help?

- Previous displays are not to scale, making spacing hard to judge
- Previous displays emphasized OTP with color coding, not even service
- Previous displays show current train location snapshot, with no history

Result: Stringlines

- Through many iterations, “Stringline” time-space diagrams built
- Numerous features added (e.g., display schedule, perf. metrics, incidents)
- Stringlines very popular with managers & analysts, some dispatcher usage (e.g., diagnosing delay causes)



Phase II: Priority list of gaps

Why identify big gaps in a table?

- Scanning broad areas of responsibility for issues remained difficult (numerous clicks/screens)
- None of the visualizations provided sufficient information without the use of hover-overs
- Tables can be sorted & filtered more flexibly than schematics/charts

Result: Gap Table

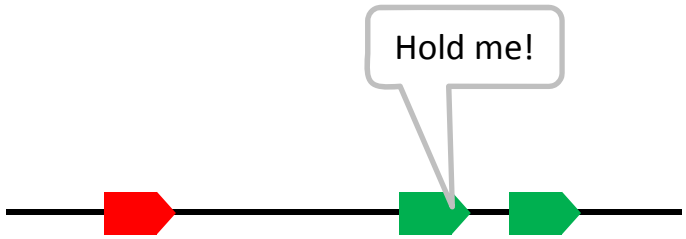
- Through relatively few iterations, “Gap Table” prototype built on top of Stringlines code
- Users could select multiple lines/territories and see largest gaps
- Factors like ridership and merges were not included

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	2
110 ST	02 1644 241/FLA	8	2	4
181 ST	01 1642 SFY/242	7	6	8
UTCA AVE	03 1720 NLT/148	7	8	1
138 3RD	06 1706 PEL/BBR	7	0	6
225 ST	01 1637 SFY/242	6	6	8
161 ST	04 1711+ WDL/UTI	6	5	7
176 ST	04 1719+ WDL/UTI	6	6	7

Lesson learned: Deciding when to hold/skip a train is more complicated than it seems

The criteria for holding are simple…

- ❑ The gap in front is small
- ❑ The gap behind is large



…except for the exceptions…

- ❖ The large gap exists because of upcoming put-in from the yard
- ❖ The large gap will be needed at a merge
- ❖ The train to be held is too full to fit additional passengers
- ❖ There are few boardings at upcoming stops
- ❖ Skipping the follower would yield better results
- ❖ Rerouting an additional train would be more effective
- ❖ …

<u>If we really want to help dispatchers, we need to:</u>

- ❑ Take the false positives off their plates
- ❑ Identify what <u>action</u> will fix the problem

Many iterations required to converge on service management recommendations

Practical experience of NYCT staff + **Precision of academic models** = **Highly-customized rules for generating hold and skip recommendations**

NYCT policy and practice

- ✓ Policy guidance from management
- ✓ Historical dispatcher actions (e.g., spacing of trains just before skips)
- ✓ Current dispatcher feedback (based on dozens of hours of analysts & dispatchers monitoring service together

Theory and academic research

- ✓ Academic research on optimal hold/skips
- ✓ Estimation of ridership information using MetroCard data
- ✓ Methods for calculating the passenger benefit/penalty for holds and skips

Phase III: Simple display of real-time recommended actions

DRAFT

Lines

1 2 3 4 5 6 All

Can filter by line

Territories

1 2 3 4 5 6 7 8 9 10 11 All

Can filter by job assignment

Last Updated:
Thu Sep 15 2016 17:13:26

Recommendations are color coded by priority, based on passenger time savings

Splitting recommendations by direction was an idea from dispatchers

Northbound

Line	Direction	Train ID	Next Stop	Hold Duration (Mins)	Stops to Skip	Gap Before (Mins)	Gap After (Mins)
6X	N	06 1702+ BBR/	28ST LEX	1		2.1	4.8

Southbound

Line	Direction	Train ID	Next Stop	Hold Duration (Mins)	Stops to Skip	Gap Before (Mins)	Gap After (Mins)
6	S	06 1658 PEL/BBR	WLCK AVE		E149 ST,143 ST	7.6	3.4
6	S	06 1654+ 177/BBR	125 ST	1.5		2.1	5.8
6	S	06 1700 177/BBR	BRK.AVE.	1.5		5.8	9.1
6	S	06 1630 PEL/BBR	68 ST	1.5		1.8	5.3

Estimated total passenger time savings: **2000 passenger-minutes** (or more), 1 ... ssenger-minutes.

Recommended holds give durations while skips list stops

Lesson learned: There are multiple useful products for different people/purposes

Stringlines

- Good for fine grained analysis of train movements, tracing cause(s) of delays
- Popular with managers and analysts
- Some dispatcher usage for recordkeeping on delays
- Not optimal for service management decision making

Recommendation Engine

- Good for real time service management
- More popular with dispatchers than stringlines
- Not useful for tracing cause(s) of delays

What can you take from our experience?

- Iterate – any plan that comes out of a meeting will be missing something important
- Collaborate – no single group has the breadth of knowledge to design the perfect tool
- Differentiate – different products work better for different people/applications
- Prioritize – when it comes to service management, small amounts of actionable information are more valuable than uninterested data