Design of Data Collection Programs

Outline

1. Operations Data Needs and Availability
2. Farebox and Automated Fare Collection Systems (AFC)
3. Automatic Passenger Counter Systems (APC)
4. Automated Vehicle Location Systems (AVL)
5. Trip Time Analyzer

Extensive + Intensive Data

Extensive: farebox

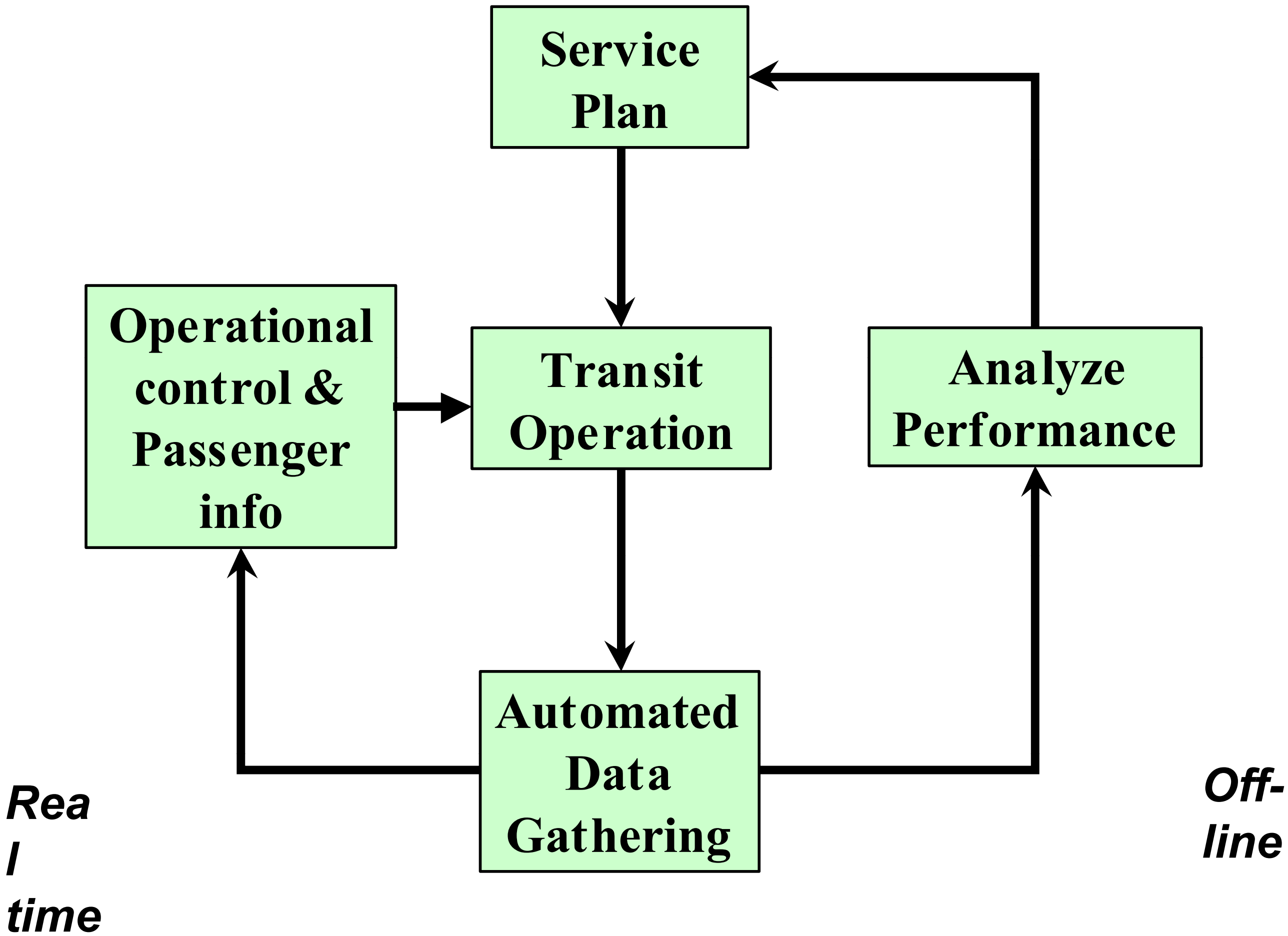
- every trip, every day (weekends, too!)
- only a rough measure of passenger activity

