

# **Transit Service Reliability**

by

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# Motivation

- **Unreliability is seen as a widespread problem**
  - **Passenger impacts**
    - **Longer wait times**
    - **Need for trip time reliability buffer**
    - **More perceived crowding**
  - **Agency impacts:**
    - **Increased costs**
    - **Reduced ridership and revenue**
    - **Reduced operator morale**
    - **Public and political problem**
    - **Reduced effective capacity**

# Motivation

- **With Automated Data Collection Systems (AVL, AFC, APC) we can now measure reliability**
- **Automated scheduling systems make it easier to revise schedules**
- **Improved communications makes it easier to change service plan in real time**
- **Pressure is on for improvement ...**

# Problem Complexity

- **Reliability is not the only service dimension of value, also have:**
  - **Speed/trip time**
  - **Productivity**
- **Reliability means different things:**
  - **To different customers**
  - **On different services**
- **A single measure of effectiveness focused on reliability may lead to poor decisions**

**BUT**

- **We do need to measure performance *wrt* reliability**

# Different Service Types

## **A. Low Frequency Service (typically defined as headways greater than 10-15 minutes)**

- **Most customers time their arrival at stops/stations based on expected service departure times (e.g. schedule)**
- **On-time performance is critical, for example:**
  - **1 minute early to 5 minutes late**
  - **0 minutes early to 3 minutes late**
  - **0 minutes early to 1 minutes late**
- **Little interaction between successive vehicles**

# Different Service Types

## B. High Frequency Service

- Most customers do not time their arrival at stops with service departures
- Expected wait time =  $F(\text{mean and variance of headways})$
- On-time performance not so critical
- Extensive interaction between successive vehicles:
  - Vehicle bunching
  - Long gaps

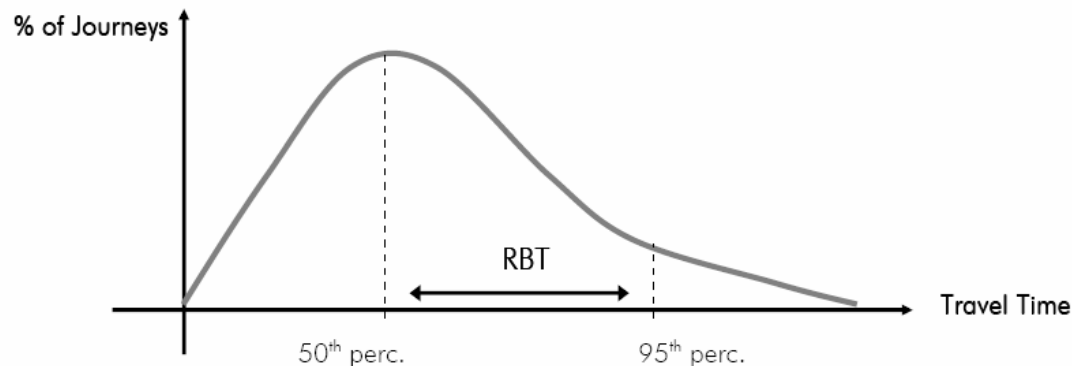
## **BUT**

- Many high frequency routes have branches and short route variants
- So many customers may still behave like those on low frequency routes
- Schedule control is much easier than headway control.....

# Reliability Metrics - Rail

## A. High Frequency Service

- use tap-in and tap-out times to measure actual station-station journey times
- characterize journey time distributions measures such as Reliability Buffer Time (at O-D level):

