Massachusetts Bay Transportation Authority

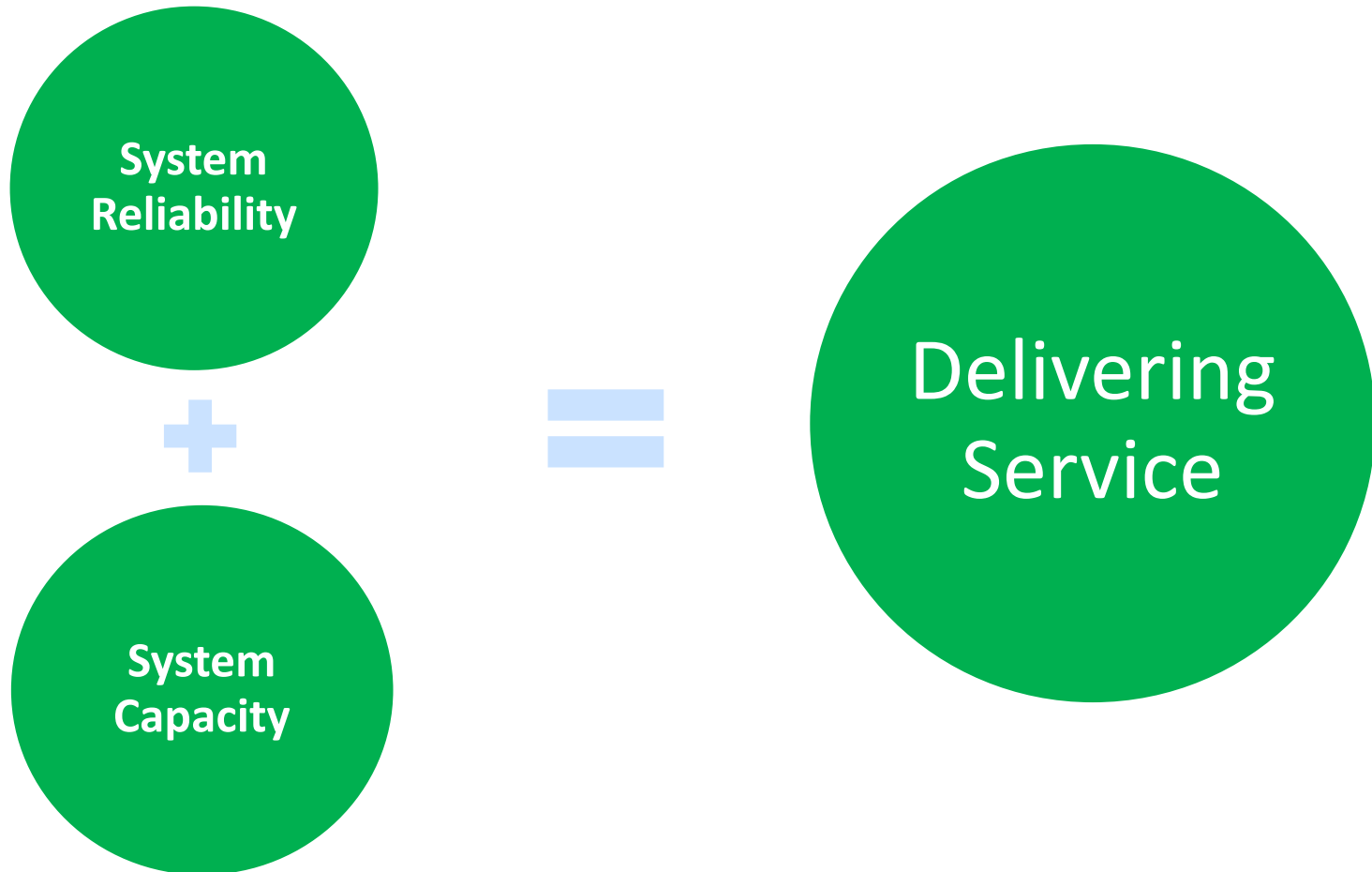# Red Line Customer Capacity Update

Fiscal & Management Control Board

September 19, 2016
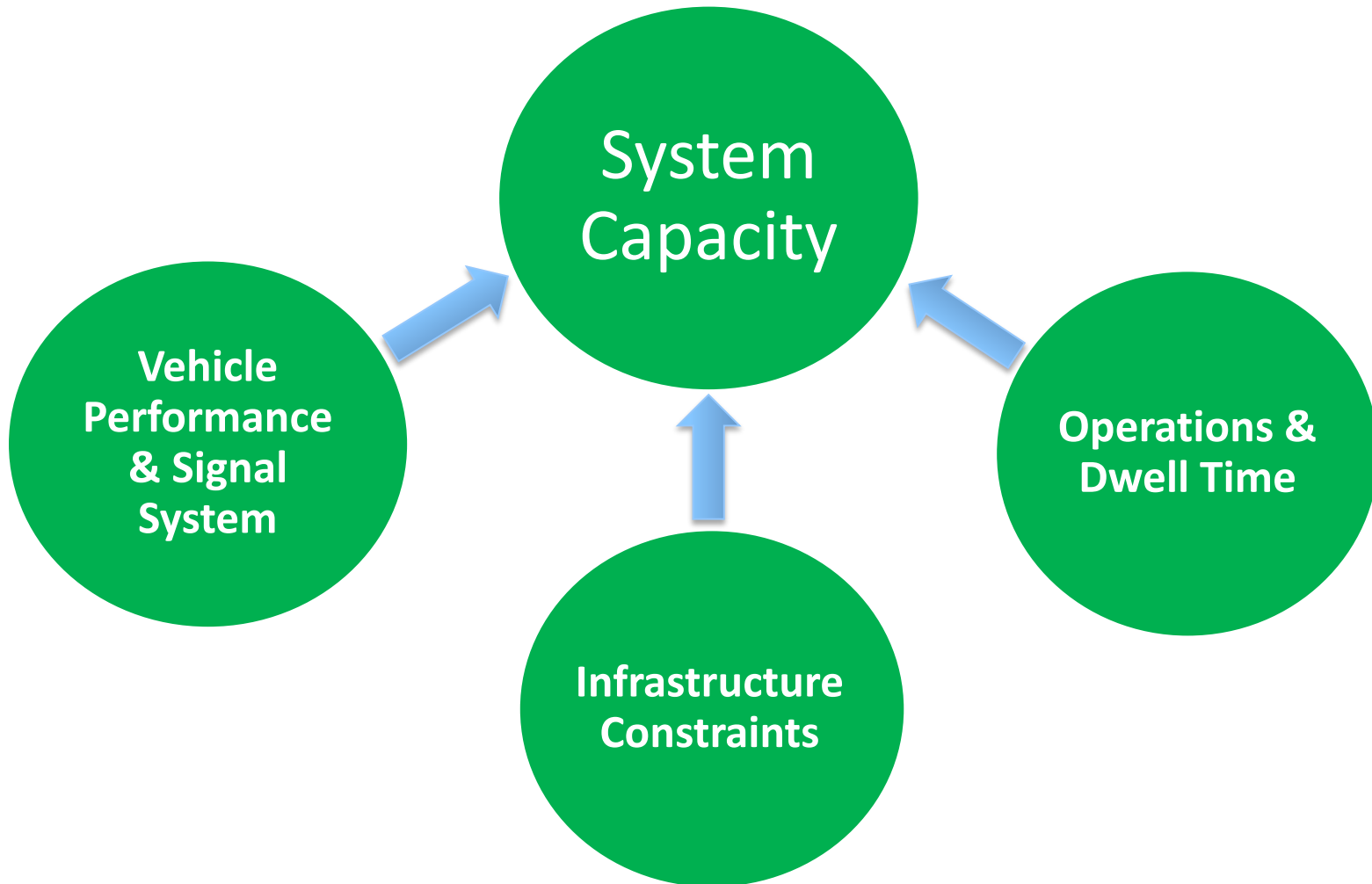
Delivering Service

System Reliability

+

System Capacity

=

Delivering Service

System Capacity

System Capacity