Intensive: ride checks, point checks, surveys

- insight on a sample of trips
- expand using farebox data
  - -- expand a survey by route, period
  - -- apply load-boardings factors found in one day's ride check

APC can be both extensive and intensive

Two Quality Loops: Real-Time and Planning



Off-Line Applications

- Monitoring service quality (several dimensions)
- Schedule improvements (running times, passenger flow)
- Match supply to demand
- Analyzing Bunching Effect
  - -- late causes early; early causes late
  - -- data on sequential buses
  - -- integrate operations data with passenger counts
  - -- operator differences
  - -- dwell times
  - -- traffic impacts (support TSP)

Traditional Farebox Data Problems

- Operator error and inattention
- Poor AFC system design
- Poor integration between AFC and other systems
- Lack of management use of data

Farebox can be your primary passenger counting tool, if …

You invest in Hardware:

- Card & transfer readers
- Link farebox to destination sign, on-board computer to segment trips, verify sign-in
- Transactional data

You invest in Software:

- Develop your own database
- Automate data screening, editing
- Integrate with schedule data, payroll, other data sources

Farebox can be your primary passenger counting tool, if …

You invest in Management:

- Someone responsible to check for data quality everyday
- Discipline, retraining for non-performing operators
- Priority in maintenance & servicing
- Manual verification counts

Estimating Ridership from Revenue

Traditional approach because:

Revenue is Accurate

- on sampled trips: read it now or later
- annual, systemwide (but possibly not by route)

However:

Relationship to Ridership Is Variable

- pass use, transfers, discounts, etc., distort the ridership-revenue relationship
- "average fare" surveys become out-of-date

Transactional Farebox Data Innovations

Key is the ability to record and retain a transaction for each passenger with ticket ID

Transfer and Linked Trip (O-D) Data

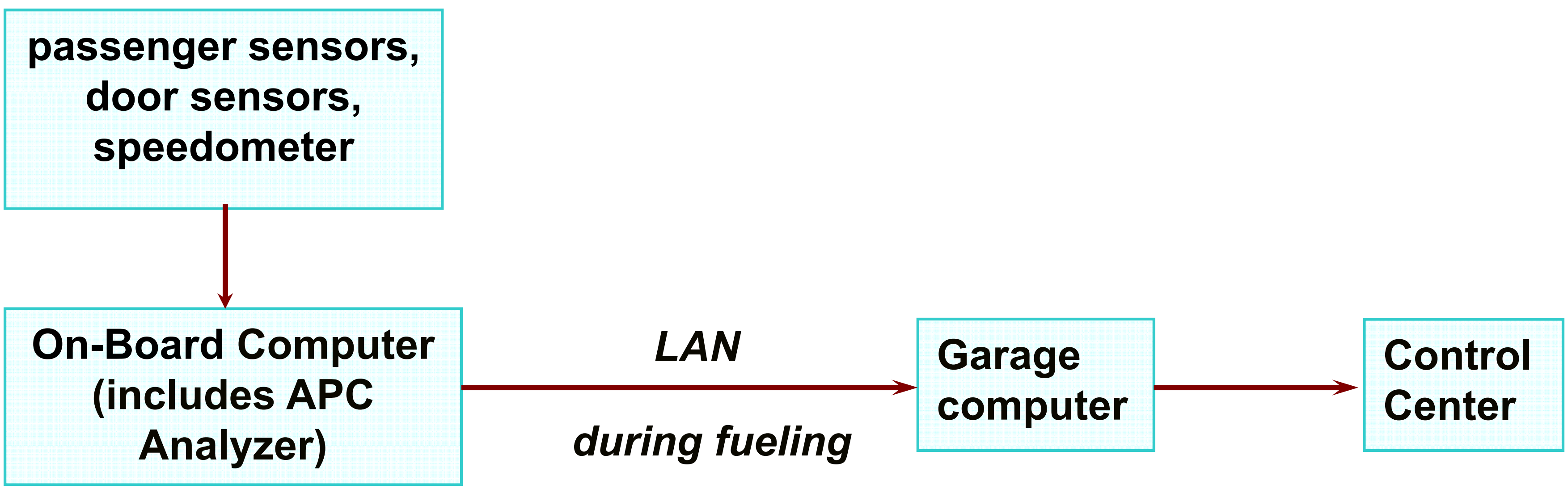
- capture time and route of previous trip encoded on pass or transfer
- successful in NYC and CTA rail systems

