AUTOMATED DATA COLLECTION TECHNIQUES (wrap-up) and DESIGN OF DATA COLLECTION PROGRAMS

Outline

1. Operations Data Needs and Availability (cont'd)
2. Automatic Passenger Counter Systems (APC)
3. Automated Vehicle Location Systems (AVL)
4. Trip Time Analyzer
5. Overall Design
6. Direct vs. Indirect Measurement
7. Data Variability

Operations Data Needs (cont.)

- **Analyzing Operator Effect (slow, fast)**
  - -- extensive data on each operator for peer comparison
- **Analyzing Traffic Impact**
  - -- isolating traffic delay from dwell time, holding
- **Analyzing Dwell Time**
  - -- integrate passenger counts, fare payment, door open times
- **Schedule Adherence**
  - -- quality: plan what you'll do, do what you plan
  - -- virtue can be lost to passengers and operators

Operations Data Collection Techniques

- **Traffic Checkers (with handheld device)**
  - -- ride check (running time, sched. adherence)
  - -- point check (headway , sched. adherence)
- ***But I want both headway and running time!***
  - -- ride check on all (or most) buses
  - -- point check at all (or most) points
- **Supervisors**
  - -- schedule adherence
- **Automatic Data Collection**

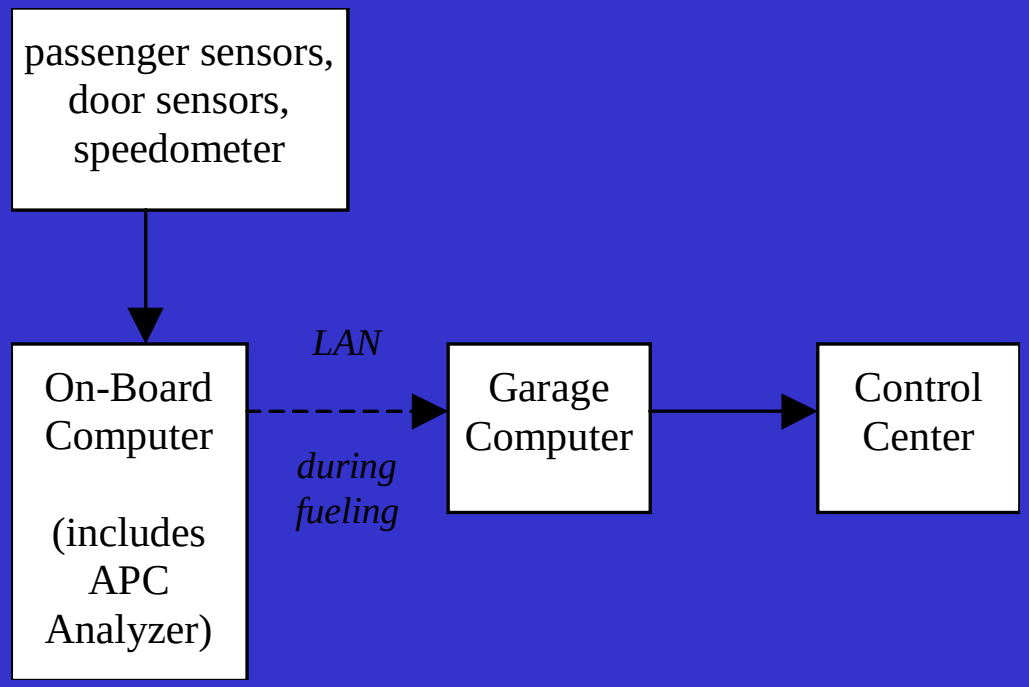
Inadequacy of Manual Data Collection

- **Running Time**
  - -- often revised based on a single day's check
  - -- frustrates operators; impossible to control
- **Recovery Time**
  - -- too little, too much
  - -- rely on rules of thumb, supervisor impressions
- **Schedule Adherence**
  - -- Measures quality of {schedule + performance}

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

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]

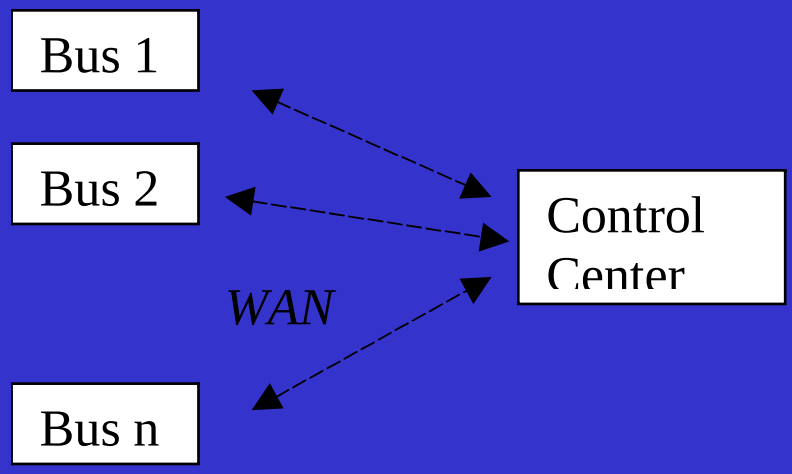
Ex: 0.5 s per poll

*** 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

- **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 Uses
Control 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**

