Contents

1 Introduction

1.1 Transit right now

- Ridership is increasing, but small
- Strong financial support from
- Trends in modal split
  - Auto is above 80%
  - Transit 2-3%
  - Biking and walking are the same as transit

1.2 Funding

- In North America, it's divided into captial and operating expenses
- Fares only pay ~1/3 of operational expenses
- Lots of federal support for capital expenses - almost 40%
  - Since operating expenses are funded less, this encourages more building and less maintenance
- Fuel taxes in NA are 10-20% of what they are in Europe

1.3 Traditional Arguments Supporting Transit

- Equity: travel for those who can't drive
- Congestion
  - Not such a good argument, papers don't support it. The capacity released it quickly filled again
- Better for the environment
  - Actually, effort it better spent making cars cleaner since they're like 80% of transport

1.4 Critical assessment

- Transport has been stabilized
- Success stories (NYC, Houston(?), Seattle)
- Institutional changes are occurring slowly

1.5 Future influences

- Urban form
- More old people
- Better tech to improve performance
- Public has higher expectation (you know exactly when the bus is coming)

1.6 Ingredients for future success

- Maintain supportive coalition
- Expand the definition of public transport
- Greater private sector involvement
- Aggressive implementation of new technology

2 Data Collection Techniques and Program Design

2.1 Summary of current practice

- Used to be manual
- Now is collected with IoT devices
- **Automated Data Collection Systems (ADCS)**
  - **Automated Fare Collection Systems (AFC)**
    - Tapping your card on/off the vehicle
  - **Automatic Vehicle Location Systems (AVL)**
    - GPS tracking for buses, train tracking based on circuit occupancy
  - **Automatic Passenger Counting Systems (APC)**
    - Sensors in bus doors
      - Use break beam sensors to tell if you're getting on or off (out of 2 beams which do you break first)
    - Counts from fare barriers
    - Load weight calculators on trains
      - In trains the brakes apply force proportional to the load in each car (lighter cars need less braking, heavier cars need more, so they dont run into each other)

2.2 Passenger counting techniques

- Manual - checker (a person)
  - Ride check (on the bus, on/off counts and running time)
  - Point check (load on board, headway - time between buses)

2.3 Sampling

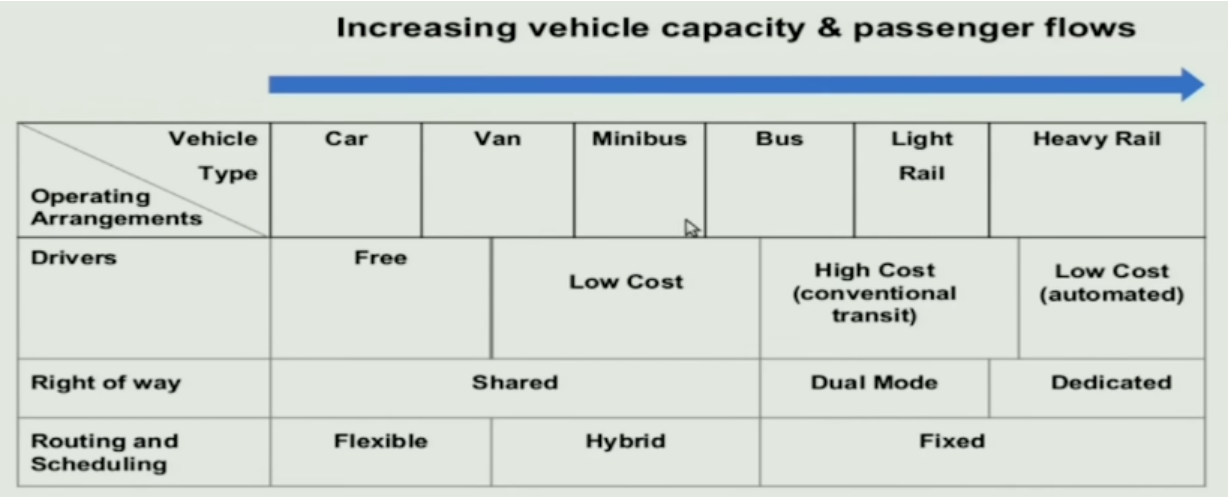
- **Simple random sampling**
- **Systematic sampling** - every 6 days, etc
- **Cluster sampling** - do as much data collection as possible
- **Ratio estimation/Conversion factors**
- **Stratified sampling** - sample sizes for each thing separately
  - E.g. you want information about students: get a large sample size on routes that serve universities

2.4 Tolerance and confidence level

- Accuracy has 2 dimensions
  - Relative tolerance: $\pm 10\%$
  - Absolute tolerance: ± 3.3

