Service Reliability Measurement using Oyster Data

- A Framework for the London Underground

David L. Uniman

MIT – TfL

January 2009

Introduction

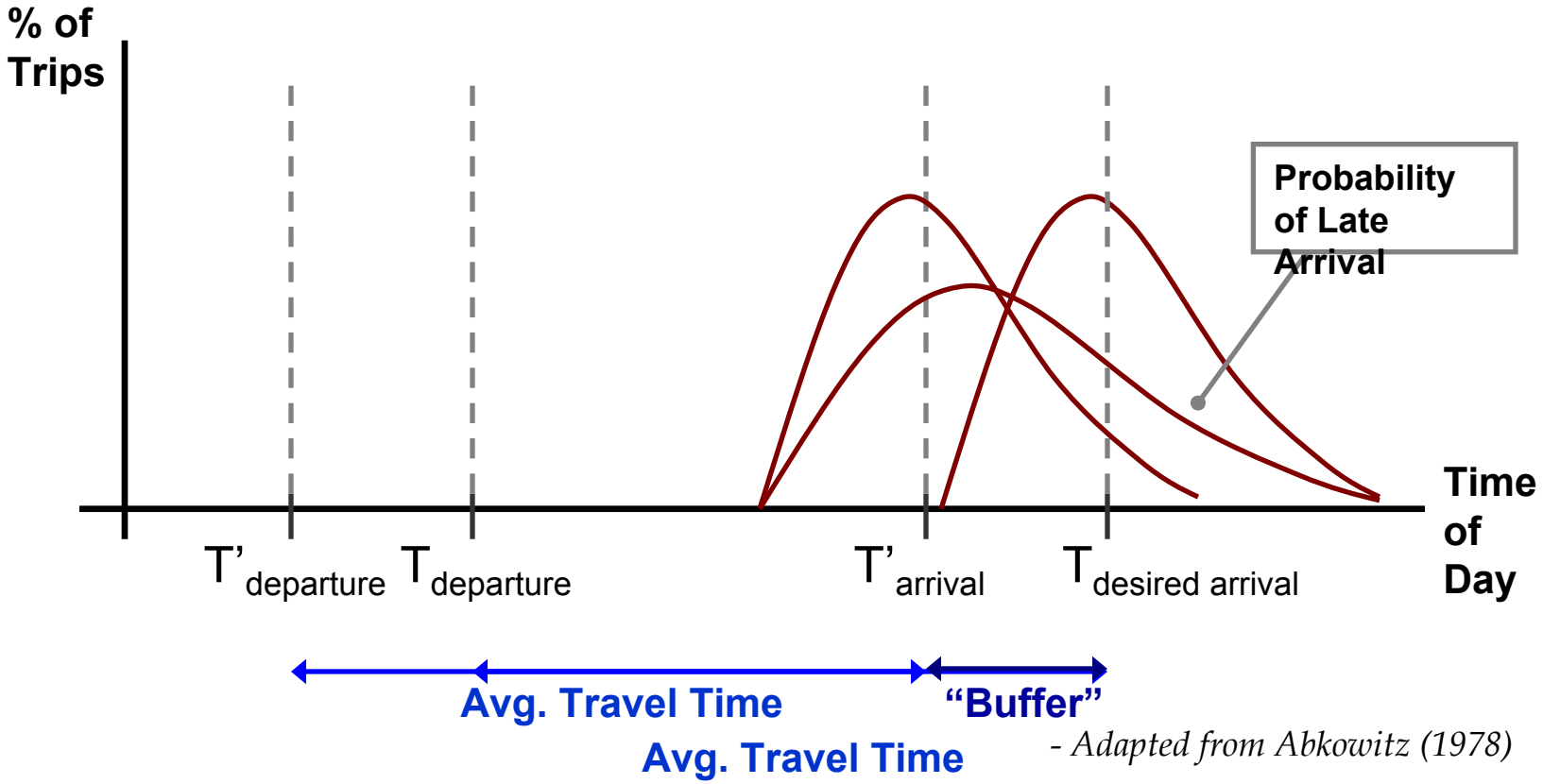
- **Research Objective**

  To develop a framework for quantifying reliability from the perspective of passengers using Oyster data that is useful for improving service quality on the Underground.

- How reliable is the Underground?
  - how do we *think* about reliability?
  - how do we *quantify* it?
  - how do we *understand* its causes?
  - how do we *improve* it?

Background – What is Service Reliability?