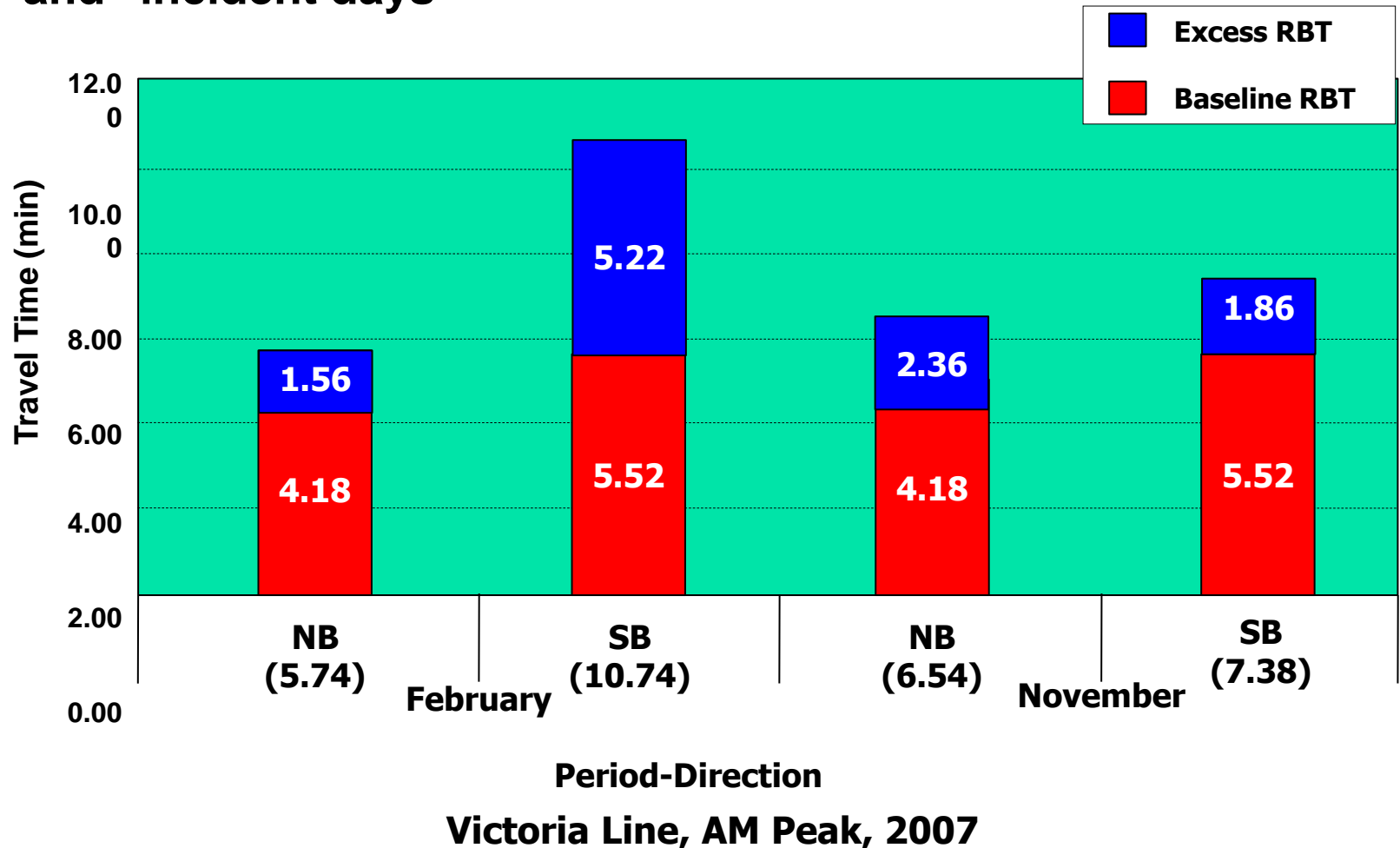


**RBT = 95th percentile travel time – median travel time**

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

# Reliability Metrics - Rail

- Aggregate to line level by distinguishing