3 Modal Characteristics and Roles

3.1 Spectrum of services



3.2 Transit categories

- Rights of way - degree of separation
  - Surface with mixed traffic (light rail/buses)
  - Longitudinal separation by at grade crossing (light rail/bus rapid transit)
  - Full separation (at grade/tunnel/elevated)
- Technologies
  - Support (how they contact the groups)
    - Rubber tire on concrete (cars, buses, some rail like Paris Metro)
    - Steel wheel on steel rail
    - Maglev
    - Suspended cars
    - Water
    - Others
  - Guidance (lateral control)
    - Steered by driver
    - Guided by track
    - Others
  - Energy and propulsion
    - Combustion engine
    - Electric
    - Compressed natural gas (CNG)
    - Hybrid
    - Others
  - Control (longitudinal)
    - Manual/visual
    - Manual/signal
    - Automatic

3.3 Basics of train control

- Divide the system into blocks
  - If a train is occupying a section, do not let any trains in the section immediately before
  - For each block further, slowly increase speed limit in that block from nothing (0, 10, 25, 40,...)
- Block system constrains the frequency of service
- Moving block system increases capacity, usually used with automatic driving systems

3.4 Levels of automated protection

- None - advisory way signals
- Manual setting of speed below speed limit - train will be automatically braked if over speed limit
- Automatic train supervision/regulation
- Full automation - sometimes has operators, needs to have platform screen doors to keep people off of track
- Capacity increased through moving block or communication based train control

3.5 What is a bus?

- Vehicle size - 10-250 passengers
- Floor height (high floor/low floor)
  - Low floor is better for accessibility, has lower dwell time
- Right of way - all options available
- Guidance - often manual, sometimes systems
- Propulsion - all options available
- Fare payment - pay outside, or pay in the bus

3.6 Examples of bus systems

- Bi-articulated buses are a thing
- In Curitiba, bi-articulated buses have high floors, and have to be boarded at specific stations with fare gates
- The Cambridgeshire Guided Busway has buses operating on dedicated "tracks" of pavement

  - Buses can also be optically guided, following a line on the floor with a camera

3.7 Light Rail

- Vehicle design
  - High/low floor
  - Articulated or not
- Right of way
  - All options available
- Operation
  - Automated or manual
- Power
  - Overhead catenaries
  - Third rail
    - On street rails, the third rail is electronically controlled and is only powered when the train is coming

3.8 Heavy Rail

- Length
  - Limited by station length
  - In some cases (like in London) they allow the last door of the last car to stay in the runnel
- Turning radius

- Right of way
  - At-grade
  - Elevated
  - Tunnel
- Station spacing
- Control
- Power

3.9 Commuter Rail

- Vehicles operating in trains with long station spacing
- Fare collection strategies
- Line length
- Through routing in CBD [central business district] (cross through city or go there and back)
  - Where to put trains when you're done
- Station spacing
- Parking capacity

3.10 Traditional and new service concepts

- Traditional
  - Bus on shared right of way
  - Streetcar on shared right of way
  - Heavy rail on exclusive ROW
  - Commuter/regional rail on semi-exclusive ROW
- New
  - Bus rapid transit
  - Light rail on exclusive ROW

3.11 Increasing diversity

- Driver arrangements
  - Part timers (cover peaks), 10 hour day (to cover peaks that are 8 hours apart), payment by vehicle type
- Routing and scheduling
- Vehicle types
- control options
- Priority options
- Dual mode operation

3.12 Bus vs rail comparison

- Rail advantages
  - Higher capacity
  - Lower unit operating cost
  - Better service quality
  - Stronger land use influence
  - Fewer negative externalities
- Bus advantages
  - Low capital costs
  - Wide network coverage
  - Single vehicle trips
  - Flexibility
  - Dual mode nature

4 Short Range Planning

4.1 Public transit planning

- Long range (>3 years)
  - Major capital investments, infrastructure
  - Usually in collaboration with government
- Medium range (1-3 years)
  - Fleet size, network size, fare policy
  - Usually in collaboration with government
- Short range (<1 year)
  - Route structure, service frequency
  - Incremental changes
  - Can be handled only by the transit authority
- Control (real time)
  - Revise schedule and route of specific vehicle

4.2 Operational planning process

- Right of way + demand => bus route design => routes and stops
- Service + demand => set timetables => departure times
- Travel time constraints => scheduling vehicles => vehicle schedules
- Operator and union constraints => scheduling drivers => crew schedules

4.3 Transit service guidelines

- Goals => objective => measures => standards
- Early arrivals are not considered on time, because it may still cause people to miss connections
- Purpose
  - Communicate to the public and their representatives how decisions are made on changes in the transit network and the allocation of resources
  - Ensure acceptable level of service quality
  - Provide a consistent and fair bases for
    - Evaluating existing services
    - Considering new services
  - Balance impreovements with efficient use of resources

4.4 Aspects covered by service guidelines

- Service design
  - Factors that are important to riders:
    - Frequency
    - Waiting time
    - Reliability
    - Access
  - Why are frequency and waiting time both here?
    - Waiting time can be independent of waiting time - if a bus comes early, it will change waiting time
- Operating perfornace
  - Service quality

4.5 Service design: schedule

- Two main components
  - Maximum (policy) headways
  - Maximum passenger crowding
    - Usually for peak corridors

5 Short Range Planning, con't.

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