Vehicle Performance & Signal System

Operations & Dwell Time

Infrastructure Constraints
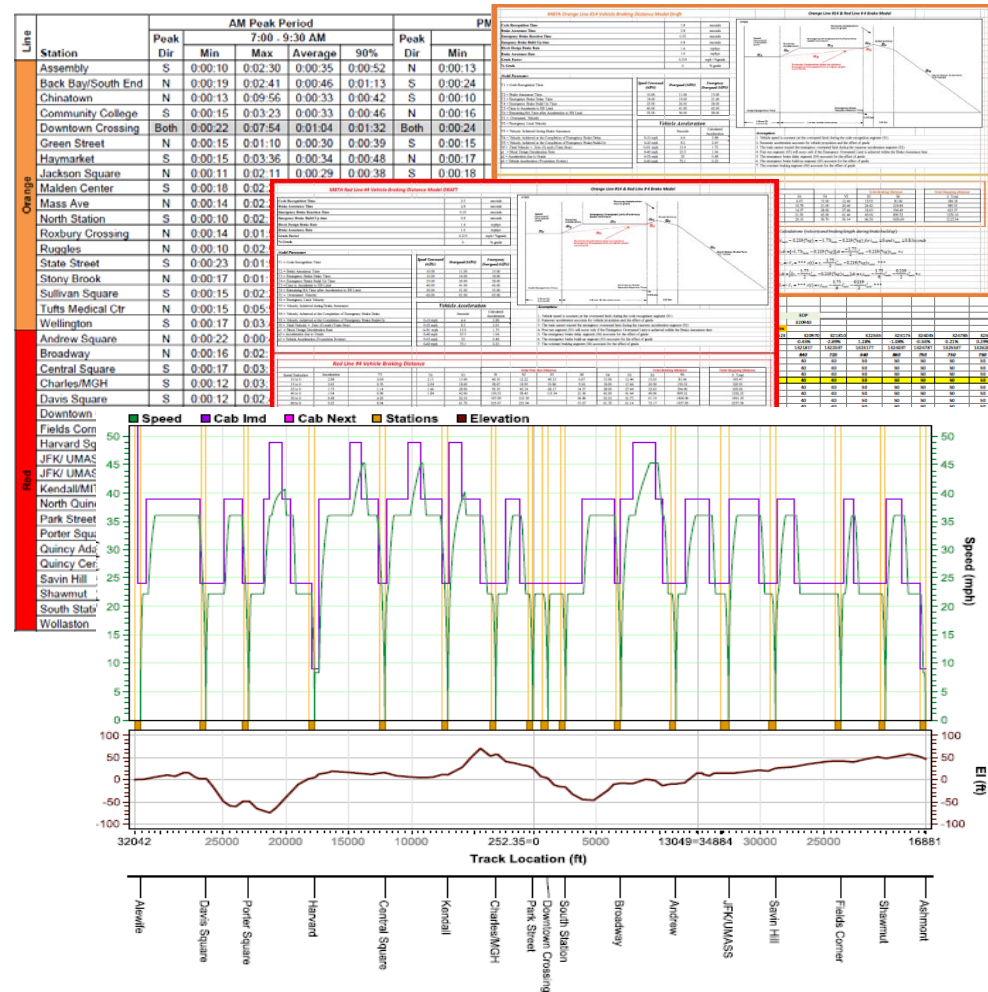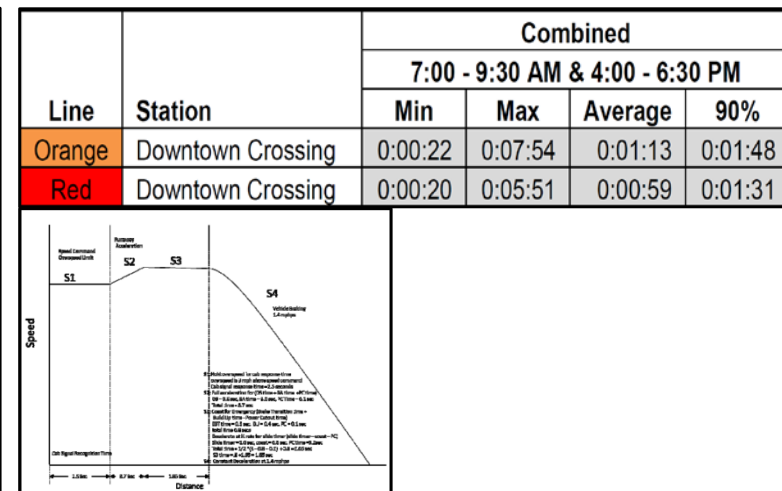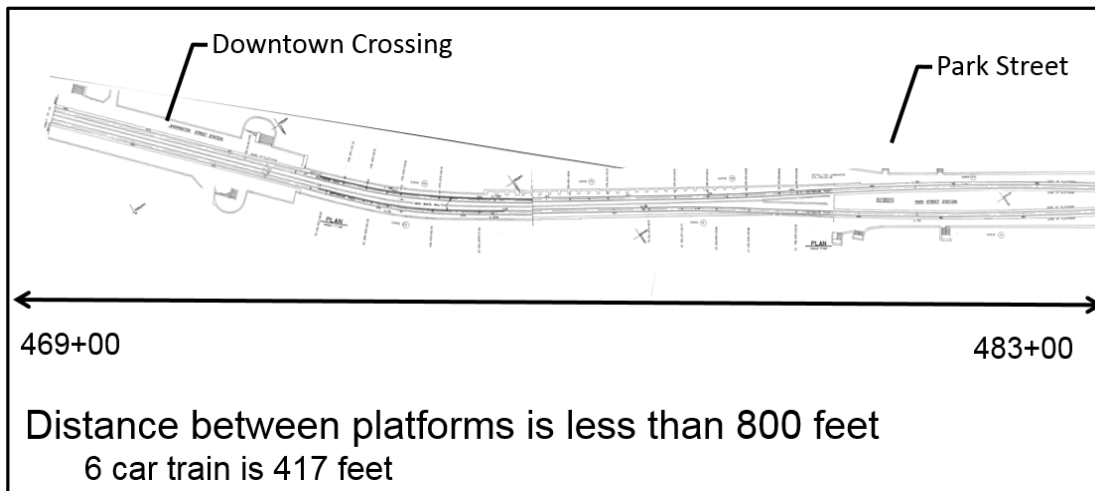
Capacity Analysis

- Extensive Independent system capacity simulation on Orange and Red Lines conducted, utilizing:

  - Actual Service Data and Visual Observations

  - Actual Signals and Station Designs

  - Vehicle Performance Modeling

  - Specific Improvement Initiatives

Analysis Results

- Current Maximum Design Capacity
  - 13 Trains per hour Red Line or
  - 20,280 Customers Per Hour

- Fixed Constraints:
  - Distance Between Stations
  - Civil Design (curves, etc.)