between "normal" and "incident days"



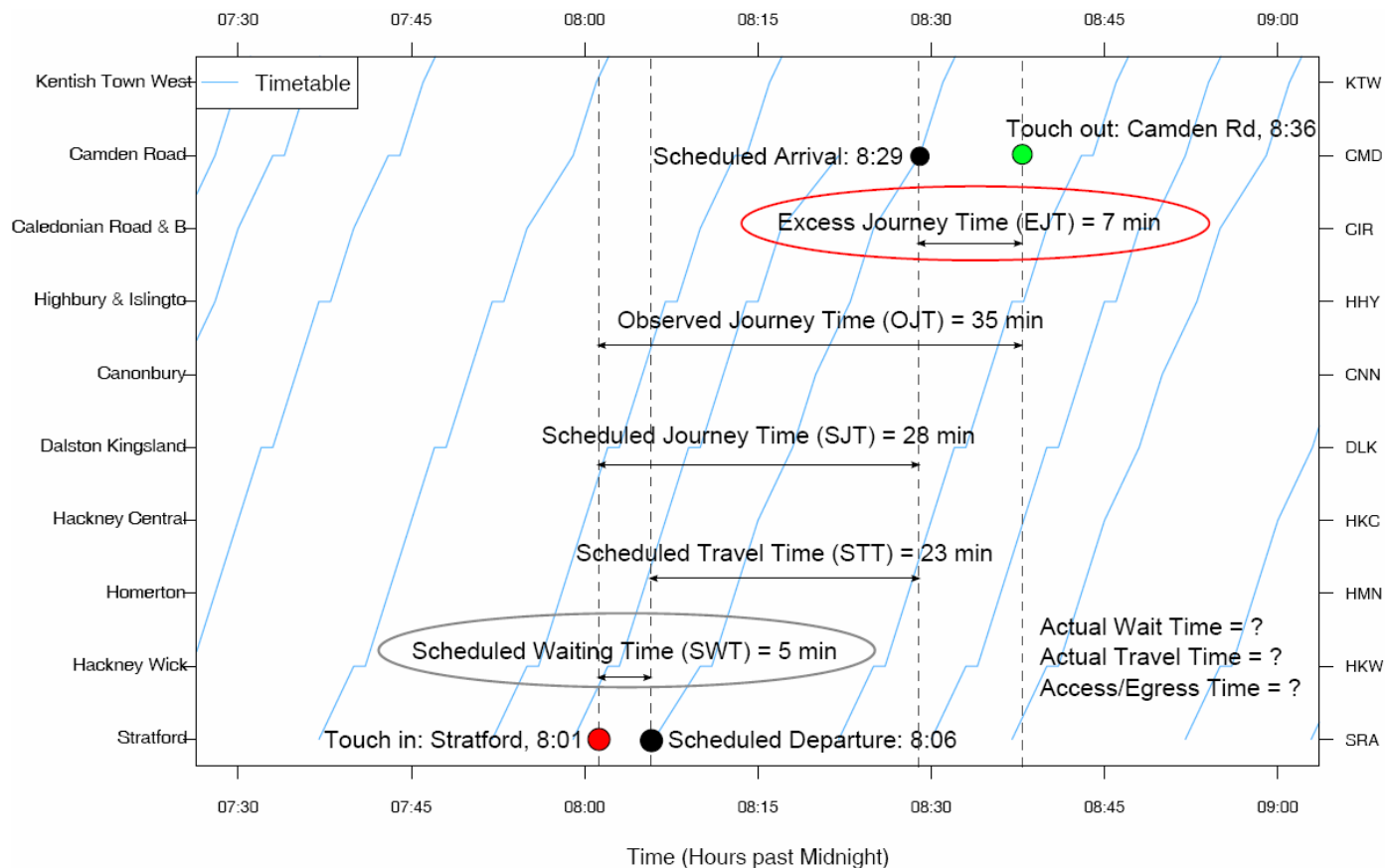
Source: David Uniman, MST thesis, MIT 2009. "Service Reliability Measurement Framework using Smart Card Data: Application to the London Underground."