Estimate load, passenger-miles

- transactional data with location stamp
- estimate alightings using symmetry

Automated Data for Off-Line Application: APC Tied to on-board computer w/ nightly upload

- APC Analyzer converts sensor signals into counts
- On-board computer stores one record per stop
- Other events may also trigger records
- Nightly upload can be painless



Passenger Detection Methods

- **Breaking light beam**
  - -- multiple beams (high/low; inner/outer pairs)
  - -- sturdy mount to prevent misalignment
- **Pressure sensitive mats**
  - -- some designs won't work with low floor
  - -- footprint detection
- **Infrared (overhead)**
  - -- requires ambient temperature < body temperature
- **Image interpretation**

Event Records & Contents

- **Stop record**
  - -- time door opened, closed
  - -- location (GPS, odometer, etc.)
  - -- on count, off count
  - -- [maximum speed since last stop]
  - -- [time at crawl speed with door closed since last stop]

- **Other record types (contain time, location)**
  - -- speed threshold passed
  - -- signpost or "virtual signpost" passed
  - -- turn began/ended
  - -- periodic (e.g., 10 s)

APC - Historic Uses

- **Mimic ride check analysis**
  - -- Route load profiles
  - -- Passenger-miles, NTD sampling
  - -- Running time distribution (limited)
  - -- On-time performance (limited)

APC - Historic Deficiencies

High cost, few vendors, short-life vendors

- -- Usually, only 10% of the fleet gets equipped

25% to 75% data recovery

- -- On / off imbalance, negative loads
- -- Route / schedule matching problems

End-of-line issues

- -- Zero-out load to prevent "drift"
- -- End-of-line operation is often irregular, hard to match
- -- Ons for next trip may begin before offs from previous are finished

Equipping 10% of the Fleet ...

- Logistical problems assigning equipped buses
- Not so bad for passenger count data ...
  - -- Sufficient for NTD
  - -- Superior to any checker force
  - -- Adequate for conventional planning methods
- Barely adequate for scheduling data (running time, schedule adherence)
  - -- 5% effective sample - each weekday trip sampled once a month
- Inadequate for detailed operations analysis
- Marginal cost of APC in integrated APC/AVL system is low

Automated Data for Real-Time Application: AVL Tied to Radio and Central Computer

Each bus polled in turn (Wide Area Network)

Polling interval

= [unit poll time]

* [no. of buses]

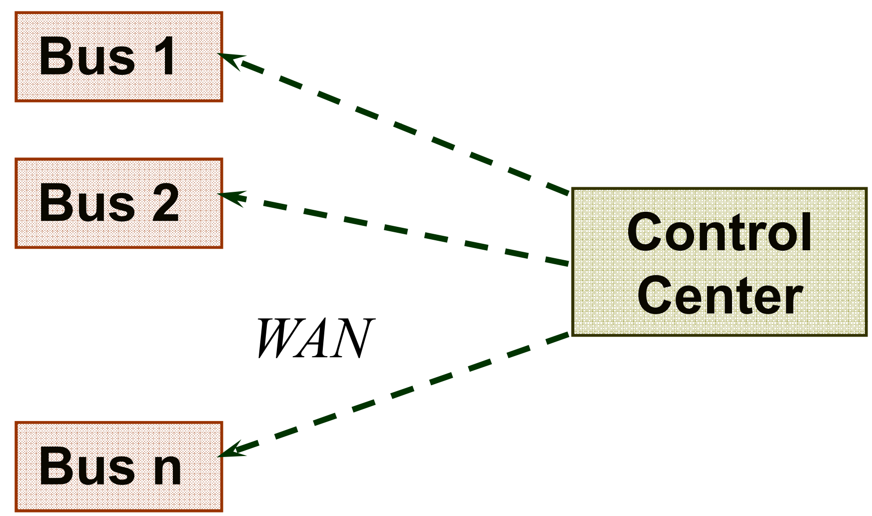
/[no. of channels]