- Manageable Constraints:
  - Vehicle Performance
  - Dwell Times

Downtown Crossing

Park Street

469+00

483+00

Distance between platforms is less than 800 feet
6 car train is 417 feet

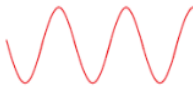| Line	Station	Combined 7:00 - 9:30 AM & 4:00 - 6:30 PM			
		Min	Max	Average	90%
Orange	Downtown Crossing	0:00:22	0:07:54	0:01:13	0:01:48
Red	Downtown Crossing	0:00:20	0:05:51	0:00:59	0:01:31

Possible Capacity Improvement Initiatives

- Additional simulations measured impact of capacity improvement initiatives, including:

  - Benefits of the new Red Line vehicles with modest signal system changes – assuming replacement of No. 3 cars

  - Reduction in Dwell Time

 - Communication Based Train Control (CBTC)

Definition of Signal Systems

- <u>Audio Frequency Track Circuits (AFTC):</u> Used to define a section of track (or Block). Detects and communicates to a train through the rails to maintain safe train separation.

  - Analog AFTC Version: Uses older analog technology - Currently used on the Red Line

  - Digital AFTC Version: Uses modern digital technology to detect

- <u>Communication Based Train Control (CBTC):</u> System-wide control technology. Uses digital telecommunications methods to detect and communicate to the train to maintain safe train separation.

Signal System Comparison

Fixed Block

CBTC Moving Block
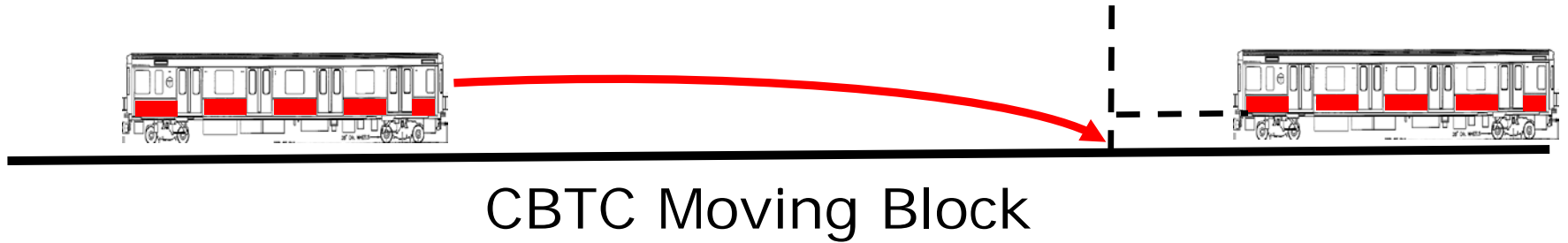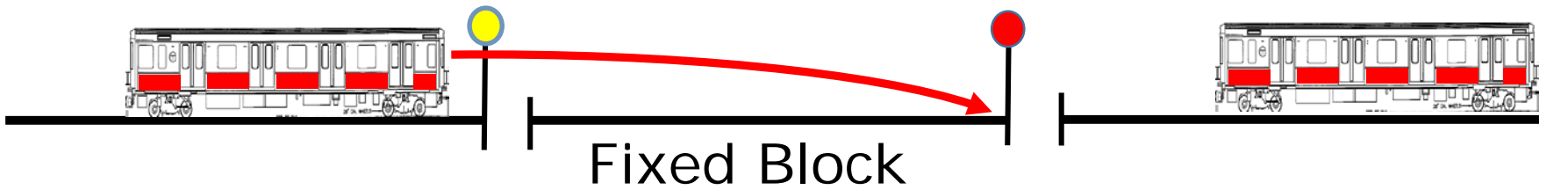
Key Role of Braking Distance

- Braking distance calculations yield the maximum distance needed to stop at a given speed