# Reliability Metrics - Rail

## B. Low-Frequency Service

- compare actual journey times with scheduled times
- compare actual journey times



# Reliability Metrics - Bus

**In contracted service delivery context, need to distinguish between:**

- A. Contractor performance: measure against contracted service expectations**
- B. Performance as seen by passenger**

**If service is unreliable, the passenger doesn't care whether the problem was caused by traffic or poor operator behavior, but the authority must be sure which caused the problem.**

# Reliability Metrics - Bus

**Challenge to measure passenger journey time because:**

- (typically) no tap-off, just tap-on
- tap-on occurs after wait at stop, but wait is an important part of journey time

**Strategy to use:**

- trip-chaining to infer destination for all possible boardings
- AVL to estimate:
  - average passenger wait time (based on assumed passenger arrival process)
  - actual in-vehicle time

# Summary Information on London Application

- **Oyster fare transactions/day:**
  - Rail (Underground, Overground, National Rail): 6 million (entry & exit)
  - Bus: 6 million (entry only)
- **For bus:**
  - Origin inference rate: 95%
  - Destination inference rate: 80-82%
- **Computation time not an issue (even for London)**

# Reliability Framework: Strategies

## Preventive

- **Maintain normal service; robust operating plans**
- **Reduce probability of problems occurring**

## Corrective

- **Return to normal service once problems arise**
- **Minimize impact on passengers**

# Reliability Framework: Preventive Strategies

- Reserve fleet of drivers and vehicles
- Exclusive bus lanes
- Fare payment off-bus
- Traffic signal priority
- Route design strategies: shorter routes, less stops
- Schedule planning
- Supervision

**BRT does much of this**

# Impact of Schedules

## Critical decisions:

- **Cycle time/half cycle time: impacts cost and terminal departure reliability**
  - Allocation of time between running and recovery time
- **Time Points: impacts cycle time and/or recovery time, reliability along route and passenger trip time**
  - Number and location
  - Schedule at each time point

# Impact of Schedules

## Traditional scheduling approaches

- **Set half cycle time so that 90-95% of vehicle departures are on time**
- **Set time point scheduled times at 65 percentile of observed running times**