Ex: 0.5 s per poll

* 1000 buses

/4 channels

− 125 s polling interval



Variable polling interval possible

Problem of Polling Interval

- **Analysis demands time at location;**
  AVL gives location at (arbitrary) time of poll
  -- interpolation errors can be significant

- **Too imprecise for efficient signal priority**
  -- predict arrival time to within 5 s
  -- detect exit time to within 1 s

Location Method 1: GPS

- Interpret signals from 4+ satellites
- Low maintenance
- More $$ = more accuracy
  - -- accurate clock
  - -- differential correction
- Lose signal in tunnels canyons & tunnels
  - -- re-radiate in subway tunnel
- Reflection (“multipath”) downtown: info deteriorates where you need it most

Other Location Methods

- **Dead reckoning**
  - -- key backup system to complement GPS
- **Odometer**
  - -- buses have electronic odometer/speedometer
  - -- subject to calibration error, drift
  - -- effective if route is known
- **Signpost (broadcasts ID)**
  - -- positive location; useful at key points
  - -- correct drift, calibrate odometer readings
  - -- useless off-route
  - -- maintenance hassle
- **Combinations of methods**

Poll Message Contents

- Time and Location
  - -- GPS coordinates
  - -- odometer reading (in “clicks”)
  - -- ID of last signpost passed
  - -- [odometer reading when signpost was passed]
- ID (bus / run / route / operator)
- Mechanical alarms
- Other info: possible, but longer message slows polling rate

AVL - Historic UsesControl Center Only

- Security
- Crisis management (see big picture)
- Line management (limited)
  - -- What actions can dispatchers take?
  - -- Comparison to schedule often unavailable
- Off-line playback for incident investigations

AVL - Historic Deficiencies

- Data not stored for off-line analysis, except for playback (incident investigation)