- This distance defines the distance that must be maintained at all times between trains
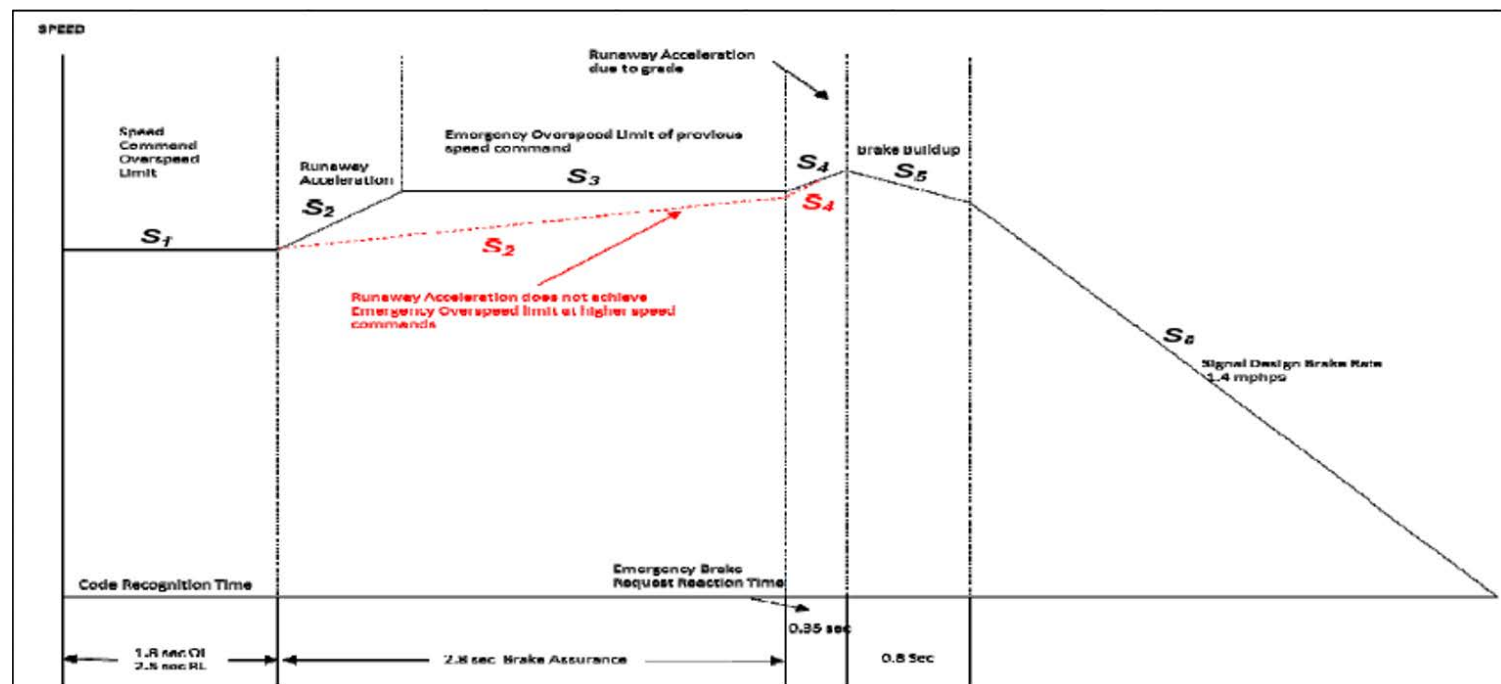
New Red Line Car Improvements

- Current Red Line signals are based on the braking calculations of the older No. 3 car

- New Red Line No. 4 Car
    - Advanced Propulsion System
    - Improved Trigger for Vehicle Signal Controller
    - Improved Braking Control Technology

New Red Line Car Improvements

- New No. 4 Cars reduce braking calculation distance by 30 percent compared to current cars
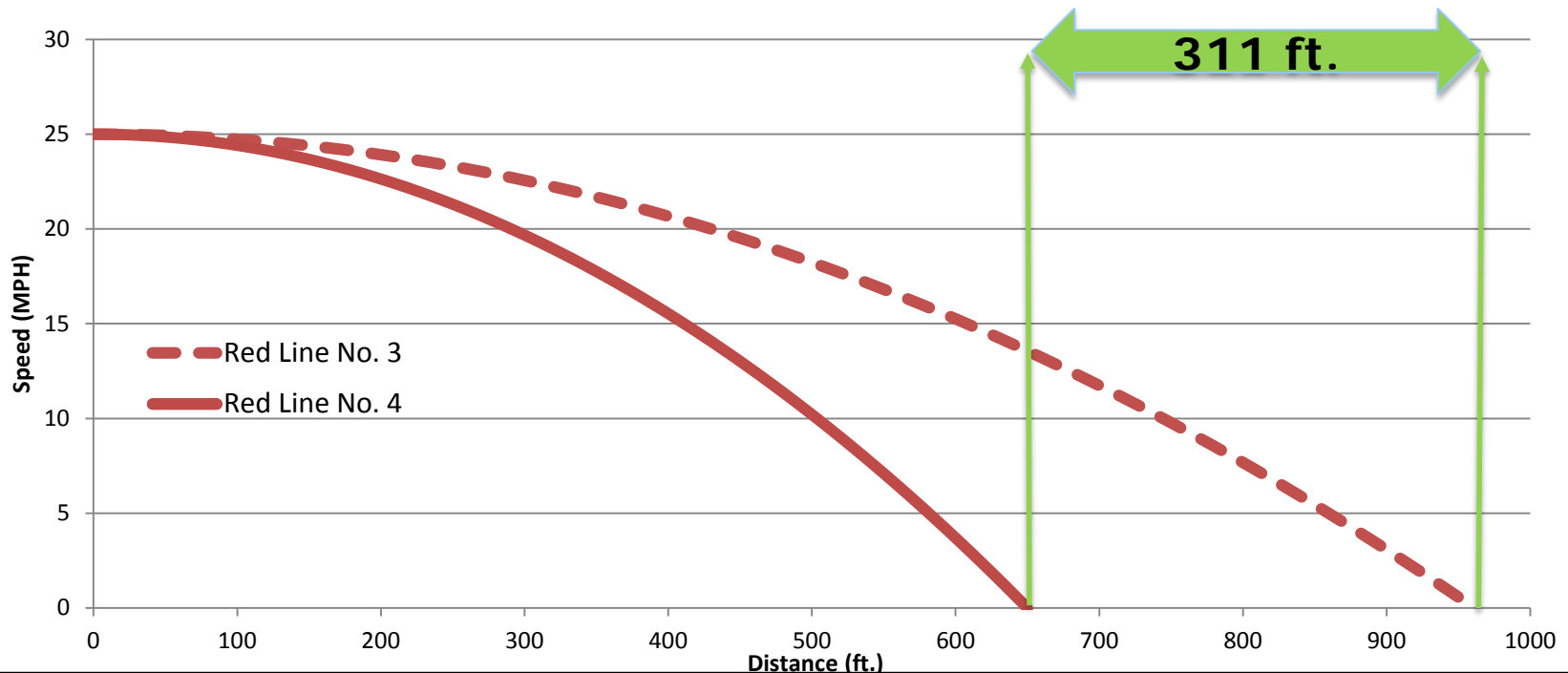
New Red Line Car Improvements