## **BUT**

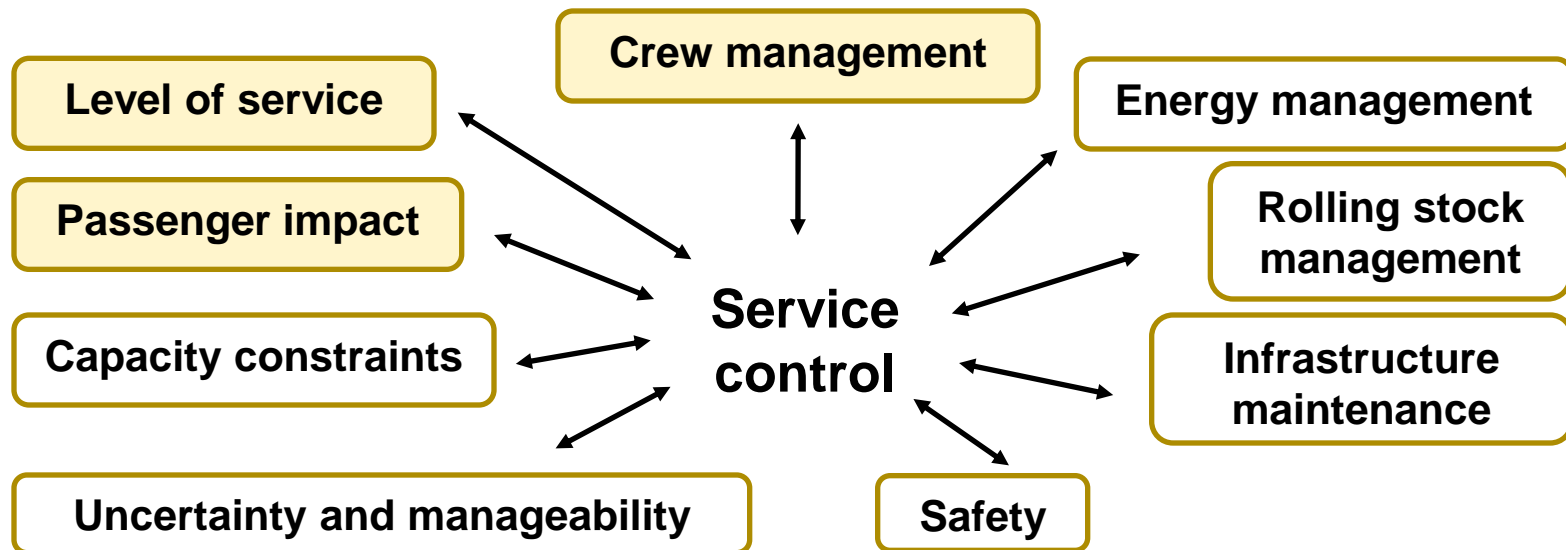
- **This doesn't recognize the feedback between scheduled time and operating speed**
- **It is not sensitive to the ratio of passengers on board versus passengers waiting at time point and further down route**



# Reliability Framework: Corrective Strategies

- **Supervision, operations control**
  - **Holding: schedule- vs headway-based**
  - **Expressing**
  - **Short-turning**
  - **Use of reserve vehicles**
  - **Traffic signal priority**
- } **major disruption strategies  
for high-frequency service**

# Rail Operations Controllers Decision Factors



- These factors can trigger service control interventions or place constraints on interventions performed for other reasons
- Conflicts between objectives are frequent
- Service control can cause unreliability!
- The question is: How can we best coordinate and integrate these objectives and constraints?