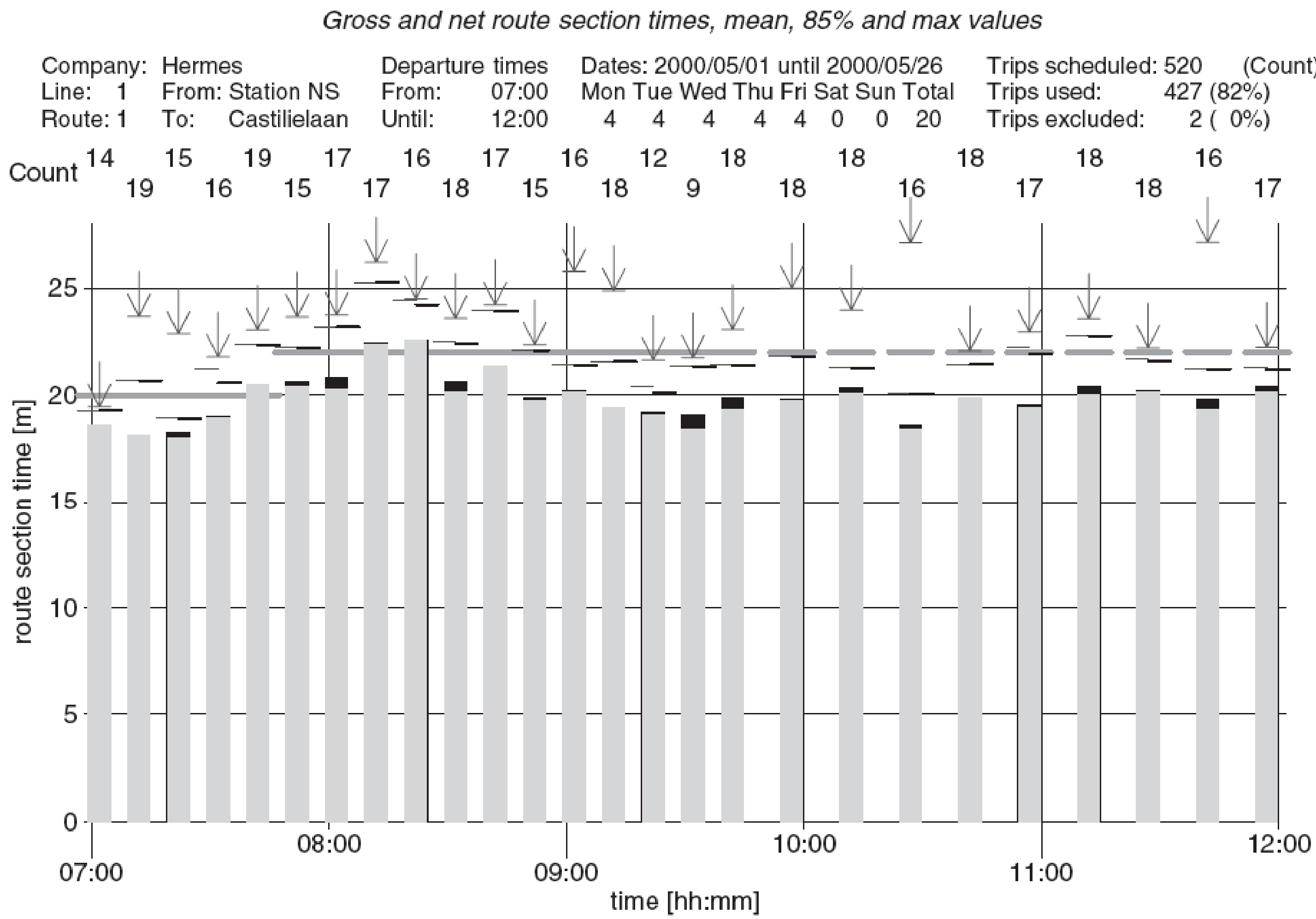
- Often unmatched to vehicle route / schedule

- Always unmatched to operator schedule

Trip Time Analyzer It's APC without the passenger counter; it's AVL without the radio

- Record location and time in on-board computer
- Record events such as door open/close, speed threshold passed, etc.
- Permits analysis of running time, delay, schedule adherence
- Dutch experience: Delft University with several transit agencies
- Equip 100% of the fleet

