The Role of Information Technology in Improving Public Transit Systems

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Transit often lags behind time…

Transit Agencies Are at a Critical Transition in Data Collection Technology:

Manual ⟹ **Automatic**

- low capital cost
- high marginal cost
- small sample sizes
- aggregate
- unreliable

- limited spatially and temporally
- not immediately available

- high capital cost
- low marginal cost
- large sample sizes
- more detailed, disaggregate
- errors and biases can be estimated and corrected
- ubiquitous
- available in real-time or quasi real-time

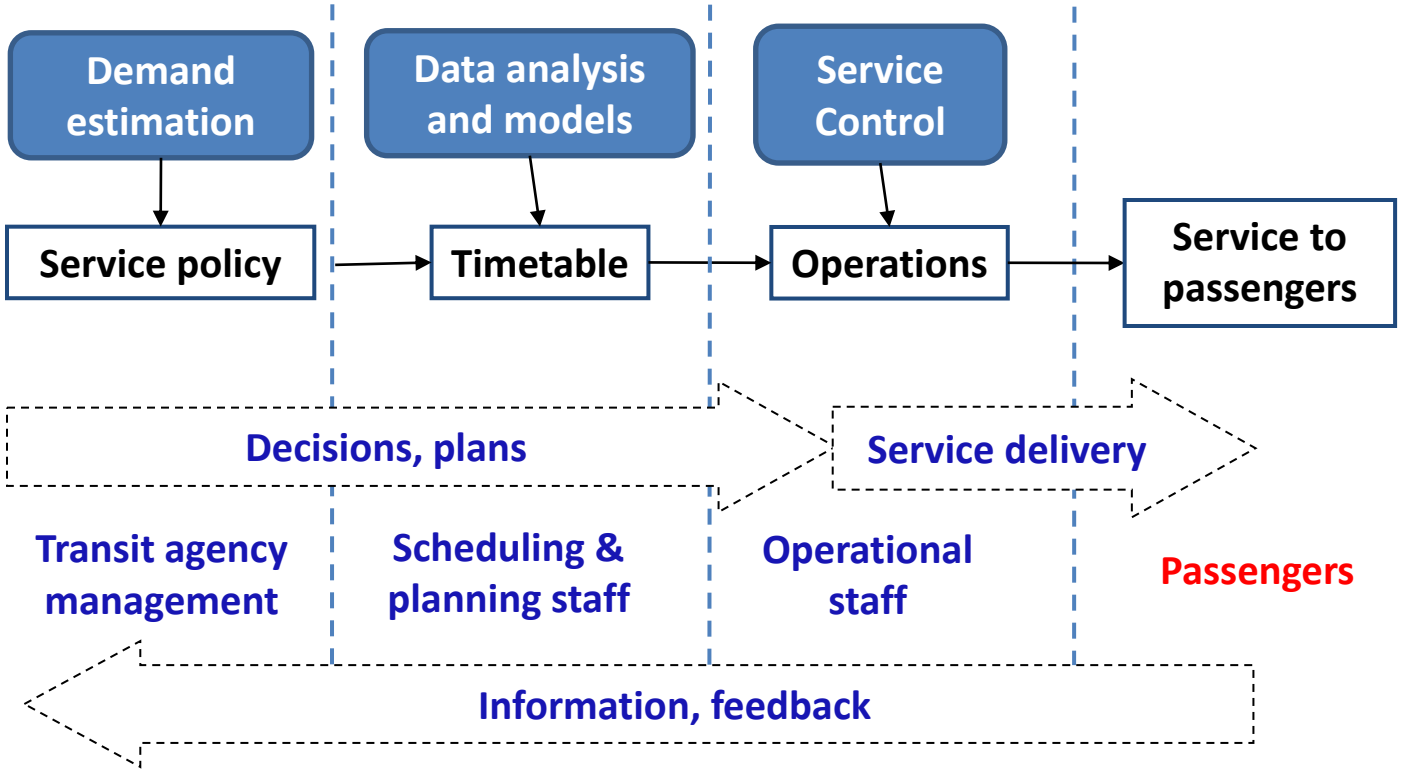
Outline

- Functions at Transit Agencies -- Traditions
- Automated Data Collection (ADC) -- Recent innovations
- “Connected Transit” -- Some speculations

Key Transit Agency/Operator Functions

- **Service and Operations Planning (SOP)**
  - Network and route / Frequency and timetable / Vehicle and crew scheduling
  - Off-line, non real-time function
- **Service and Operations Control and Management (SOCM)**
  - Deviations from SOP / unexpected changes in demand
  - Real-time function
- **Customer Information (CI)**
  - Information on routes, journey times, vehicle arrival times, reliability
  - Both static and dynamic
  - Both pre-trip and en-route
- **Performance Measurement and Monitoring (PMM)**
  - Operator performance against SOP
  - Service measurement from customer viewpoint
  - Traditionally an off-line function

Transit Service Delivery Process*



* Source: "Diagnosis and Assessment of Operations Control Interventions: Framework and Applications to a High Frequency Metro Line." MST Thesis, André Carrel; MIT, 2009.

Traditional Relationship Between Functions

- **SOP → SOCM + CI**
- **Reasonable as long as SOP is sound and deviations from it are not large**
- **Fundamentally a static model in an increasingly dynamic world**

Recent innovations

Automated Data Collection (ADC) Systems

- Automatic Vehicle Location Systems (AVL)
  - bus location based on GPS
  - train tracking based on track circuit occupancy
  - real-time availability of data
- Automatic Passenger Counting Systems (APC)
  - bus systems based on sensors in doors with channelized passenger movements
  - passenger boarding (alighting) counts for stops/stations
  - train weighing systems to estimate number of passengers on board
  - traditionally not available in real-time
- Automatic Fare Collection Systems (AFC)
  - increasingly based on contactless smart cards with unique ID
  - provides entry (exit) information (spatially and temporally) at the individual level
  - traditionally not available in real-time

Impact of ADCS on Transit Systems

IMPACT ON Service and Operations Planning

- **AVL:** detailed characterization of route segment running times
- **APC:** detailed characterization of stop activity (boardings, alightings, and dwell time)
- **AFC:** detailed characterization of fare transactions for individuals over time

IMPACT ON Service and Operations Control and Management

- **AVL:** identifies current position of all vehicles, deviations from SOP

IMPACT ON Customer Information

- **AVL:** supports dynamic Customer Information
- **AFC:** permits characterization of trip-making at the individual level; provides information on reliability of travel time

IMPACT ON Performance Measurement and Monitoring

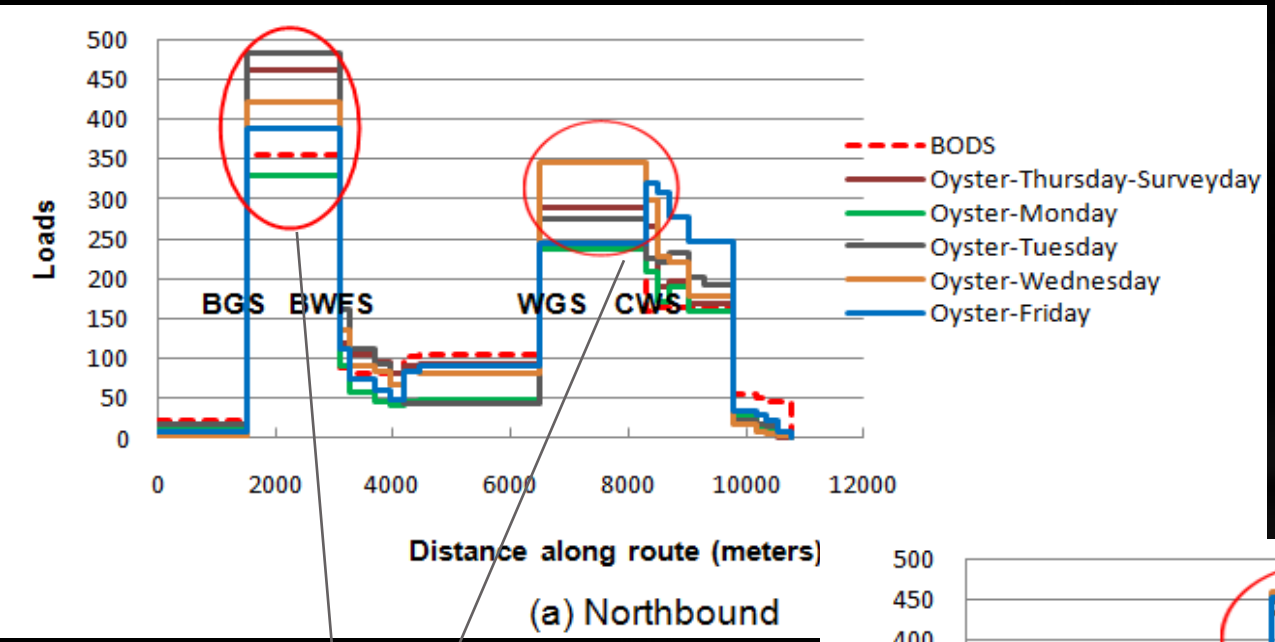
- **AVL:** supports on-time performance assessment
- **AFC:** supports passenger-oriented measures of travel time and reliability

Example applications

Bus Passenger Origin-Destination Inference Using Automated Data Collection Systems in London, UK