- New No. 4 cars will run faster for longer
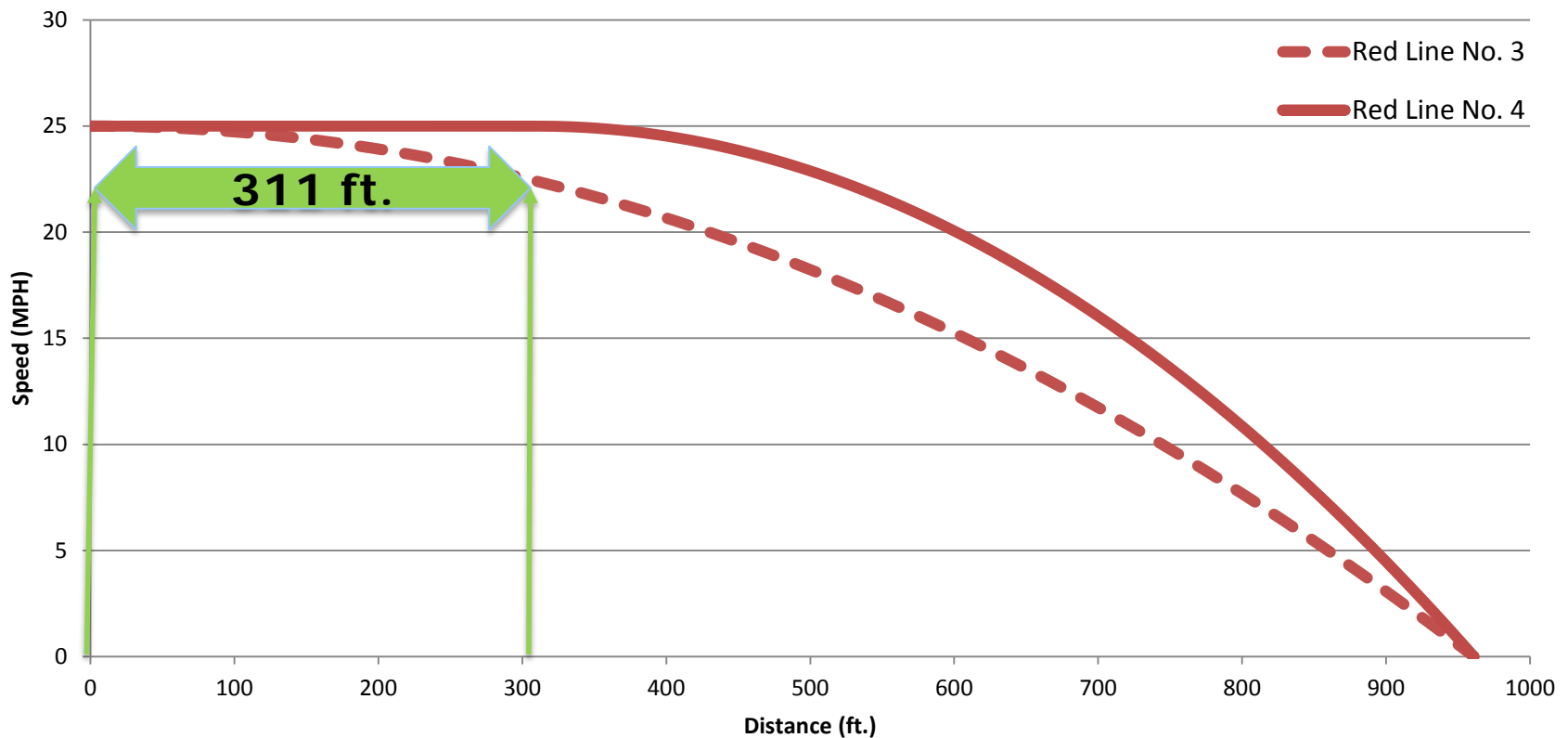
New Vehicles Could Increase Capacity by 50 Percent