Observed Running Time by Scheduled Trip

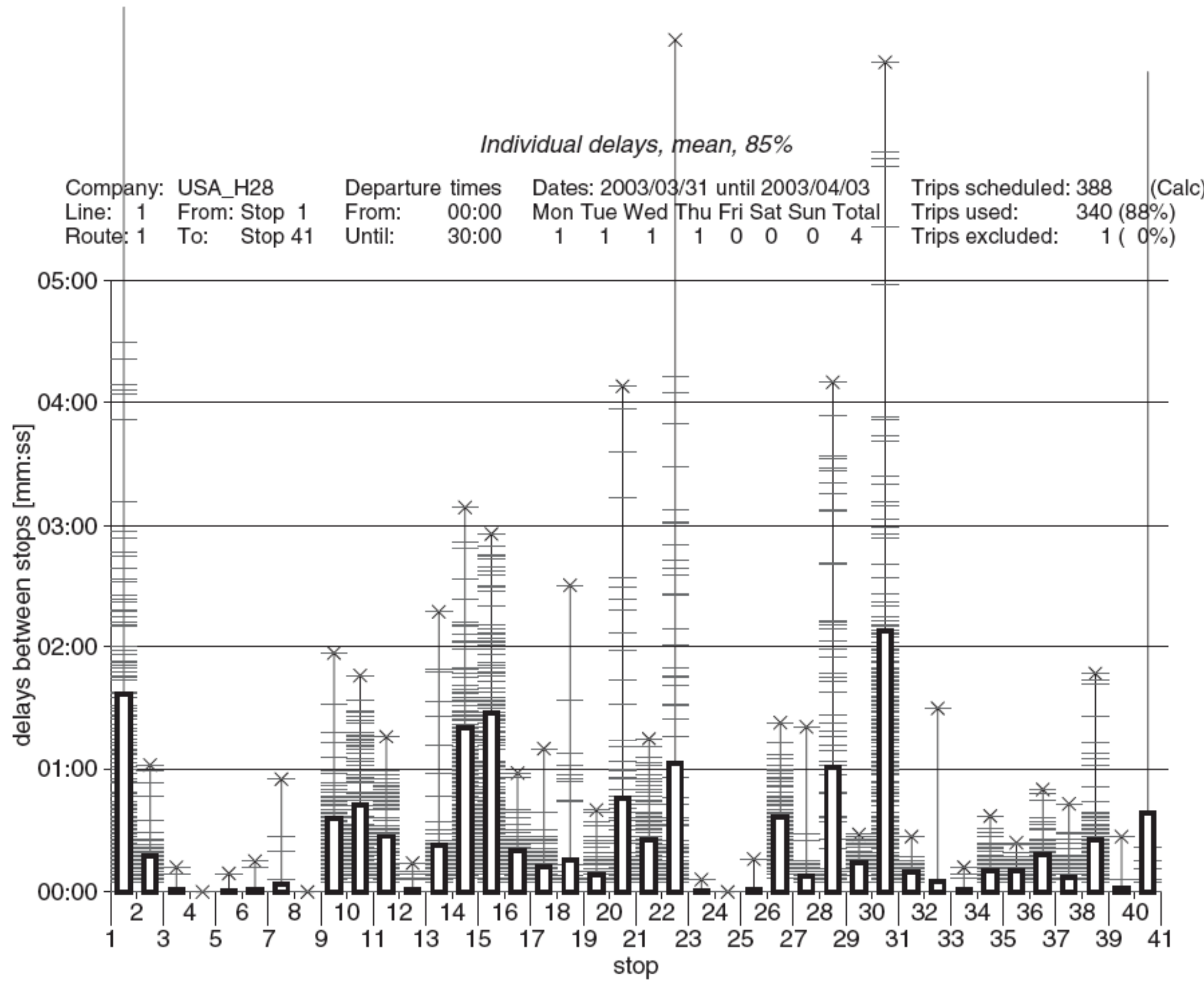


Source: Hermes (Eindhoven), generated by TriTAPT

Figure 2. Observed running time by scheduled trip.

From: Furth, P., B. Hemily, T.H.J. Muller, and J.G. Strathman, "Using Archived AVL-APC Data to Improve Transit Performance and Management." Transportation Research Board, TCRP Report 113, 2006.