Wei Wang

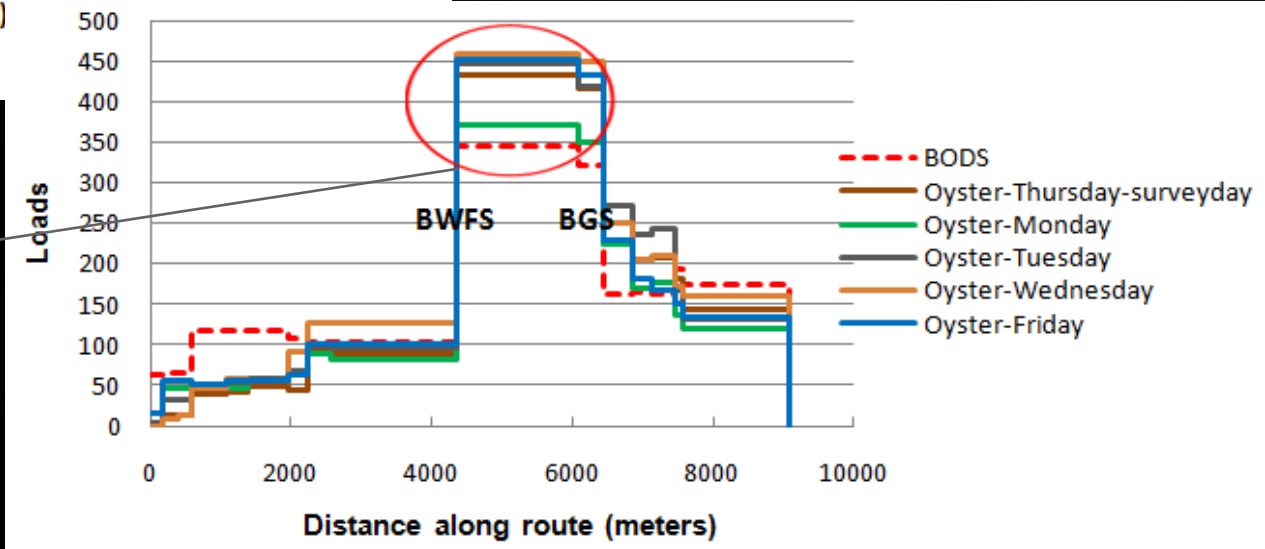
Weekday Load Profile Variation



(a) Northbound

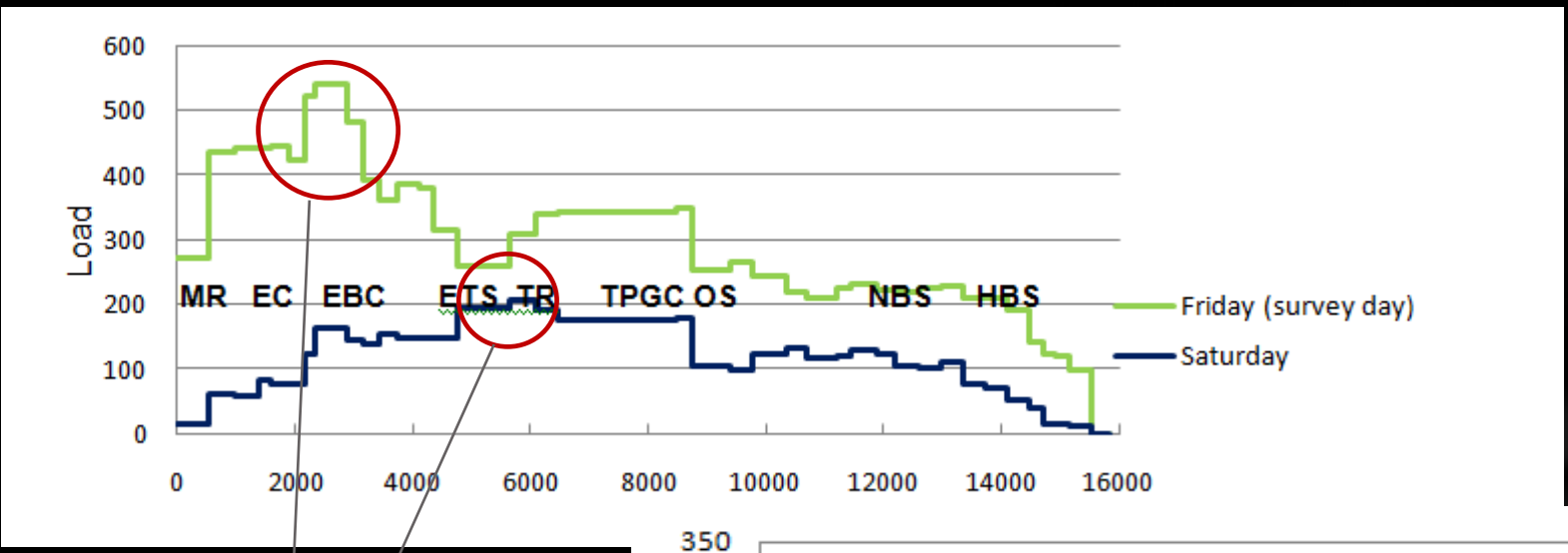
Load Profile Variation Across Days
--Route W4

different peak loads



(b) Southbound

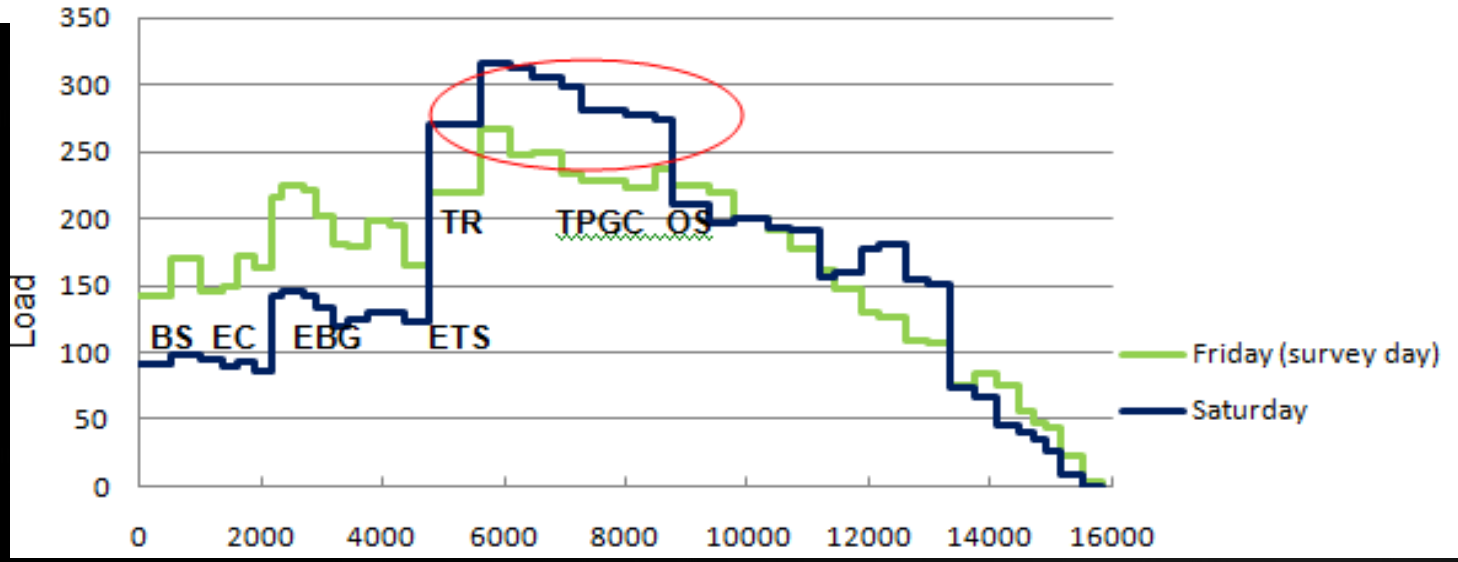
Weekday vs. Weekend Load Profile



AM Peak (Westbound)

Load profiles for Route 307

Different locations of peak loads
-- non-work purposes at weekend



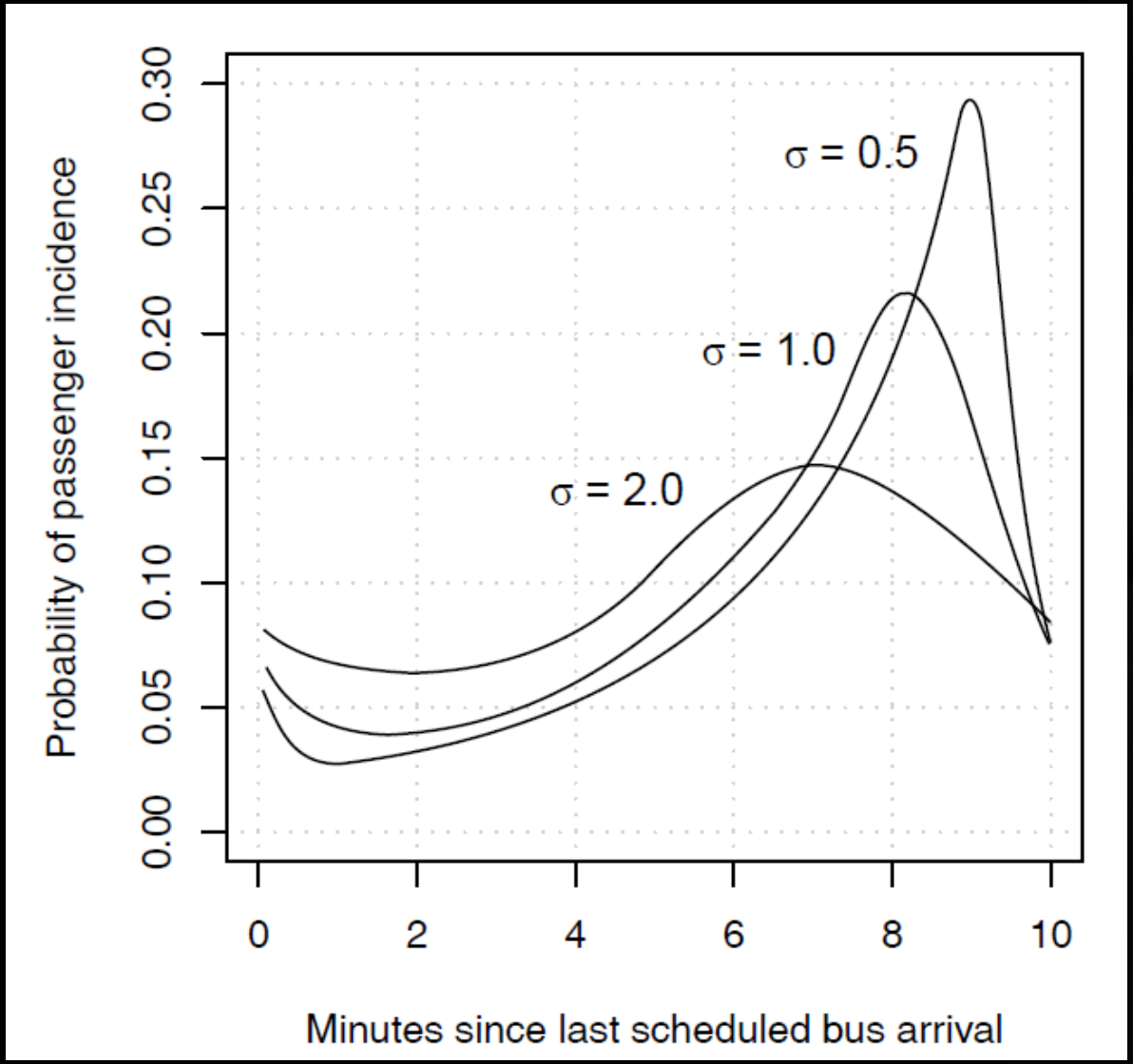
PM Peak (Westbound)