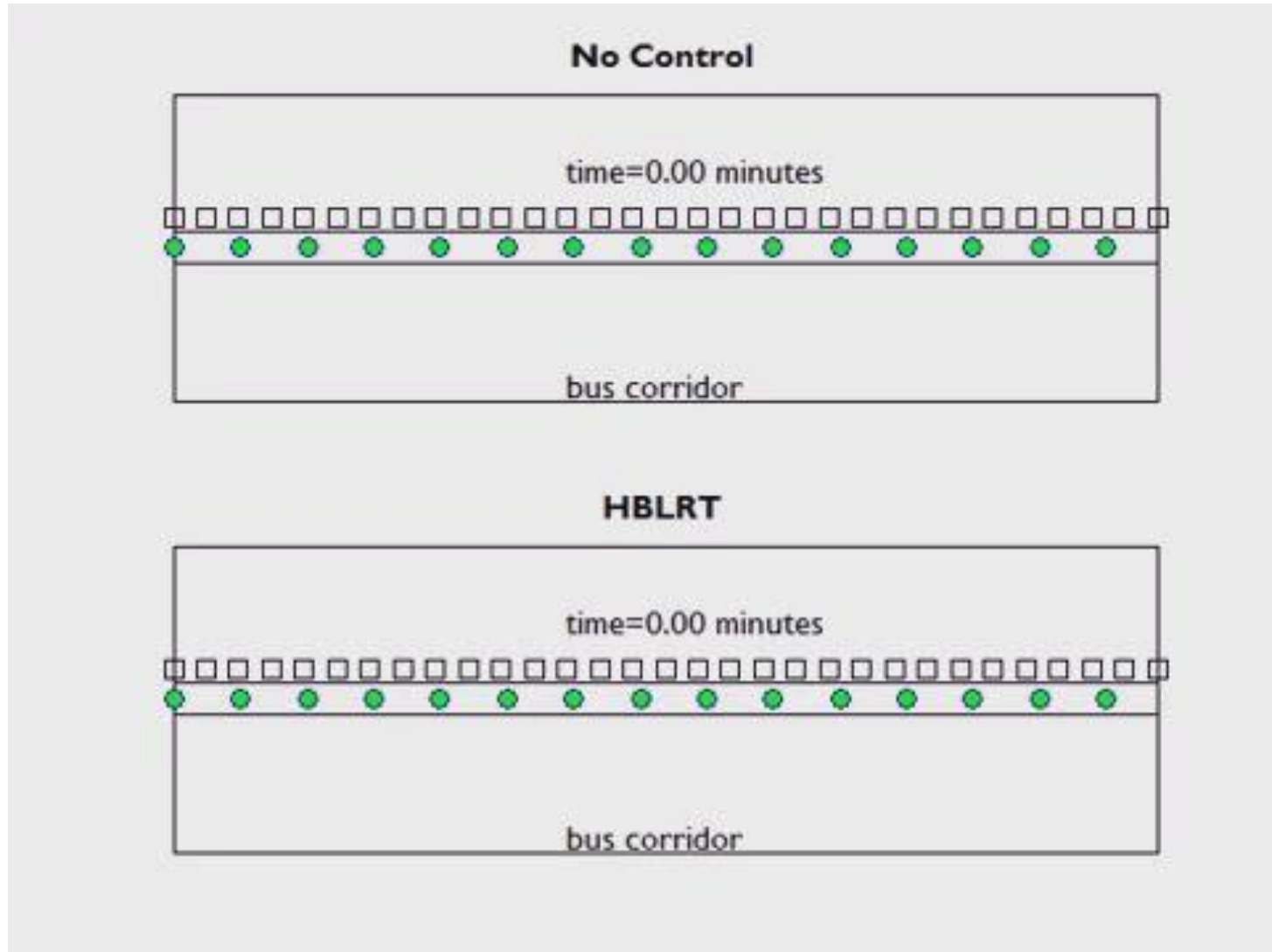
Source: "Diagnosis and Assessment of Operations Control Interventions: Framework and Applications to a High Frequency Metro Line." MST Thesis, André Carrel; MIT, 2009.

# State of Practice in Operations Control

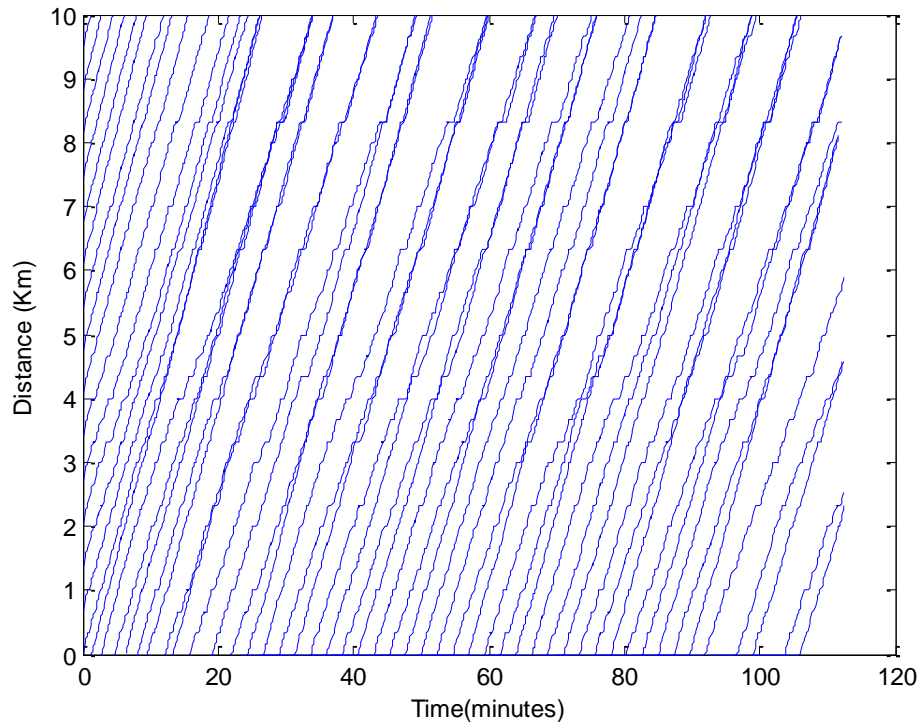
- **Advances in train control systems help minimize impacts of small incidents**
- **Major disruptions still handled in individual manner based on judgement and experience**
- **Little effective decision support for controllers**
- **Simplistic view of objectives and constraints in model formulation**
- **Substantial opportunities for more effective models**