- With the new vehicles' performance, minor speed code changes and replacement of the No. 3 cars, Red Line theoretical maximum capacity increases from 13 to 20 trains per hour

    - 50% increase in customers carried per hour

Red Line Simulation Results Existing vs. Expected New Car

Analysis of CBTC Analysis

- A detailed analysis assuming a moving block CBTC system on the Red Line was completed

- Analysis found that a CBTC system would produce an improvement of just one train per hour beyond the improvement from the new cars and minor system changes

- Major Red Line capacity improvements can be achieved without implementing very costly CBTC

- Long dwell times in the downtown area and close spacing of stations limit CBTC as much as they limit fixed block systems
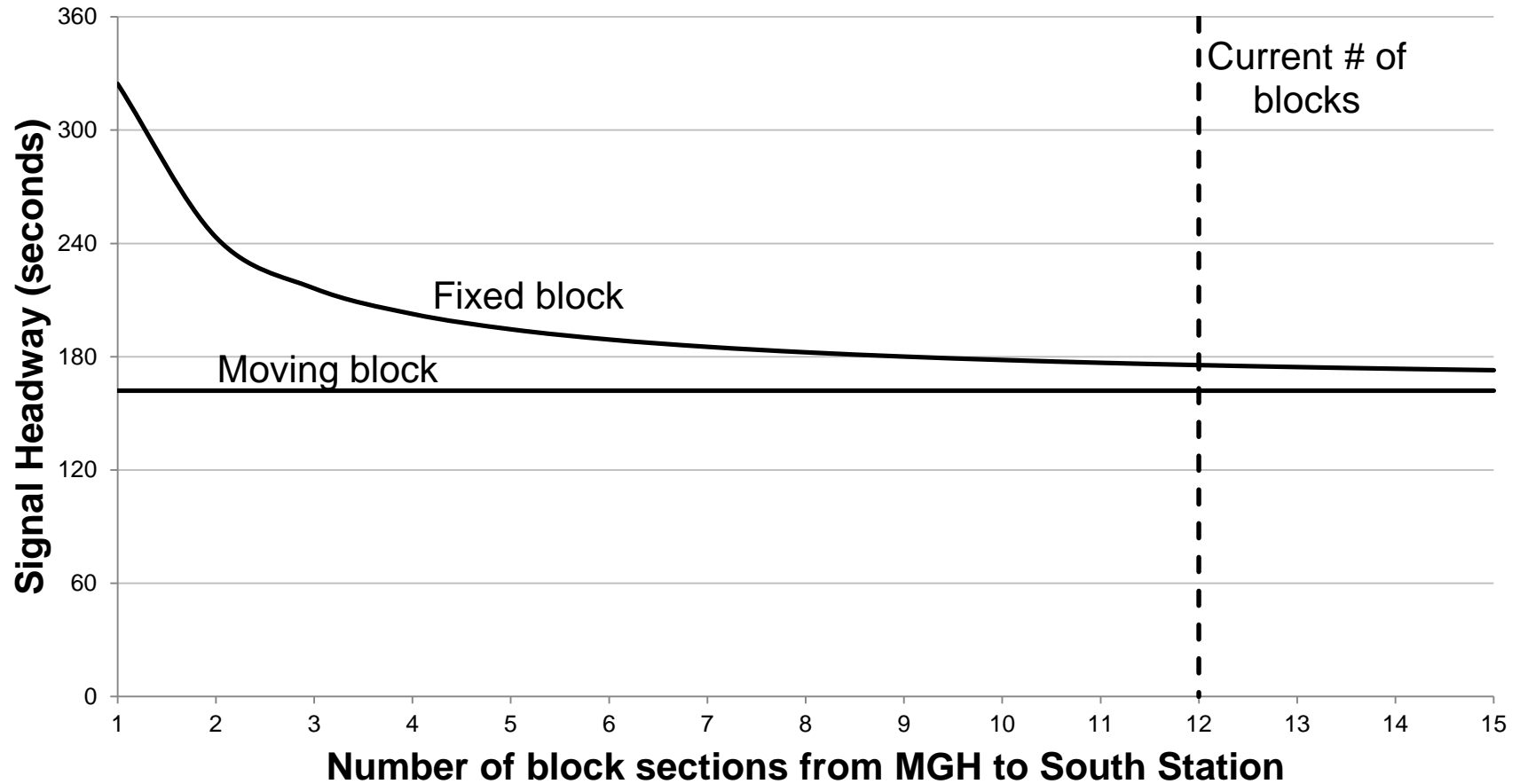
Minimal CBTC Impact Explained

- The shorter the block length, the closer the system is to the ideal CBTC (moving block) braking distance

- MBTA block lengths in the central subway already average less than 500 feet (6 car trains are 416 feet long)

Fixed Block vs CBTC

Dwell Time

- Station dwell times limit capacity

- Dwell times most limiting to capacity occur at:
  - Downtown Crossing
  - Park Street
  - State Street