Analyzing Passenger Incidence Behavior
in Heterogeneous Transit Services Using Smartcard Data

Michael Frumin, Metropolitan Transportation Authority
Jinhua Zhao, University of British Columbia

Jan 25, 2012

Passenger Incidence Behavior



Incidence Behavior Categories

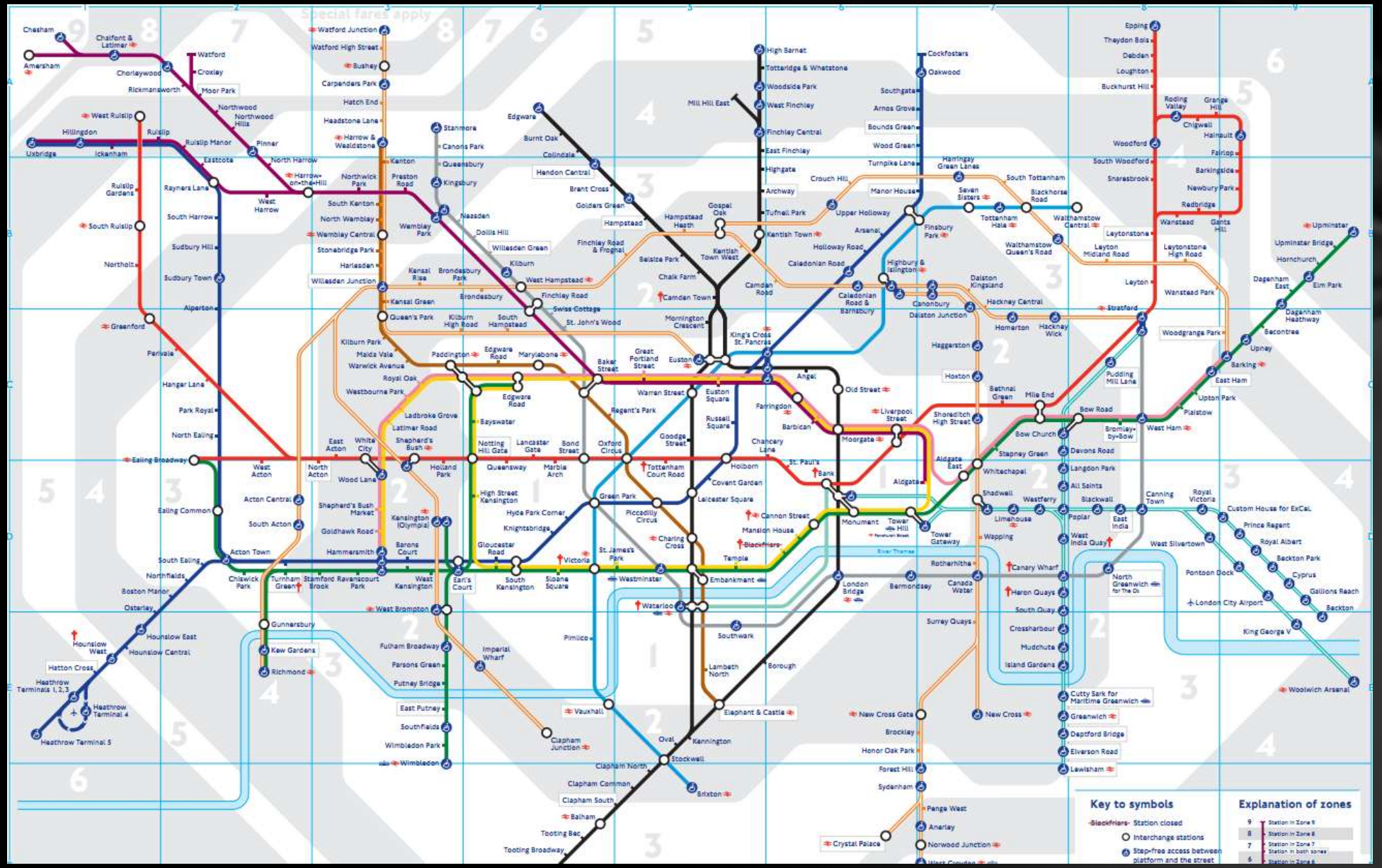
- Random incidence
- Timetable-dependent incidence

Influencing Factors

- Headway length
- Service reliability
- Awareness
- Need to save time

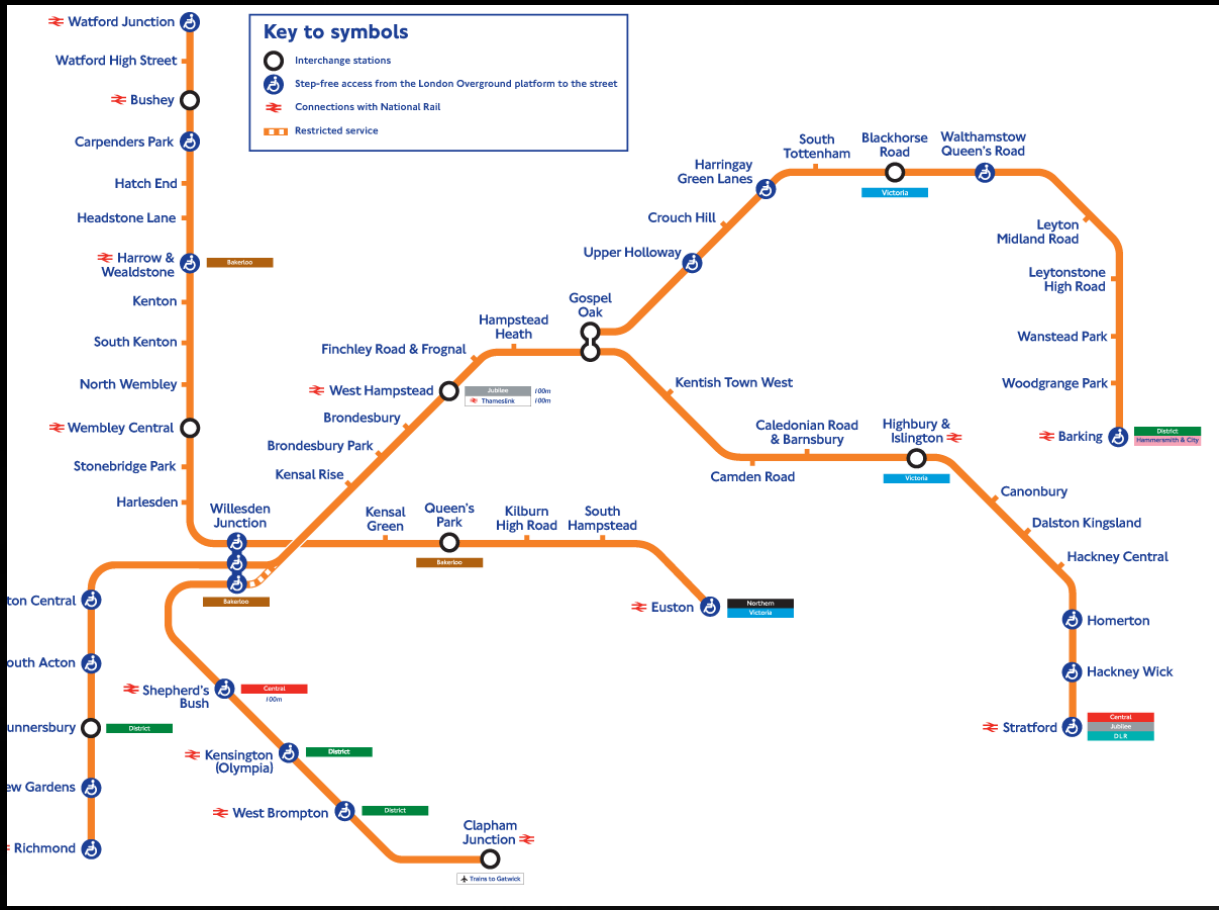
Adopted from Bowman and Turnquist (1981)

Transport for London (TfL)