- Reliability means the degree of predictability of the service attributes including comfort, safety, and especially travel times.
  - Passengers are concerned with average travel times, but also with certainty of on-time arrival



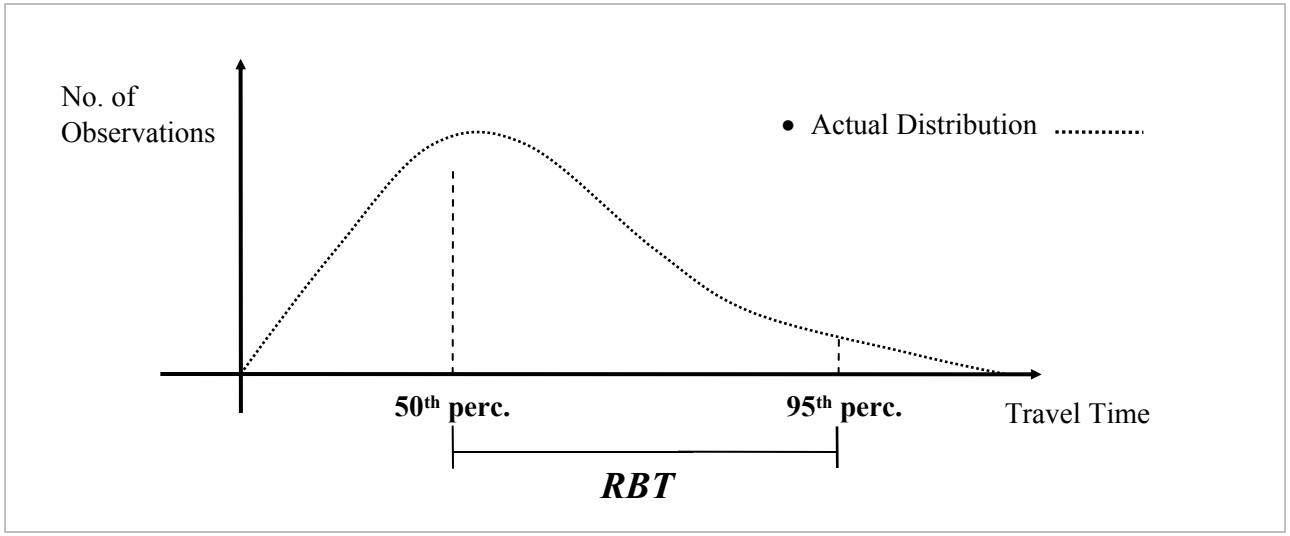
- Adapted from Abkowitz (1978)

Framework - Reliability Buffer Time Metric

- Criteria for Reliability Measure
  - Representative of passenger experience
  - Straightforward to estimate and interpret
  - Usefulness and applicability – compatible with JTM
- Propose the following measure: **Reliability Buffer Time (RBT) Metric**

  "The amount of time above the typical duration of a journey required to arrive on-time at one's destination with 95% certainty"

RBT = (95th percentile – 50th percentile)$_{\text{O-D, AM Peak, LUL Period}}$ sample size ≥ 20