# Research results...

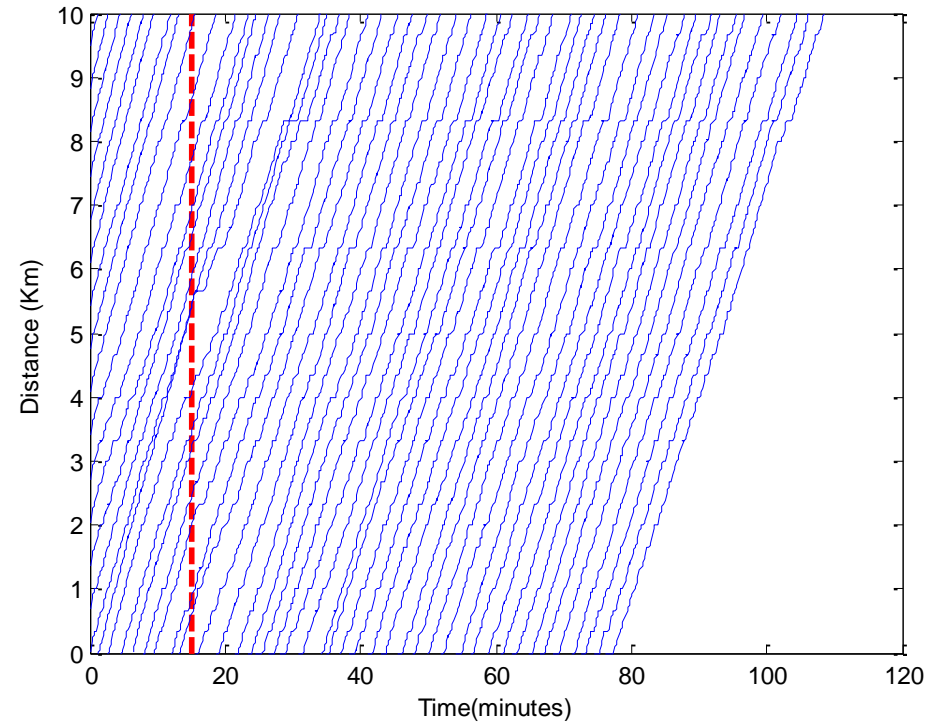
# Headway control



# We achieve regular headways!



No Control

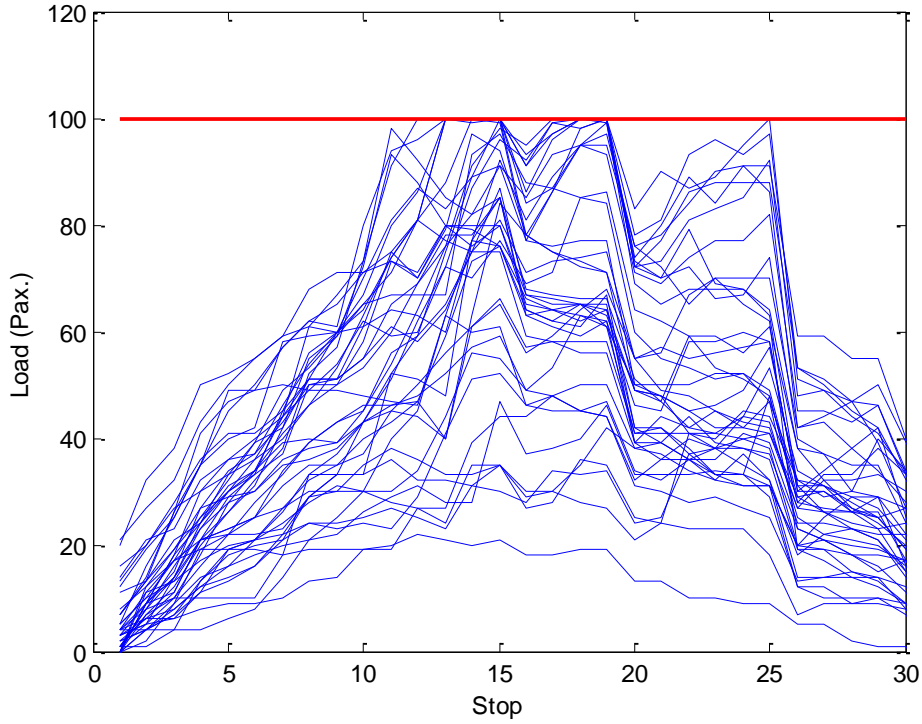


Control

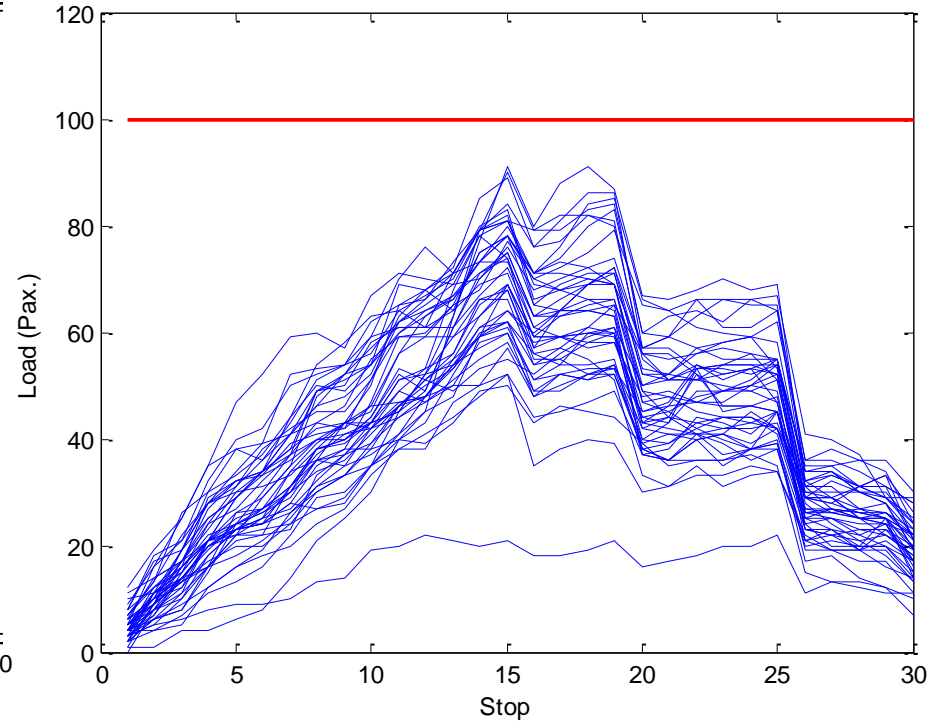
# Excess Waiting Time Drops!

	No control	Simple control	Sophisticated Control
<b>Wfirst</b>	3654.20	667.14	73.06
<b>Std. Dev.</b>	1196.42	738.44	188.96
<b>% reduction</b>		-81.74	-98.00
<b>Wextra</b>	777.65	379.24	343.60
<b>Std. Dev.</b>	784.90	608.44	120.95
<b>% reduction</b>		-51.23	-55.82
<b>Win-veh</b>	156.52	2004.85	1020.95
<b>Std. Dev.</b>	68.80	669.44	110.13
<b>% reduction</b>		1180.87	552.27
<b>Tot</b>	4588.37	3051.22	1437.61
<b>Std. Dev.</b>	1920.05	1966.02	320.08
<b>% reduction</b>		-33.50	-68.67