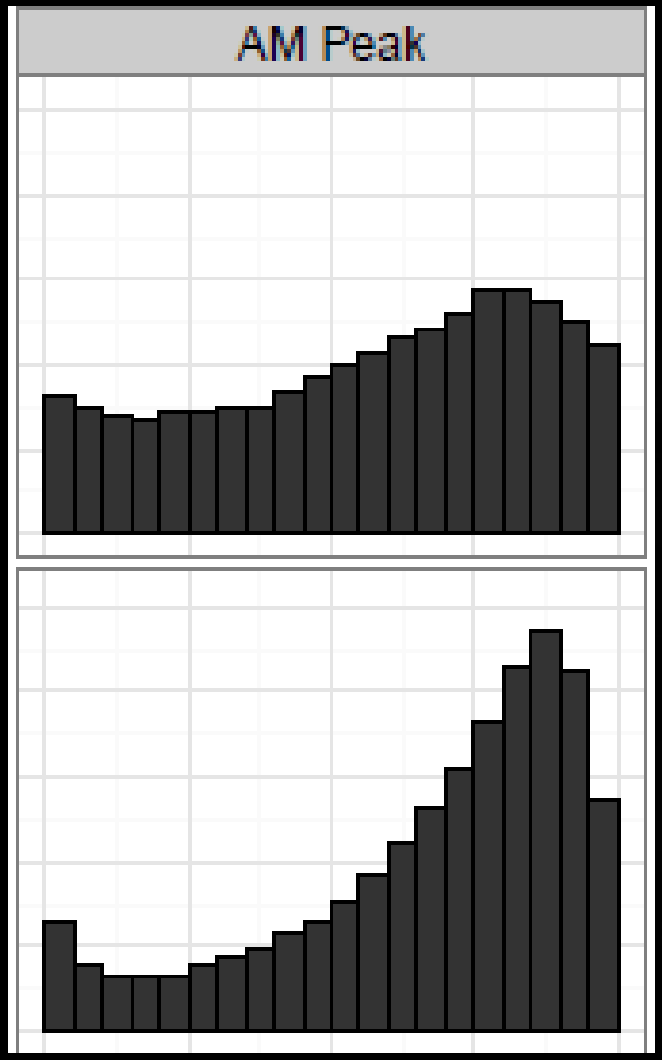
London Overground

- Circumferential services
- Zones 2 and 3
- Integrated with Underground and National Rail
  - 19 interchange stations
- 27 units of rolling stock
- 407 scheduled weekday train trips
- Silverlink → TfL in 2007



Service Pattern (Line)	Code	Primary Terminals	Frequency (Peak tph)
North London Line	NLL	Stratford ⇔ Richmond	4-6
Gospel Oak to Barking Line	GOB	Gospel Oak ⇔ Barking	3
Watford DC Line	WAT	Watford Junction ⇔ London Euston	3
West London Line	WLL	Clapham Junction ⇔ Willesden Junction	2-3