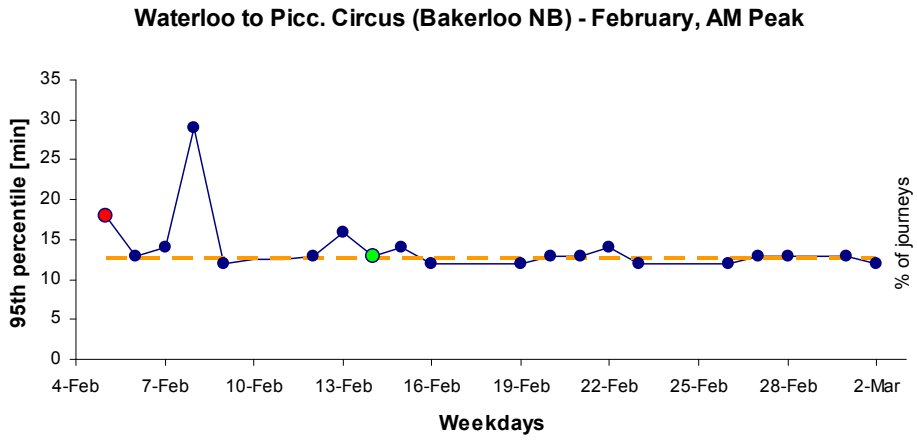


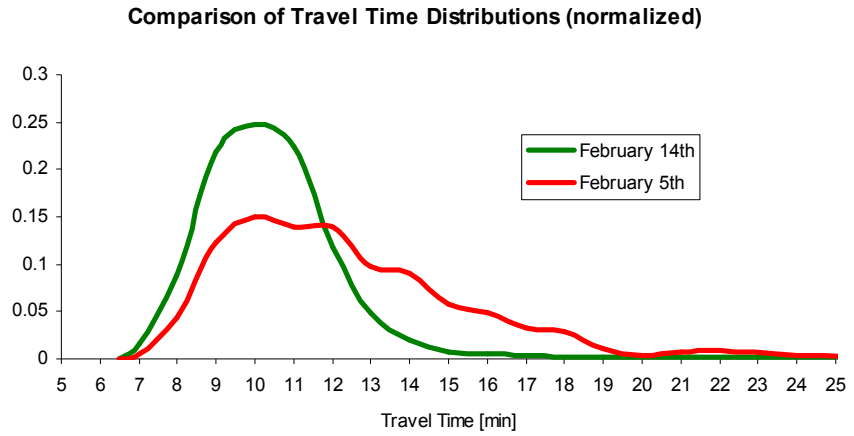
Framework – Separating Causes of Unreliability

- Two types of factors that influence reliability and affect the applicability & usefulness of the measure:

  1. Chan (2007) found evidence for the effects of **service characteristics** on travel time variability – impact on aggregation (e.g. Line Level measure)

  2. In this study, observed that reliability was sensitive to the performance of a few (3-4) days each Period, which showed large and non-recurring delays (believe **Incident-related**)





Framework – Classification of Performance

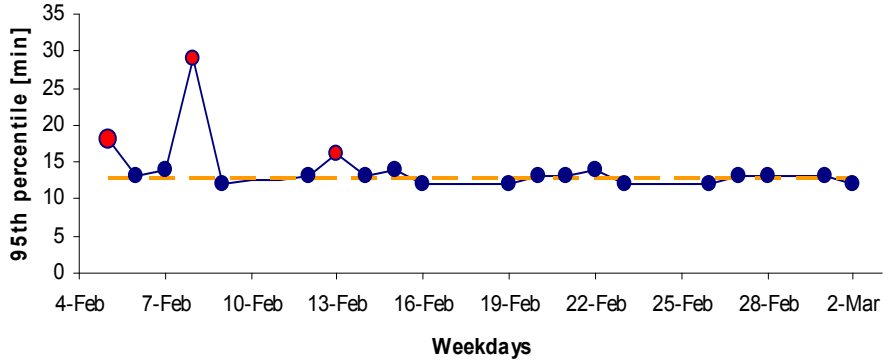
- Propose to classify performance into two categories along two dimensions – degree of recurrence and magnitude of delays
  - Relate to reliability factors and strategies to address them

Recurrent Reliability	Incident-Related Reliability
Day-to-day (systematic) performance	Unpredictable or Random (unsystematic) delays
Includes the effects of service characteristics and other repeatable factors (e.g. demand)	Unreliability caused by severe disruptions, additional to inherent levels of travel time variation
Can be considered as the Underground's potential reliability under "typical" conditions	Together with performance under "typical" conditions, makes up the actual passenger experience

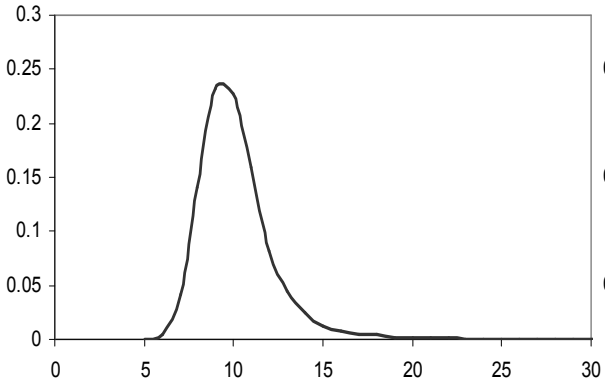
- Methodology – use a classification approach based on a Stepwise Regression to automate process

Framework – Classification of Performance

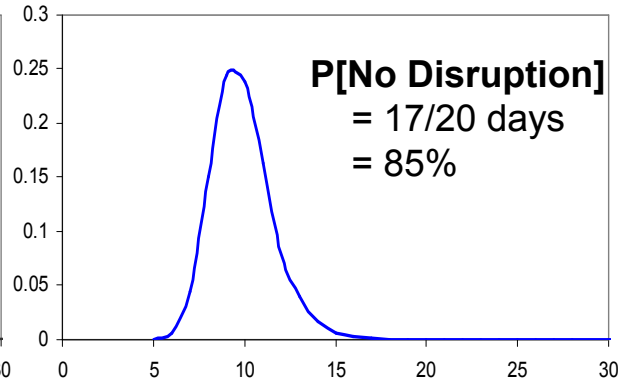
- **Bakerloo Line Example:** Waterloo to Piccadilly Circus – AM Peak, Feb. 2007