- Improving dwell time could enable capacity increase of 15-20%

Orange Line

| | | AM Peak Period | | | |
| | Peak | 7:00 - 9:30 AM | | | |
Station	Dir	Min	Max	Average	90%
Assembly	S	0:00:10	0:02:30	0:00:35	0:00:52
Back Bay	N	0:00:19	0:02:41	0:00:46	0:01:13
Chinatown	N	0:00:13	0:09:56	0:00:33	0:00:42
Comm. College	S	0:00:15	0:03:23	0:00:33	0:00:46
Downtown Xing	Both	0:00:22	0:07:54	0:01:04	0:01:32
Green Street	N	0:00:15	0:01:10	0:00:30	0:00:39
Haymarket	S	0:00:15	0:03:36	0:00:34	0:00:48
Jackson Square	N	0:00:11	0:02:11	0:00:29	0:00:38
Malden Center	S	0:00:18	0:02:21	0:00:37	0:00:50
Mass Ave	N	0:00:14	0:02:27	0:00:37	0:00:55
North Station	S	0:00:10	0:02:12	0:00:45	0:01:08
Roxbury Xing	N	0:00:14	0:01:51	0:00:33	0:00:47
Ruggles	N	0:00:10	0:02:57	0:00:36	0:00:48
State Street	S	0:00:23	0:01:54	0:01:03	0:01:30
Stony Brook	N	0:00:17	0:01:14	0:00:34	0:00:44
Sullivan Sq.	S	0:00:15	0:02:29	0:00:41	0:01:03
Tufts Med Ctr.	N	0:00:15	0:05:57	0:00:35	0:00:45
Wellington	S	0:00:17	0:03:48	0:00:47	0:01:25

Red Line

| | | AM Peak Period | | | |
| | Peak | 7:00 - 9:30 AM | | | |
Station	Dir	Min	Max	Average	90%
Andrew Sq.	N	0:00:22	0:00:42	0:00:26	0:00:29
Broadway	N	0:00:16	0:02:14	0:00:38	0:00:54
Central Sq.	S	0:00:17	0:03:14	0:00:41	0:01:01
Charles/MGH	S	0:00:12	0:03:15	0:00:42	0:01:02
Davis Sq.	S	0:00:12	0:02:47	0:00:36	0:00:49
Downtown Xing	Both	0:00:20	0:05:11	0:00:56	0:01:27
Fields Corner	N	0:00:10	0:02:31	0:00:37	0:00:53
Harvard Sq.	S	0:00:20	0:04:27	0:00:47	0:01:09
JFK/UMASS-ASH	N	0:00:19	0:06:22	0:00:42	0:00:51
JFK/UMASS-BRT	N	0:00:19	0:04:16	0:00:45	0:01:02
Kendall/MIT	S	0:00:16	0:02:43	0:00:37	0:00:53
North Quincy	N	0:00:19	0:14:02	0:00:51	0:01:08
Park Street [R]	S	0:00:23	0:02:26	0:00:56	0:01:18
Porter Sq.	S	0:00:16	0:03:11	0:00:36	0:00:53
Quincy Adams	N	0:00:10	0:02:13	0:00:27	0:00:38
Quincy Center	N	0:00:36	0:00:45	0:00:39	0:00:41
Savin Hill	N	0:00:16	0:03:01	0:00:37	0:00:54
Shawmut	N	0:00:13	0:02:50	0:00:27	0:00:41
South Station	N	0:00:19	0:04:20	0:00:57	0:01:22
Wollaston	N	0:00:15	0:08:22	0:00:36	0:00:45

Key Future Decisions

- Future of the Red Line No. 3 Car

- Red Line Fleet Size

- Signal and Power Infrastructure Investments

- <u>Future Presentation</u>
  - Dwell Time Customer Campaign

Thank you

Terms and Definitions

- Trains per Hour (TPH): A unit we use in our simulations to represent the number of six car trains that travel a given section of our line.

- Max or Maximum Capacity: The theoretical number of TPH that can travel a given section of our system based on defined constraints.

- Crush Capacity: Measured in TPH and it represents the max capacity achievable while simultaneously not causing exponentially increasing delays behind each train. Assumes some trains are stopped for short periods between stations and it more closely resembles actual operation.

- Defined Constraints: The variables used to calculate capacity.

  - Stopping Distance: The calculated distance a train needs to come to a complete stop

  - Dwell Time: The time a train is stopped at a given location

  - Signal Block Length: The physical length of a given section of signal system with a red light entry control.

  - Speed Code: Speed Limit issued by the wayside Train Control System

  - Fixed Constraints: Those variables that require significant effort to change (station spacing, signal system, actual vehicle performance)

  - Manageable constraints: Those variables that are more easily changed (dwell time, speed codes, signal block length)

Terms and Definitions

- Customer Capacity: A calculation that estimates the maximum number of passengers a car or train can carry.

  - 6 car Red Line Train = 1,560 customers (6x260)

    - 13 TPH= 20,280 customer per hour
    - 20 TPH = 31,200 customer per hour (53.85% difference)

  - 6 car Orange Line Train = 1,230 customers (6x205)
    - 10 TPH = 12,300
    - 13 TPH = 15,990