Passenger Incidence Distribution Comparison



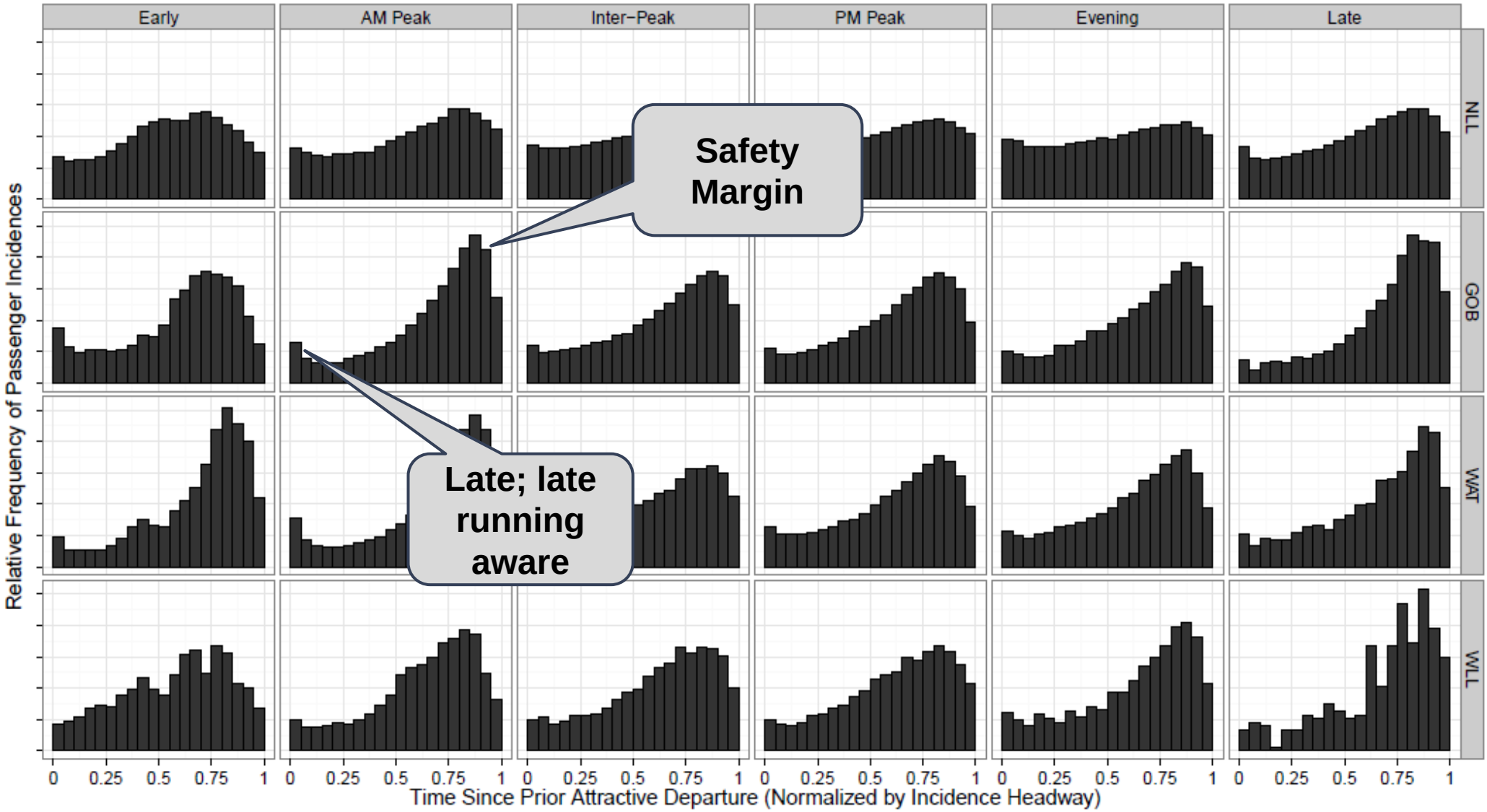
North London Line

- Shorter Headway
- Less reliable service

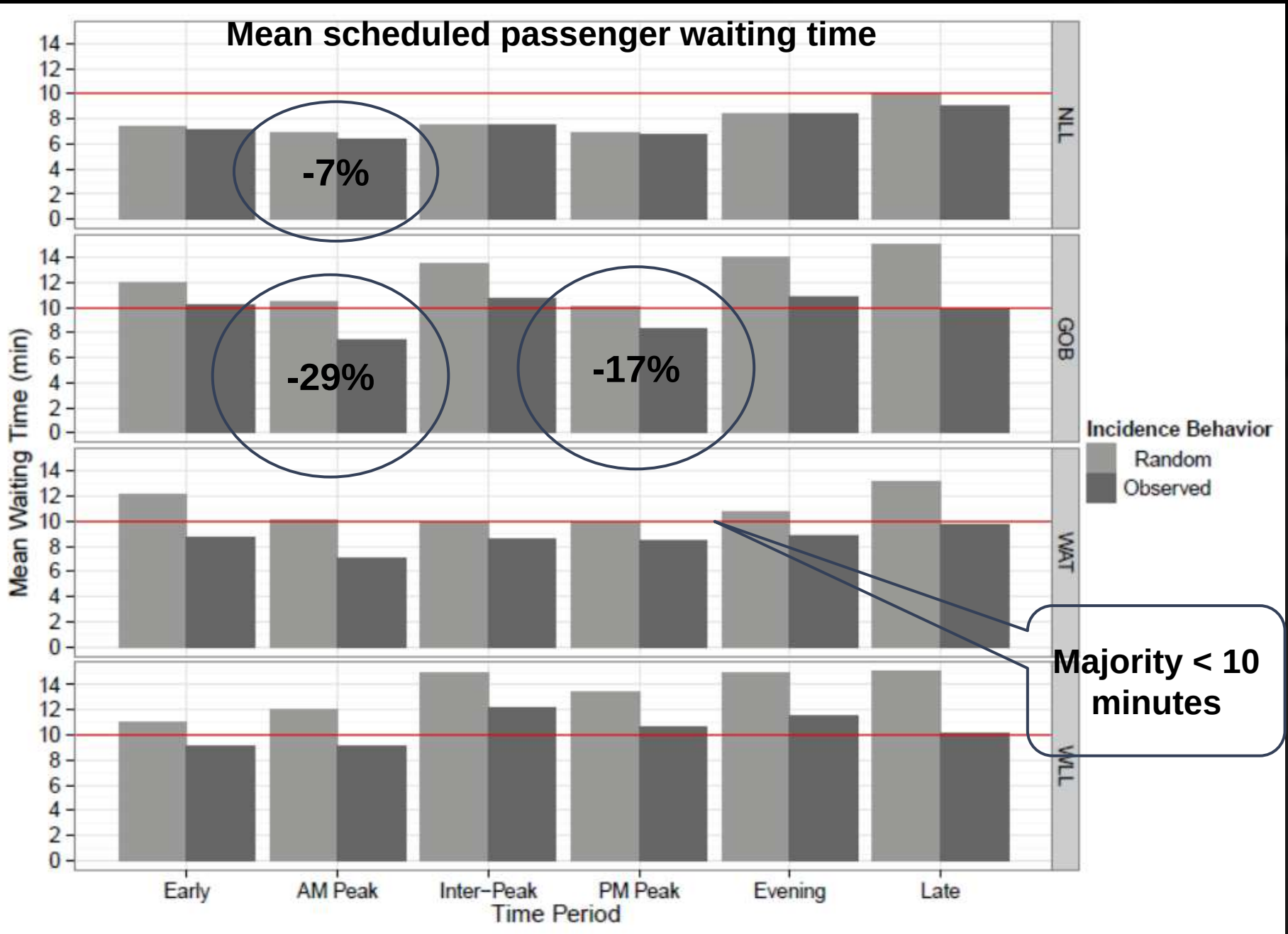
Gospel Oak to Barking Line

- Longer Headway
- More reliable service

Passenger Incidence Distribution by line and time



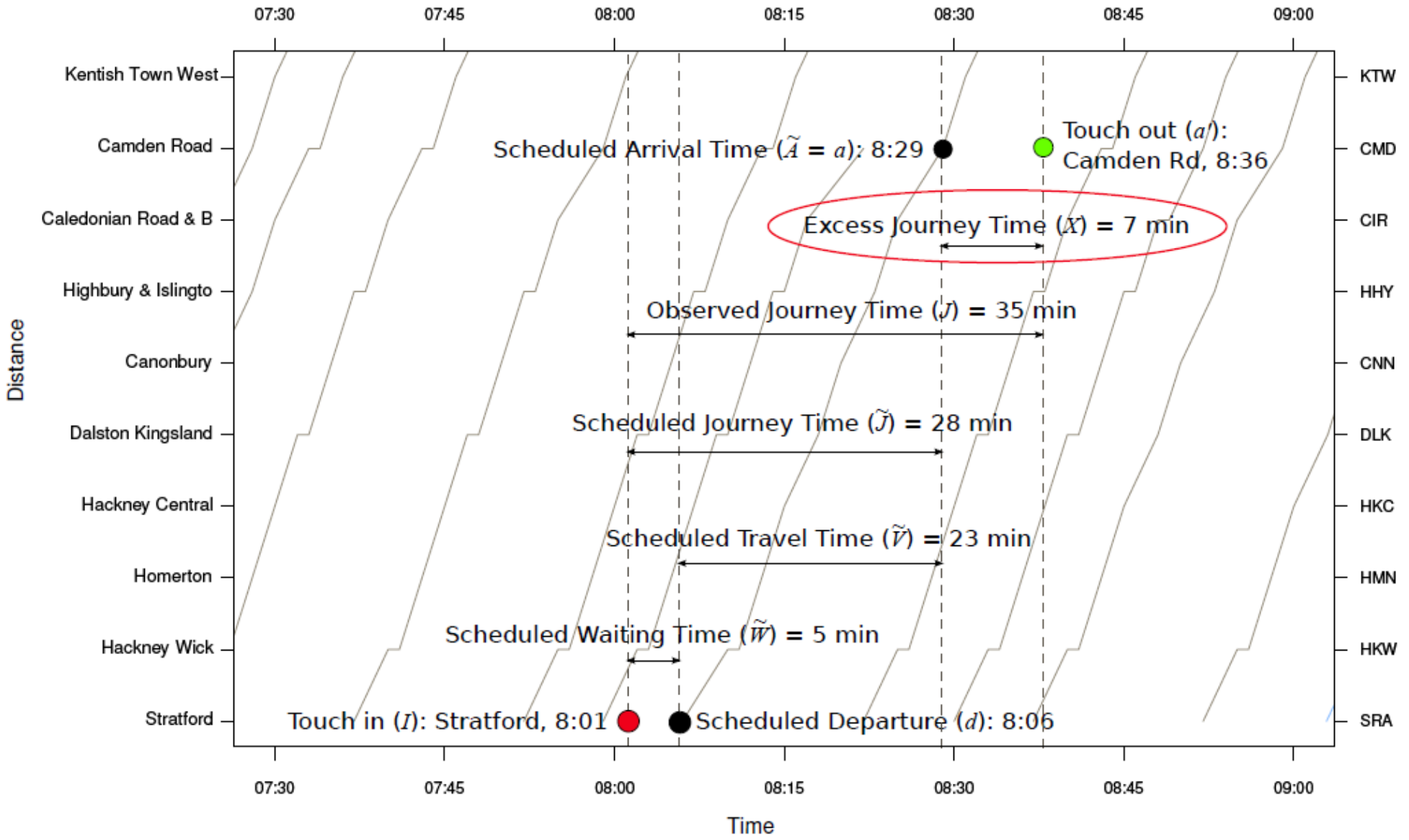
Random incidence vs. Observed Incidence

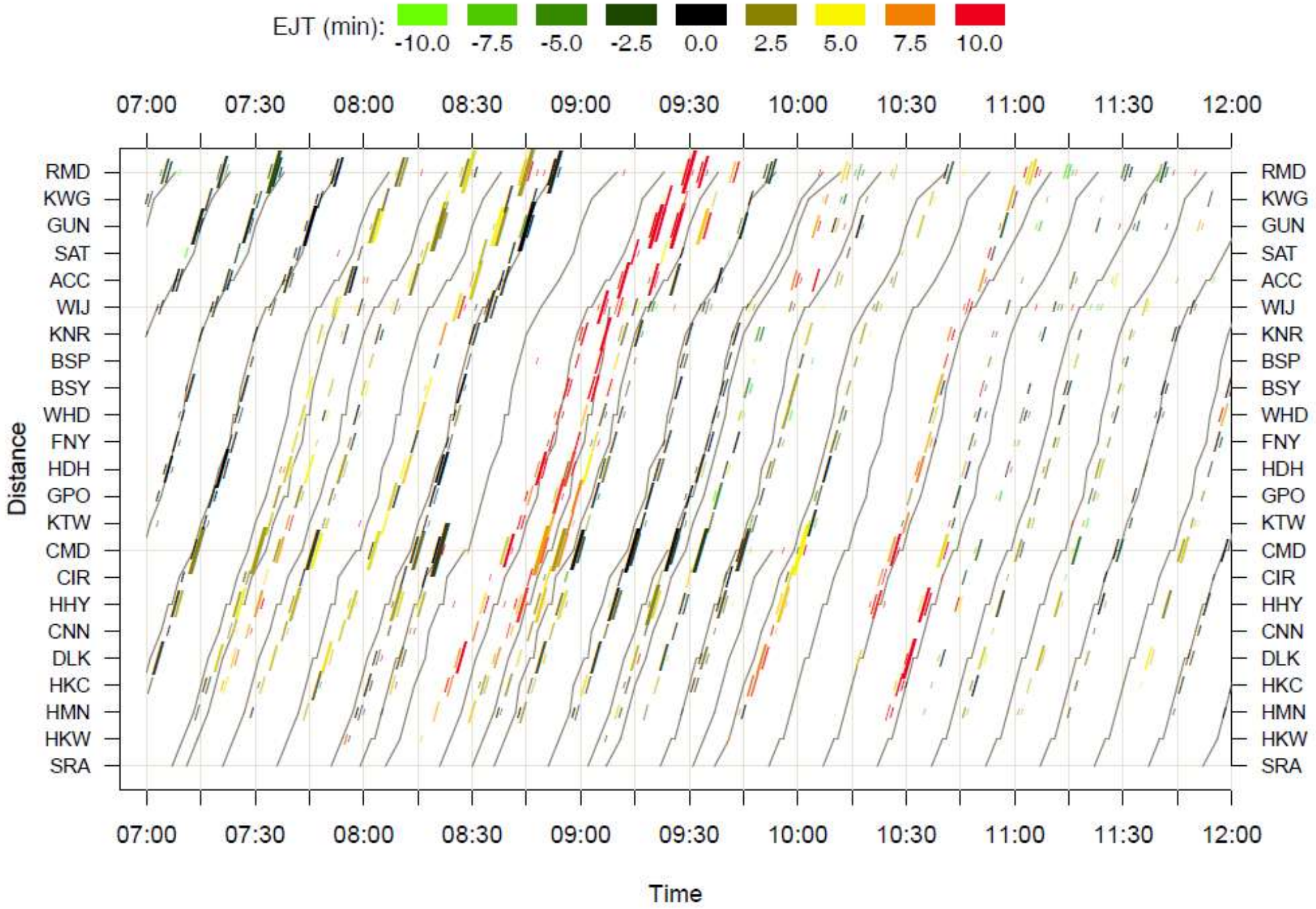


Excess Journey Time Estimation for the London Overground Network

Michael Frumin

Excess Journey Time Measured by Oyster Card Data




EJT (min):
-10.0
-7.5
-5.0
-2.5
0.0
2.5
5.0
7.5
10.0
07:00
07:30
08:00
08:30
09:00
09:30
10:00
10:30
11:00
11:30
12:00
RMD
KWG
GUN
SAT
ACC
WIJ
KNR
BSP
BSY
WHD
FNY
HDH
GPO
KTW
CMD
CIR
HHY
CNN
DLK
HKC
HMN
HKW
SRA
Distance
Time