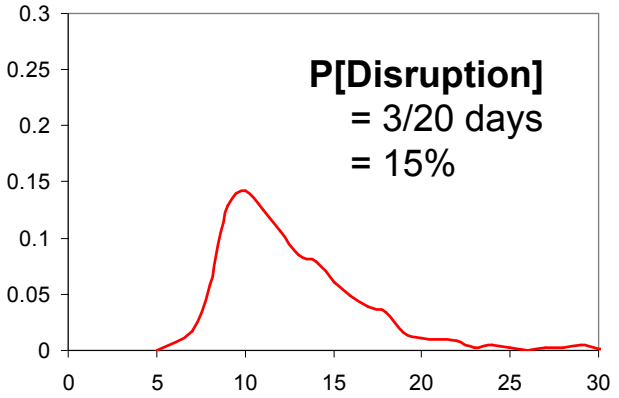
$$\mathbf{T.T.}_{\text{Actual}} = \mathbf{P}[\text{No Disruption}]*\mathbf{T.T.}_{\text{Recurrent}} + \mathbf{P}[\text{Disruption}]*\mathbf{T.T.}_{\text{Incident-related}}$$



$\mathbf{RBT}_{\text{Actual}}$ = 4-min



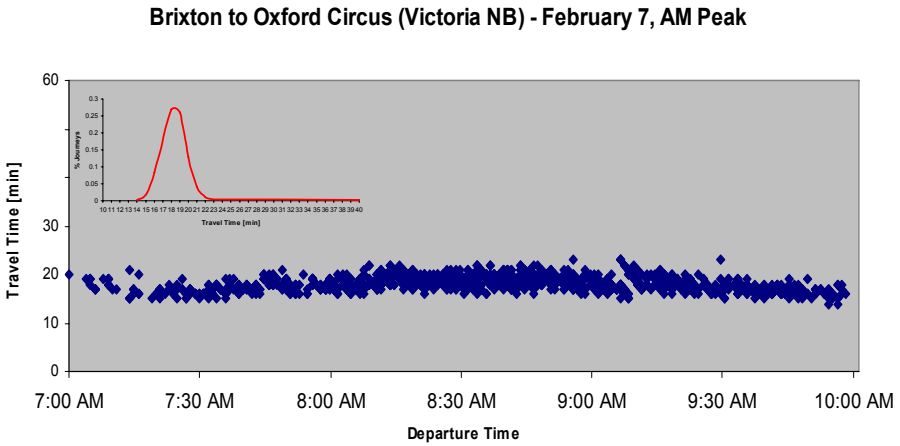
$\mathbf{RBT}_{\text{Recurrent}}$ = 3-min

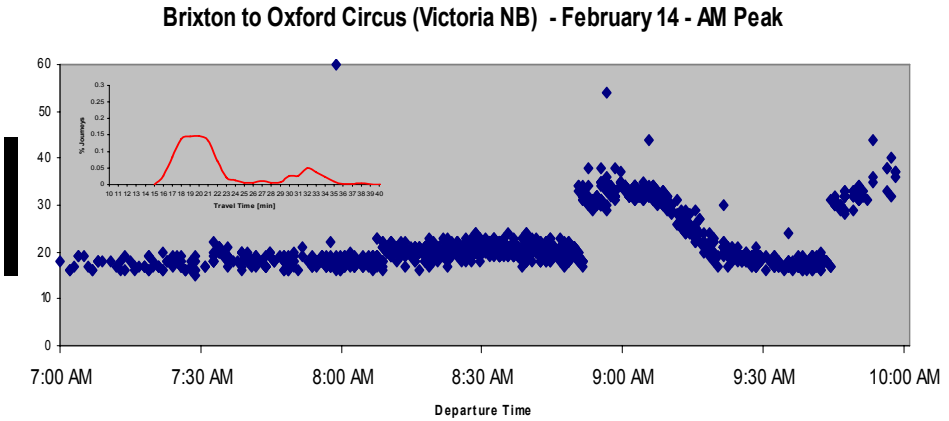


$\mathbf{RBT}_{\text{Incident-related}}$ = 10-min

Framework – Validation with Incident Log data

- Validation of **non-recurrent** performance with Incident Log data (from NACHs system) confirmed Incident-related disruptions as the primary cause





Date	Cause Code	Result	Indicative NAX's	Incident Start	Incident End
February 7	Fleet	Train Withdrawal	2.6124	7:02am	8:20am
February 7	Customer - PEA	Train Delay	3.5756	9:16am	9:19am