# Comfort Reliability



No Control

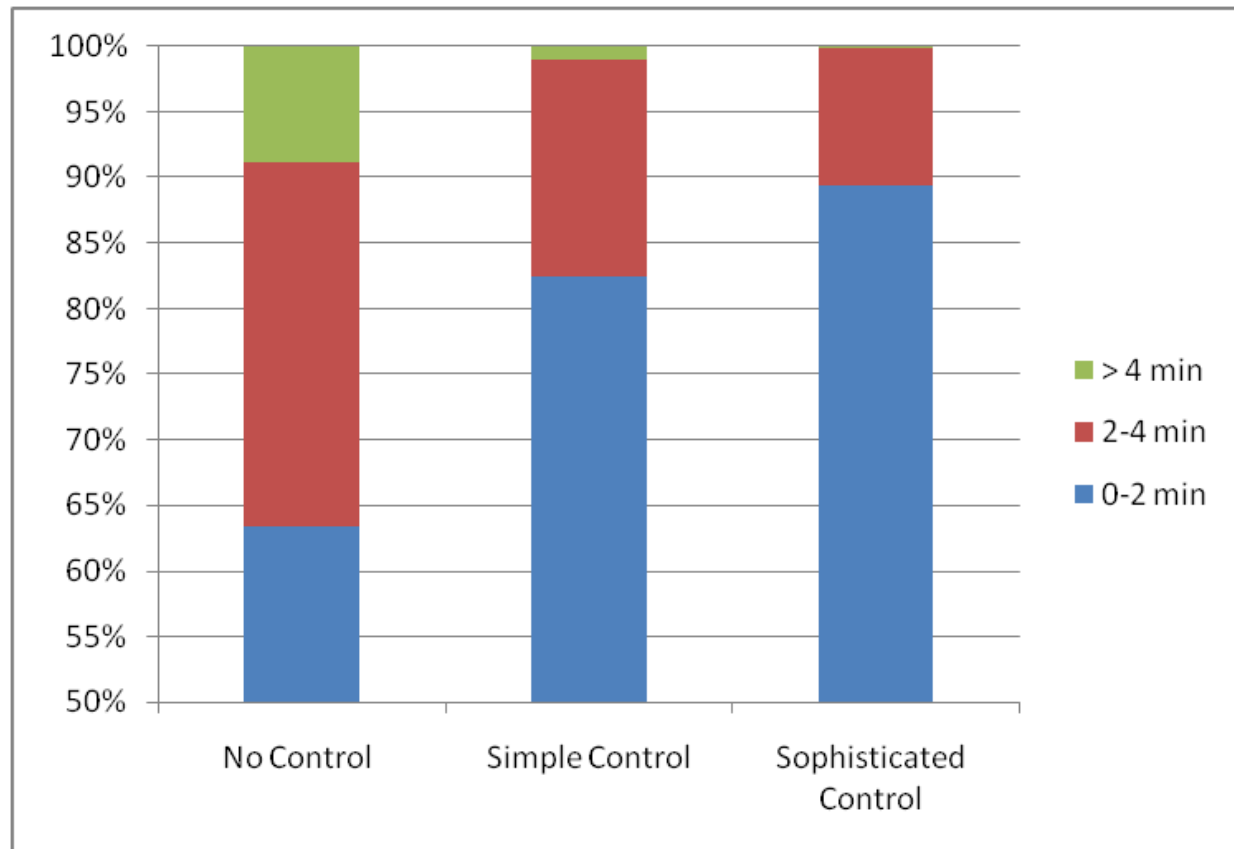


Control

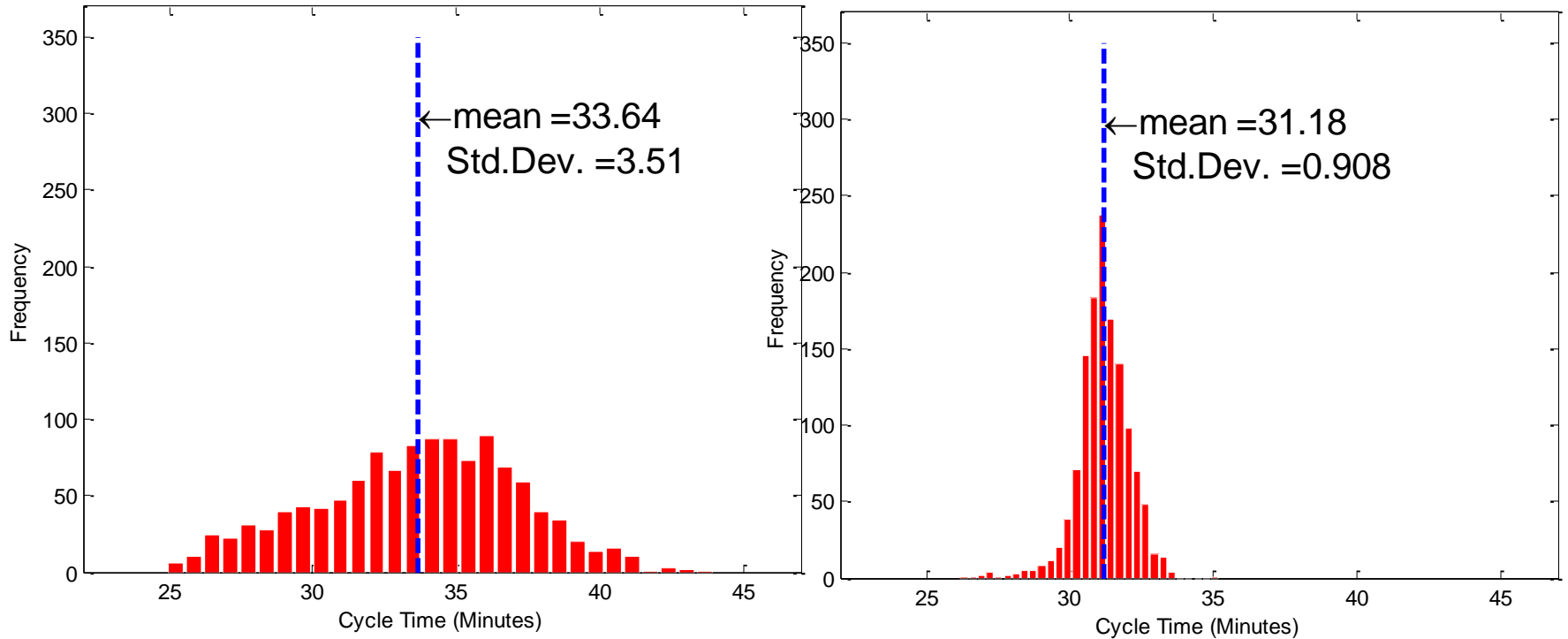


# Impact on Reliability for the Passenger

## • Waiting time distribution



# Impact on Reliability for the Operations



No Control

Control

# IMPACTS

- **Reduces waiting time excess in 60%**
- **Evenly distributes passengers across buses**
- **Reduces cycle times (7%) and variability (25%)**
- **Reduces passengers waiting too much to 2%**

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