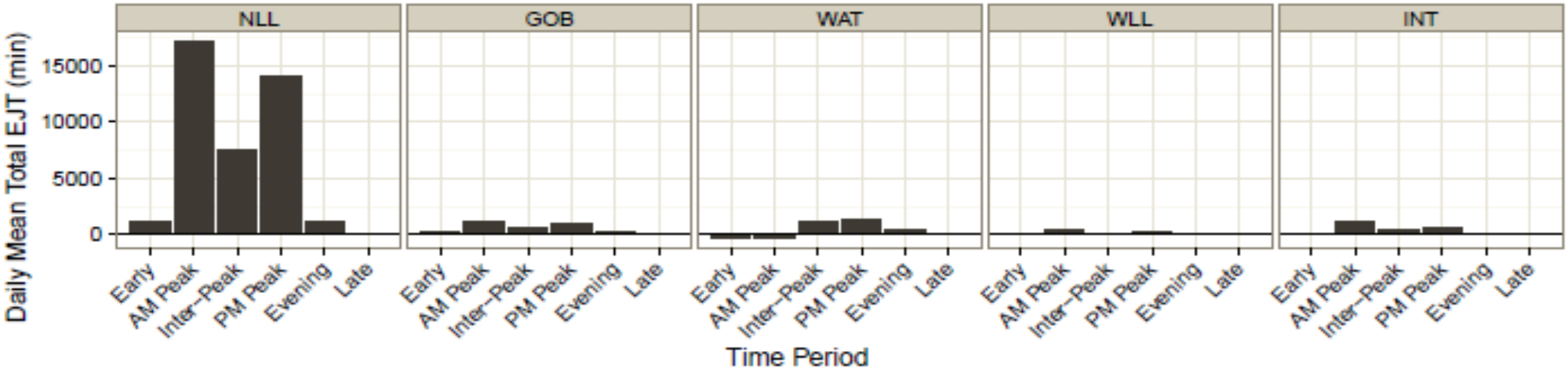


Figure 8-4: Total EJT, by line and time period

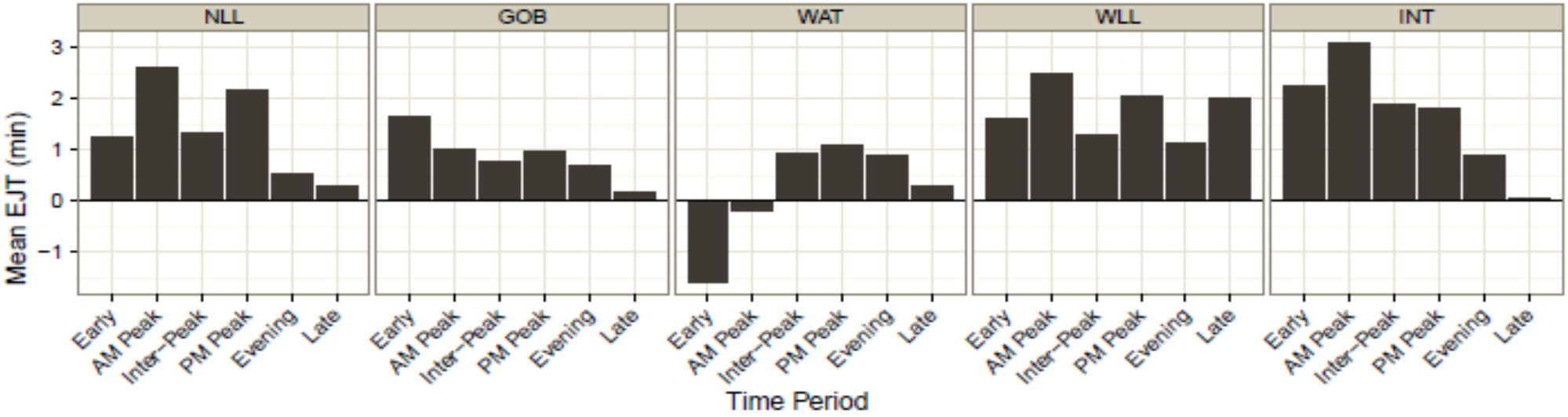


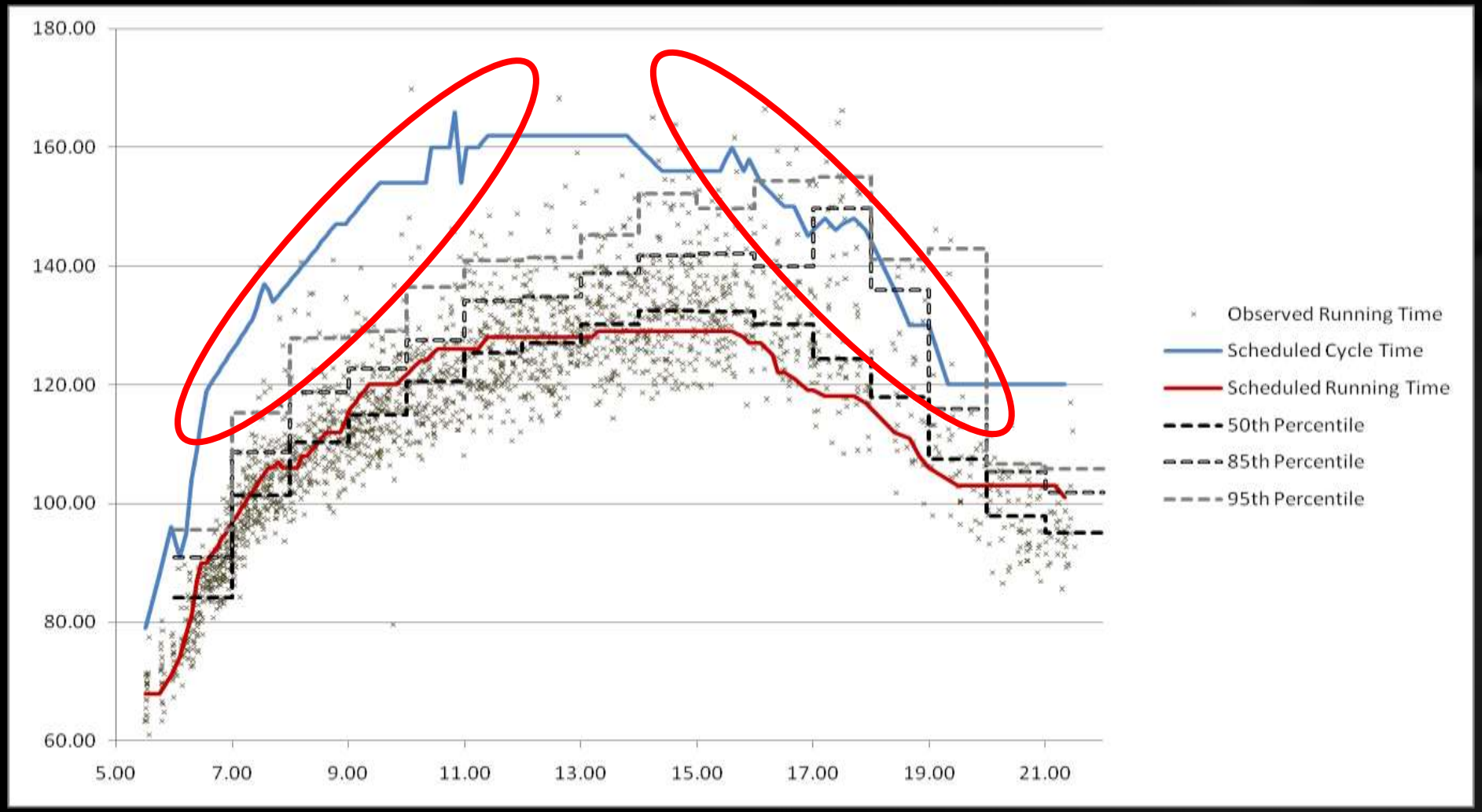
Figure 8-5: Mean EJT, by line and time period

Applications of iBus Data Towards Improving Service Reliability and Scheduling

Yossi Ehrlich

Bus Scheduling Analysis

Route 98



Service Reliability Measurement Framework using Smart Card Data: Application to the London Underground

David Uniman

Passenger perspective: OD Level

Excess Waiting Time

Excess In-Vehicle Travel Time

Excess Journey Time (EJT)

EJT = Median Journey Time – Scheduled Journey Time

Against an absolute standard

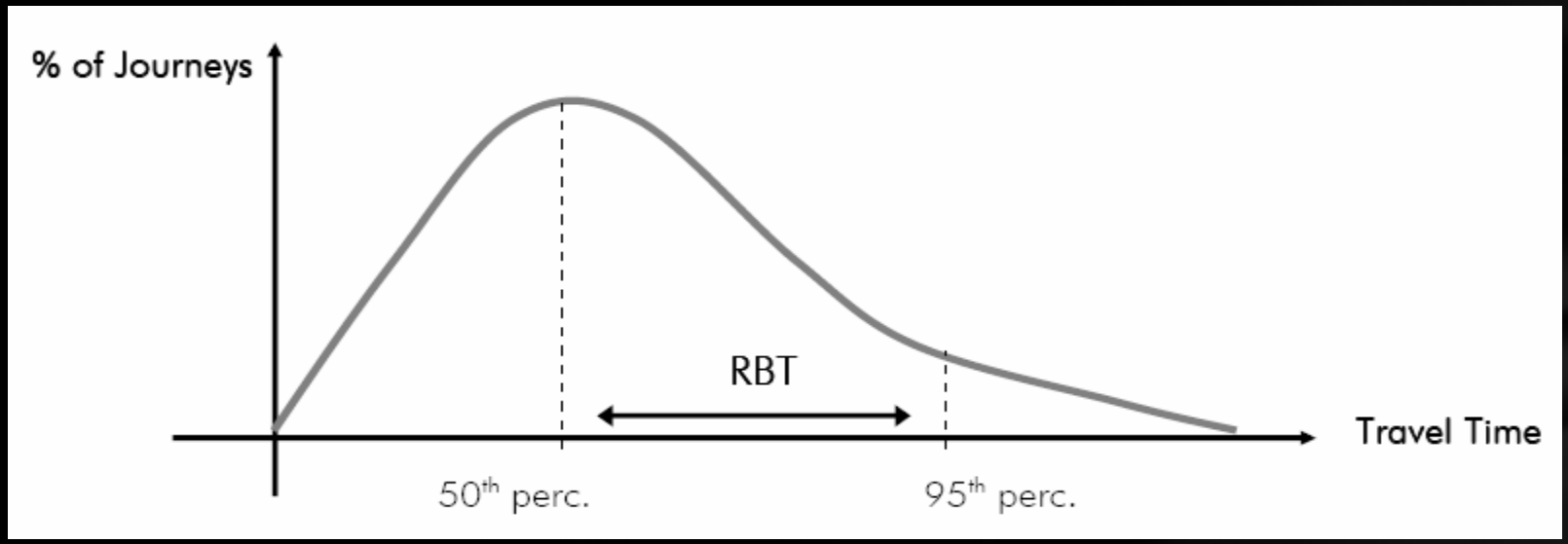
Reliability Buffer Time (RBT)