Date	Cause Code	Result	Indicative NAX's	Incident Start	Incident End
February 14	Customer - PEA	Train Delay	9.8803	8:03am	8:06am
February 14	Signals	Train Delay	47.8043	9:05am	9:16am
February 14	Signals	Partial Line Suspension	45.4703	9:57am	11:19am

Excess Reliability Buffer Time Metric

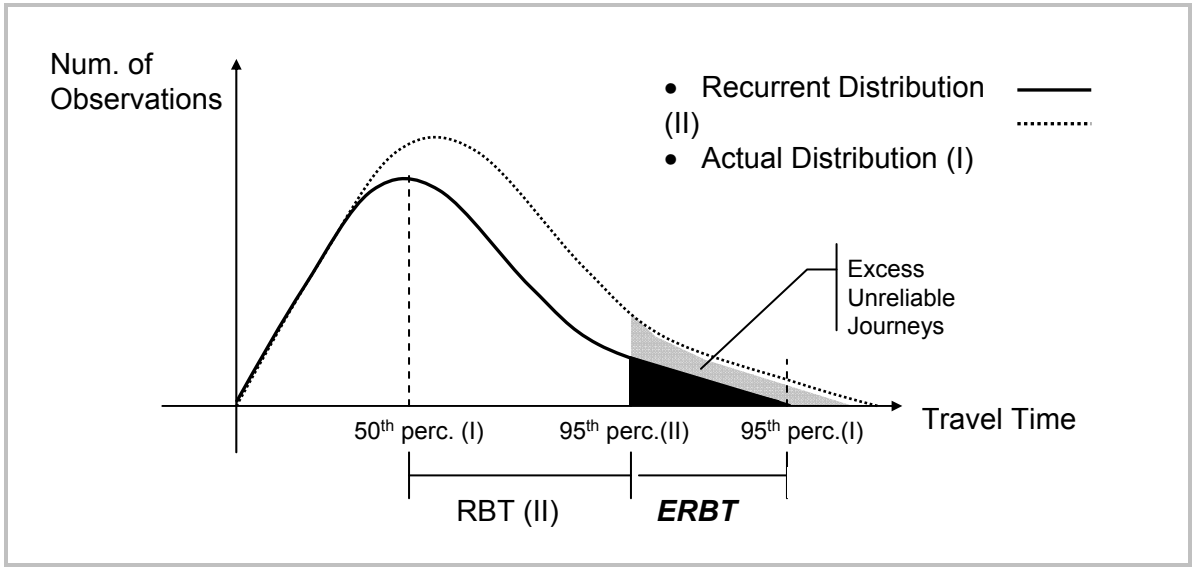
- Using these 2 performance categories, we can extend our reliability measure by comparing the **actual** performance with a **baseline** value

- Propose the following: **Excess Reliability Buffer Time (ERBT) Metric**

  "The amount of buffer time that passengers need to allow for to arrive on-time with 95% certainty, in excess of what it would have been under disruption-free conditions."

$$\textbf{ERBT} = (RBT_{Actual} - RBT_{Recurrent})_{\text{O-D, AM Peak, LUL Period}} \quad \text{sample size} \geq 20,$$