Delays by Segment

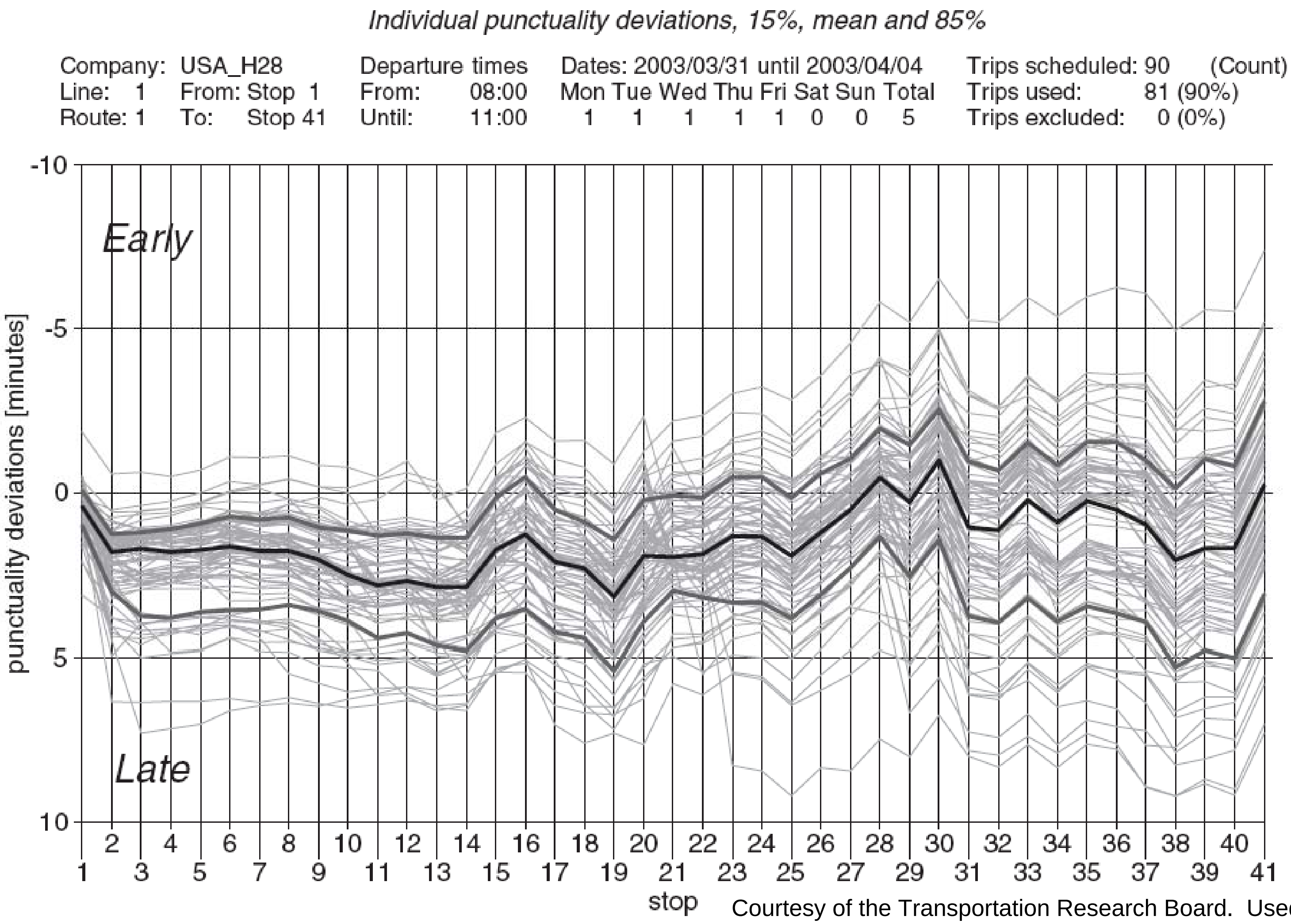


Source: Delft University, generated by TriTAPT

Figure 3. Delays by segment.

From: Furth, P., B. Hemily, T.H.J. Muller, and J.G. Strathman, "Using Archived AVL-APC Data to Improve Transit Performance and Management." Transportation Research Board, TCRP Report 113, 2006.