RBT = 95th percentile travel time – median travel time

Passenger Incidence Behavior

Relative to its own distribution

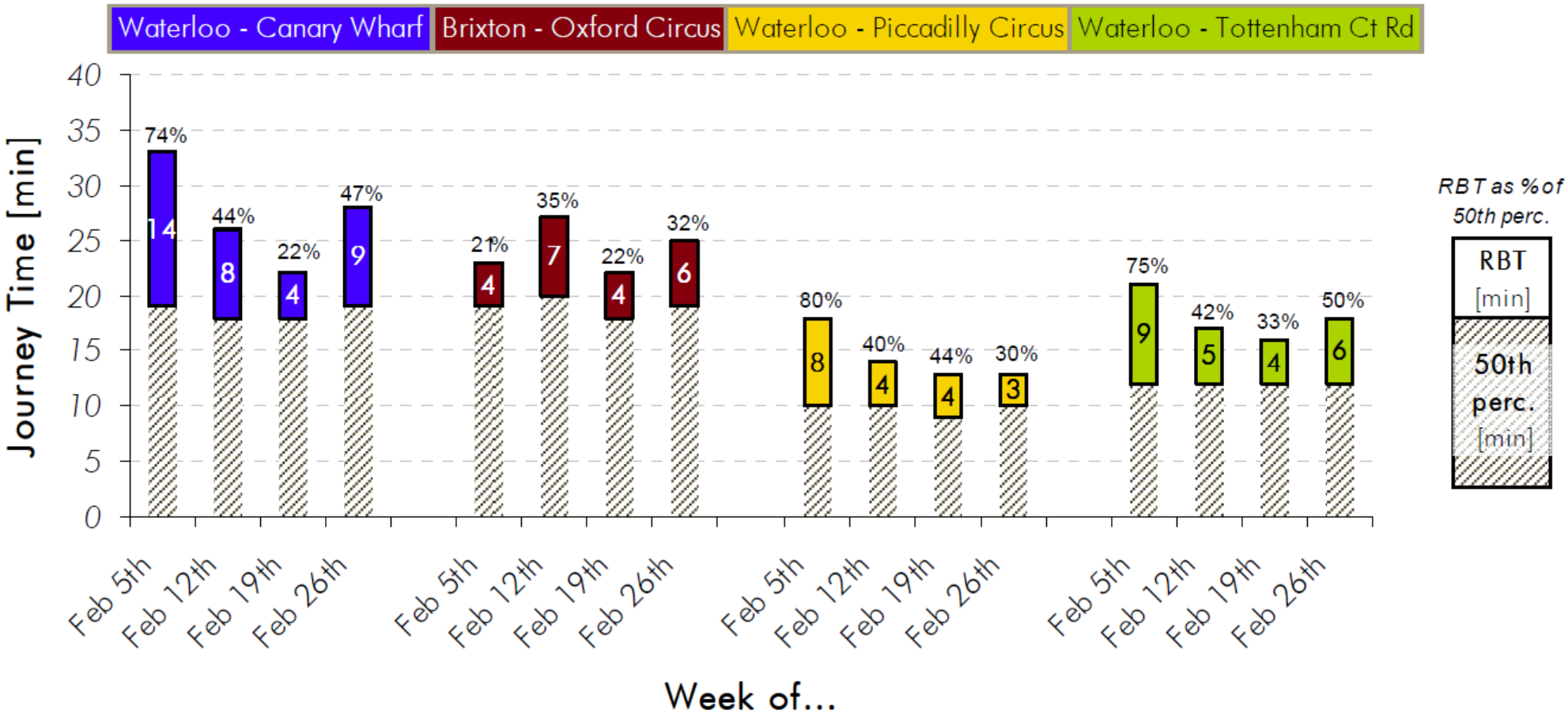
Reliability Buffer Time (RBT)



RBT = 95th percentile travel time – median travel time

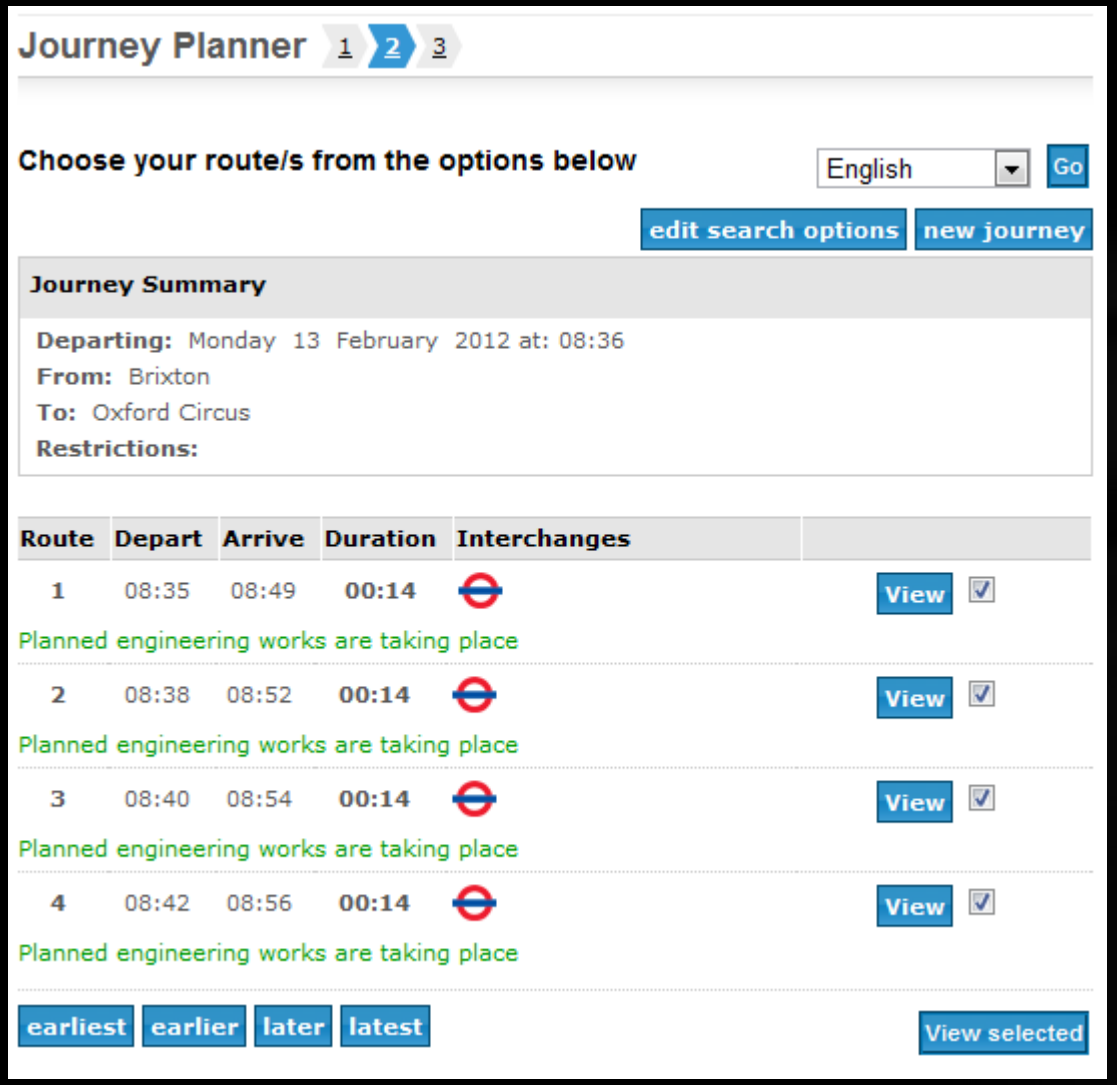
Additional time a passenger must budget to arrive late no more than 5% of the time

Weekly median journey time and the RBT



AM Peak, Feb. 2007

Journey Planners



Transport for London: http://journeyplanner.tfl.gov.uk

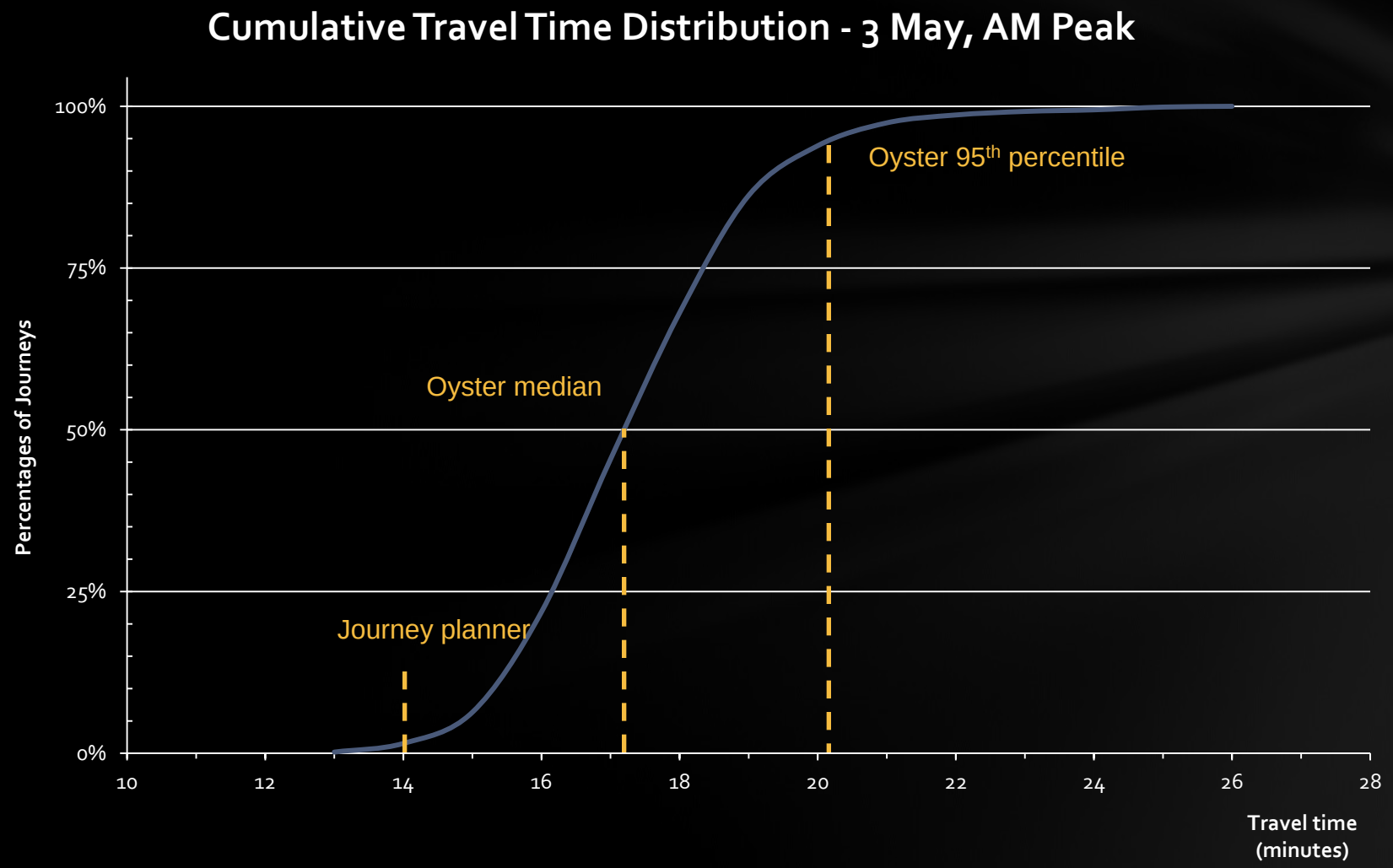
Translink:

http://tripplanning.translink.ca/

New York:

http://tripplanner.mta.info/MyTrip/ui_web/customplanner/tripplanner.aspx

Customer Information vs. Reality: Brixton to Oxford Circus (Victoria)