cumulative baseline

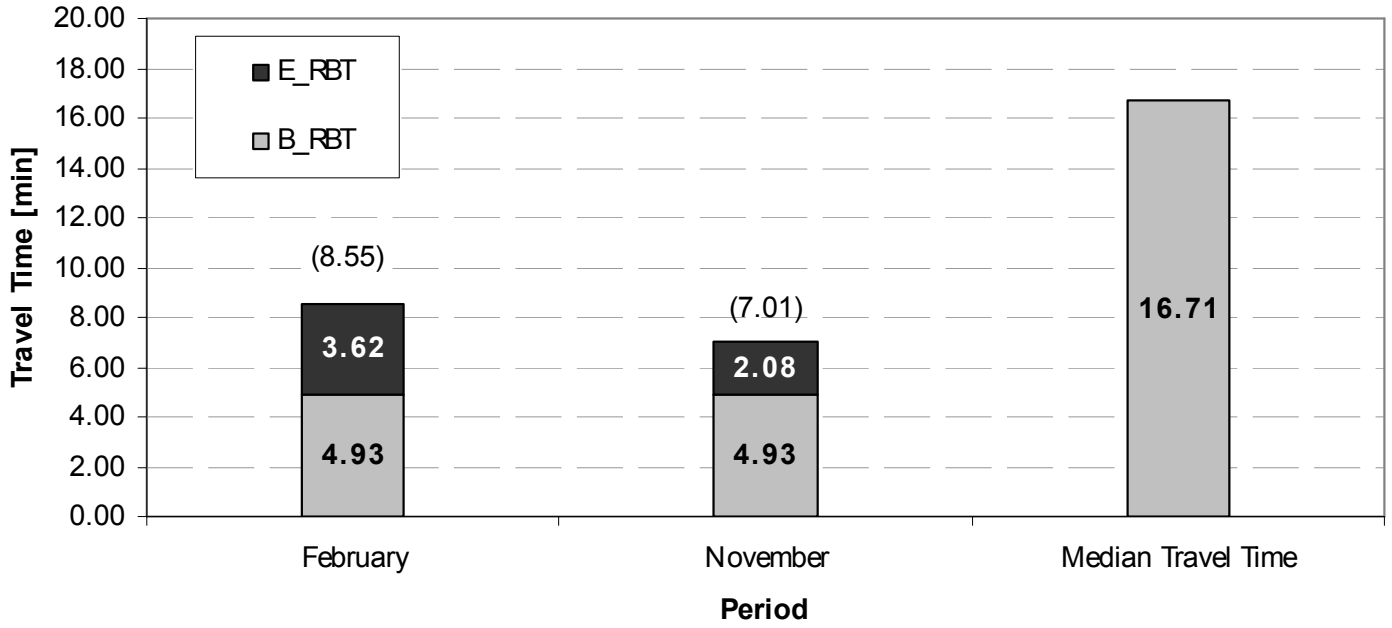


Application # 1 – JTM Reliability Addition

- Use measure for routine monitoring and evaluation of service quality – propose to include it within JTM as an additional component.
  - RBT form is compatible is JTM – units (min, pax-min), aggregation (Period, AM Peak, O-D), estimation (Actual, Scheduled, Excess & Weighted)

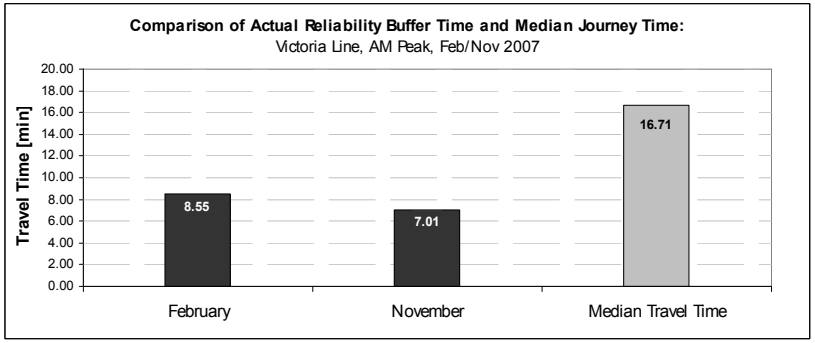
TPT | AEI | PWT | IVTT | C&I | RBT

- Apply RBT measure to Victoria Line – AM Peak, Feb. & Nov. 2007



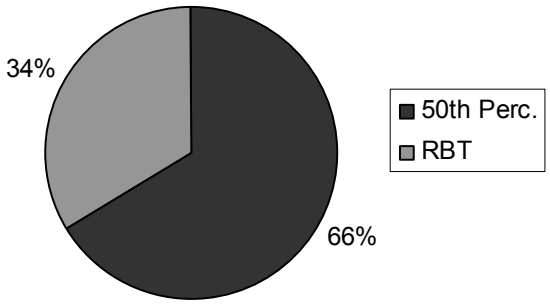
Application # 1 – JTM Reliability Addition

- Actual<u>W eighted</u> RBT value estimation
  - Contribution to Service Quality (i.e. Perceived Performance)

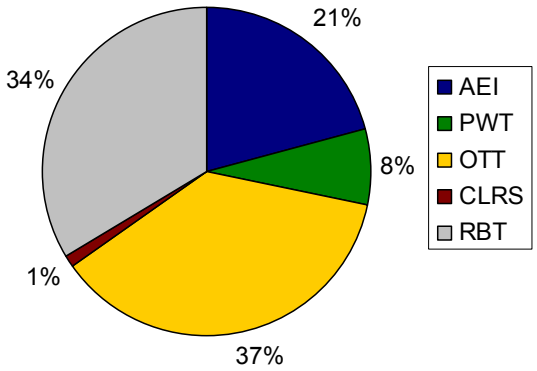


  - Compare contribution of RBT to other JTM components through VOT **– FEB. 2007**