Data Collection Program Elements

A. Baseline:
   - Develop route profiles
   - Define base conditions
   - Develop conversion factors

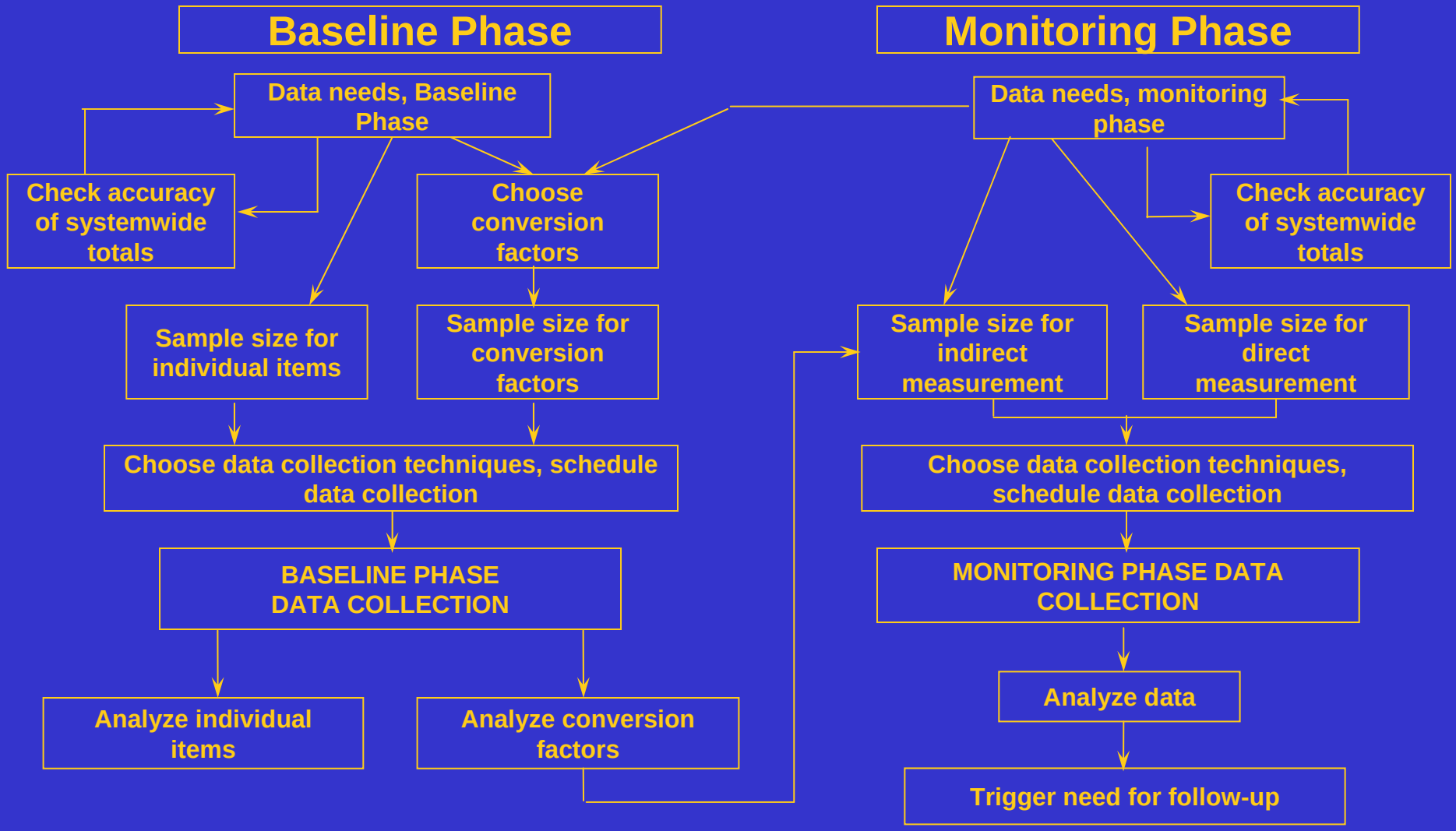
B. Monitoring:
   - Detect changes based on selective data collection
   - Use conversion factors to estimate other data

C. Follow Up:
   - Develop new route profiles
   - Selective additional data
   - Special studies

Conversion Factors

Auxiliary Data Item	Inferred Data Item
Load or Revenue	Boardings
Boardings, Load or Revenue	Passenger Miles
Point Load	True Maximum Load
Revenue	Peak Point Load

Designing a Data Collection Program



Default Values for Coefficient of Variation of Key Data Items

Data Item	Time Period	Route Classification	Default Value
Maximum Load	Peak	< 35 pass./trip	.50
		≥ 35 pass./trip	.35
	Off- Peak	< 35 pass./trip	.60
		35-55 pass./trip	.45
		> 55 pass./trip	.35
	Evening	All	.75
	Owl*	All	1.00
	Sat, 7 AM-6 PM	All	.60
	Sat, 6 PM-1 AM	All	.75
	Sun, 7 AM-1 AM	All	.75
Boardings, Passenger Miles	Peak	< 35 pass./trip	.42
		≥ 35 pass./trip	.35
	Off- Peak	< 35 pass./trip	.45
		35-55 pass./trip	.40
		> 55 pass./trip	.35
	Evening	All	.73
	Owl*	All	.80
	Sat, 7 AM-6 PM	All	.45
	Sat, 6 PM-1 AM	All	.73
	Sun, 7 AM-1 AM	All	.73
Running Time	All	short (≤ 20 min.)	.16
		long (> 20 min.)	.10

*Owl default values are the same for weekdays and weekends