ADCS - Potential and Reality

Potential

- Integrated ADCS database
- Models and software to support many agency decisions using ADCS database
- Providing insight into normal operations, special events, unusual weather, etc.
- Provide large, long-time series disaggregate panel data for better understanding of travel behavior

Reality

- Most ADCS systems are implemented independently
- Data collection is ancillary to primary ADC function
  - AVL - emergency notification, stop announcements
  - AFC - fare collection and revenue protection
- Many problems to overcome:
  - not easy to integrate data
  - requires substantial resources

Connected Transit

Higher need, poorer reality

Speculations

Bus bunching

Bus and rail integration

Transit and car integration

Bus Priority

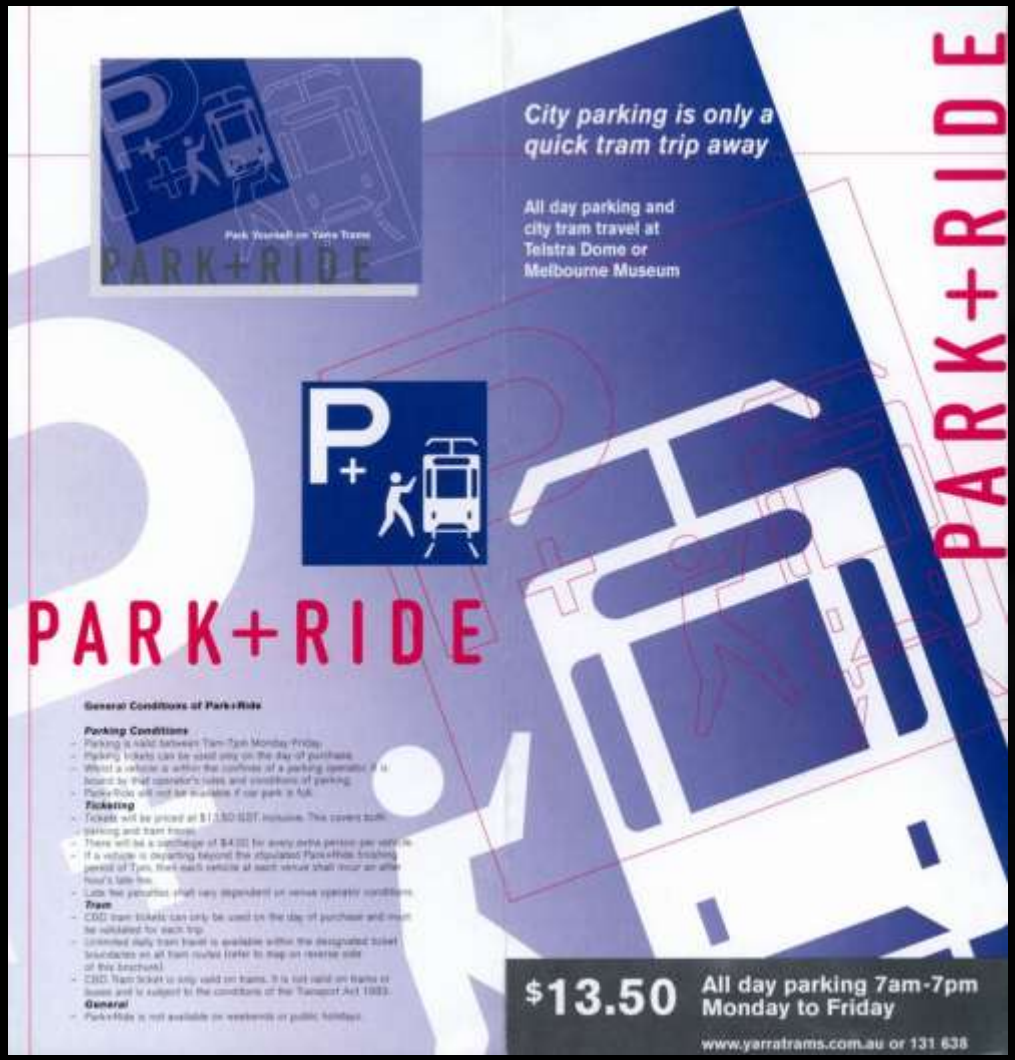
Dynamic Bus Priority

Straddling Bus

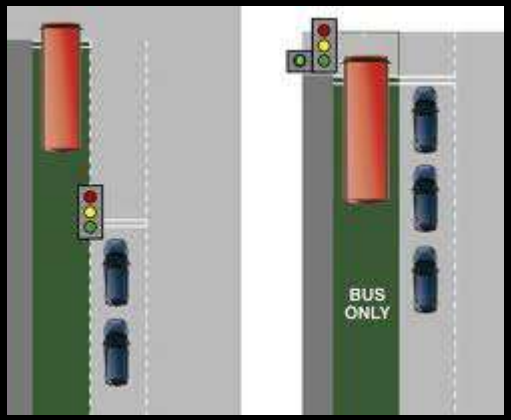
A late bus tends to get later…

Bus to rail/bus coordination

Park and Ride



Bus Priority / Bus Rapid Transit



Dynamic Bus Priority / Bus Lane

Dynamic Bus Priority / Bus Lane

Dynamic Road Marking

Dynamic Bus Priority / Bus Lane

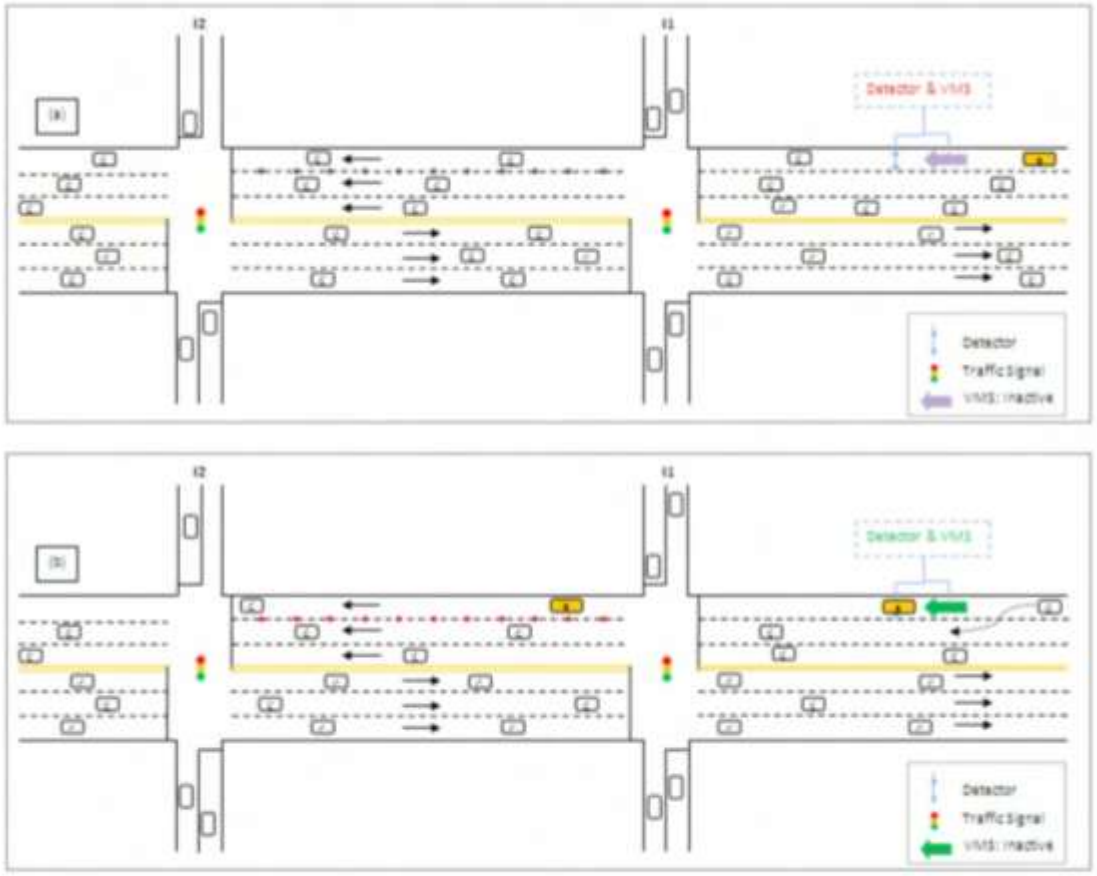


Figure 1 Structure of the dynamic bus lane

Straddling Bus

Straddling Bus

Straddling Bus

http://www.youtube.com/watch?v=Hv8_W2PAorQ

Emerging Possibilities

- Better understanding of Passenger Demand
  - OD / load / boarding and alighting
  - access distances / passenger arrival
  - response to service and fare changes at disaggregate level
- **New focus on reliability**
- More robust SOPs
- Operations management based on real-time data
- Realistic and meaningful customer information
- Combining multiple data sources: Oyster, iBus, train tracking, load weighing, entry/exit control, manual counts

Thank you!

Jinhua Zhao