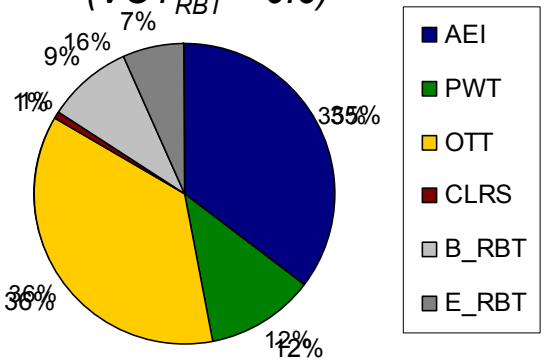
<u>Unweighted</u>
(VOT_{RBT} = 1.0)



<u>Unweighted, JTM Proportions*</u>
(VOT_{RBT} = 1.0)



<u>Weighted, JTM Proportions</u>
(VOT_{RBT} = 0.6)

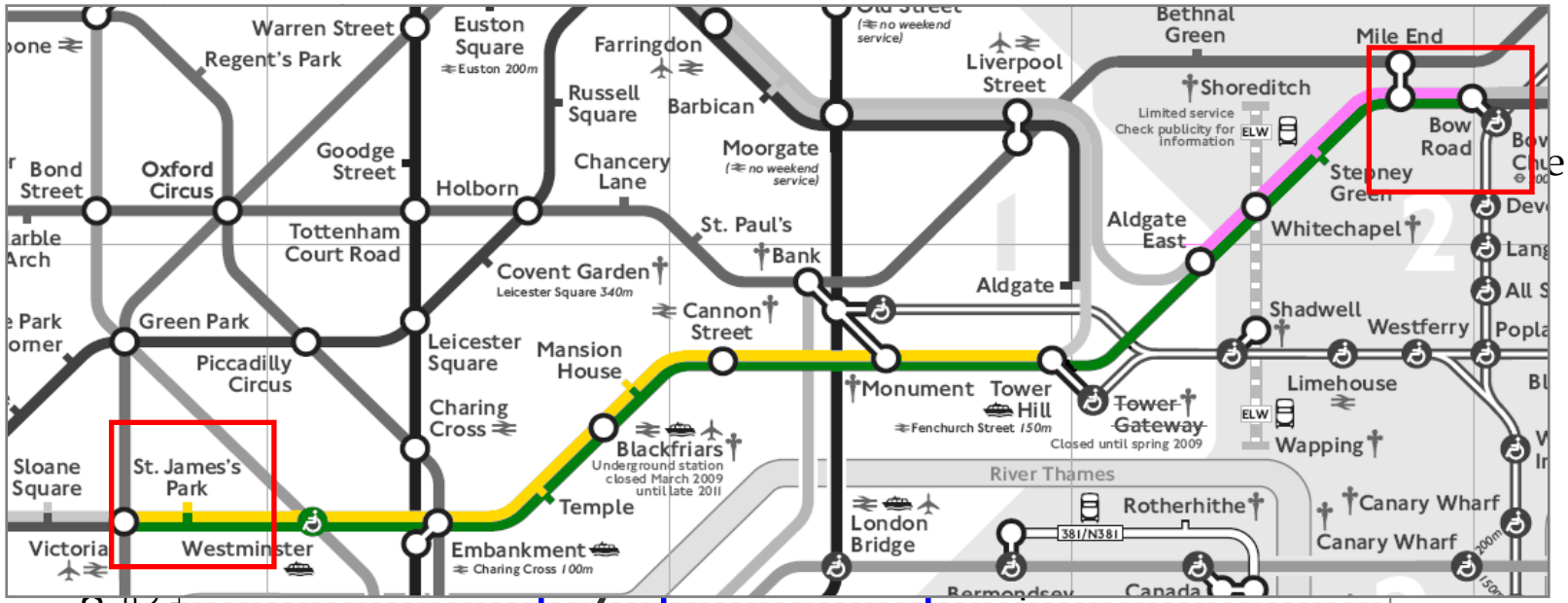


** total 101% due to rounding*

Application # 2 – Journey Planner Reliability Addition

- Better information reduces uncertainty by closing the gap between expectations and reality – improve reliability of service
  - ➢ Propose more **COMPLETE** information through **Journey Planner**