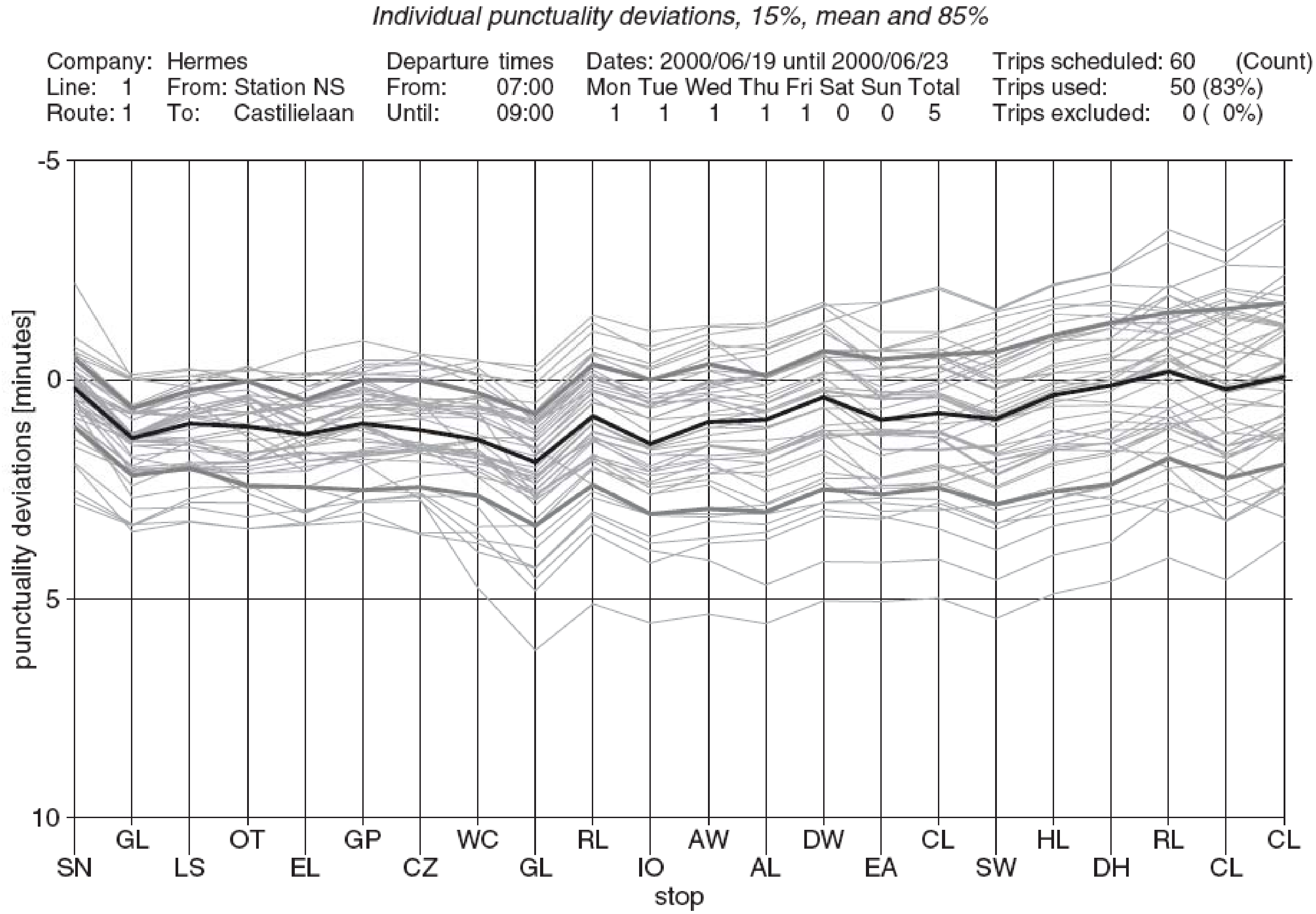
Schedule Deviation Along a Route



(a) Showing Both Systematic and Strong Random Deviation

From: Furth, P., B. Hemily, T.H.J. Muller, and J.G. Strathman, "Using Archived AVL-APC Data to Improve Transit Performance and Management." Transportation Research Board, TCRP Report 113, 2006.

Schedule Deviation Along a Route



(b) Showing Little Systematic or Random Deviation

Source: Hermes (Eindhoven), generated by TriTAPT

From: Furth, P., B. Hemily, T.H.J. Muller, and J.G. Strathman, "Using Archived AVL-APC Data to Improve Transit Performance and Management." Transportation Research Board, TCRP Report 113, 2006.

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