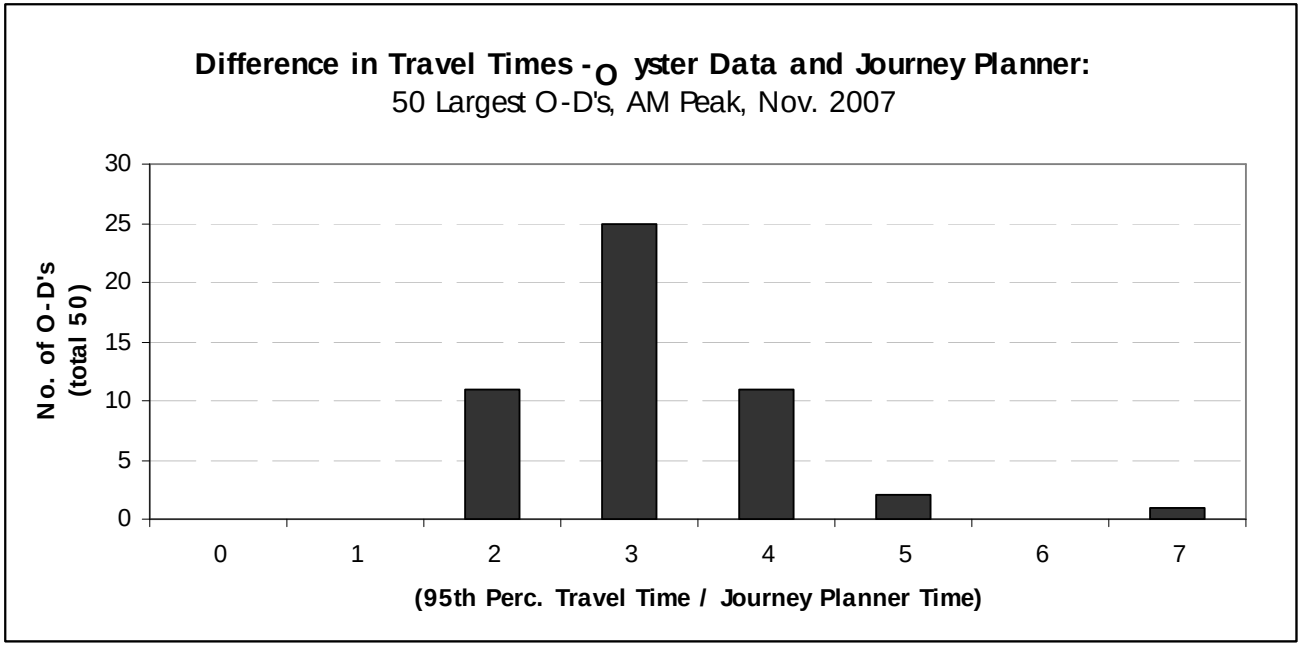
SIMPLE EXAMPLE: David's morning commute – **Bow Road** to **St. James' Park**



Route	Depart	Arrive	Duration	Interchanges	
1	08:31	08:56	00:25		View ☑
2	08:36	09:00	00:24		View ☑

Application # 2 – Journey Planner Reliability Addition

- Assessment: Journey Planner information is INCOMPLETE in 2 ways:
  1. Journey Planner consistently underpredicts Oyster journey times - possibly AET & PWT – leaves around 30-50% of journey to chance
  2. Expected journey times not helpful for passengers concerned with on-time arrival (e.g. commuters)



Application # 2 – Journey Planner Reliability Addition

- Possible representation of new journey information:

SIMPLE EXAMPLE: David's morning commute – **Bow Road** to **St. James' Park**

Journey Summary

Departing: Wednesday 14 January 2009 at: 08:30
From: Bow Road
To: St James's Park
Restrictions:

Route	Depart	Arrive	Duration	Interchanges	
1	08:27	08:52	00:25		View
2	08:31	08:56	00:25		View

Chose to:

Depart at… →

Arrive by… →

Route	Depart	Expected Arrival	Latest Arrival	Duration *(up to)*	Interchanges	
1	08:27	08:57	09:11	00:30 *(00:41)*		View
2	08:19	08:49	09:00	00:30 *(00:41)*		View

Conclusions & Recommendations

1. Reliability is an important part of service quality, relative to average performance, and should be accounted for explicitly.
   - ✓ **Monitor and evaluate reliability through JTM Extension**

2. Incidents have a large impact on service quality through unreliability, which may be underestimated through focus on average performance.
   - ✓ **Use Oyster and Reliability Framework to improve monitoring and understanding through NACHs (measurement vs. estimate)**

3. The impacts of unreliability on passengers can be mitigated through better information.
   - ✓ **Update travel information and include reliability alternative in Journey Planner**

Conclusions & Recommendations

4. In order to manage performance, we need to be able to measure it first.

   ✓ **Framework contributes to making this possible, and sheds light on some of the broader questions…**

- How reliable is the Underground?
  - how do we *think* about reliability?
  - how do we *quantify* it?
  - how do we *understand* its causes?
  - how do we *improve* it?

Thank You

• Special thanks to people at TfL and LUL that made this research possible and a memorable experience

1.258J / 11.541J / ESD.226J Public Transportation Systems

Spring 2010