From personal to mass transit

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40 years in transportation

• Transit network planning - VIPS
• Taxi fleet management - Taxi80
• Multi-discipline PRT research - Chalmers
• Road traffic research – KTH
• 5 PRT patents
• VP, Advanced Transit Association
Storyline

• A challenging podcar application
• Five strategies to cope with large demand
• => Mass transit with podcars
The challenge

- Dense urban area in California
- Very large employers
- Severe highway congestion
- Promote non-car modes
- Transfers from Train and LRT
- Connecting buildings (horizontal elevator)

Contract with PRTConsulting
Our tentative design

- 50 stations
- 48 kms main guideway (6 % double)
- 4 bi-level intersections out of 54
- Speeds 36 and 45 kph
- Headway 3 secs (as certified)
- 900 vehicles with 6-seats
Morning peak hour demand

- 13,000 passengers
- 30% of trips from 3 transfer stations
- 400 passengers from one train
- Many dispersed destinations
Train / PRT station
Morning peak demand 13 000 / h
Personal Rapid Transit

- Average 1.5 passengers per vehicle
- Can carry 4 800 passengers
- 24 mins waiting
Ride-matching at departure

- System knows requested destinations
- First passenger determines destination
- Destination sign over vehicle
- System assigns vehicle when enough load (5 of 6)
- ...or after max holding (1 min)
Ride-sharing morning

- In relations with >1 party per minute
- 7 % of relations have 60 % of all trips
- 48 % of passengers matched
- Average load 3.9 passengers
- 11 400 passengers carried
- 11 minutes waiting
Evening peak most challenging

- Many small origins
- Less opportunities for matching
- 43% of passengers matched (48)
- 10,800 passengers carried (11,400)
Standing passengers?

- Vehicle for 6 seated + 6 standing
- Limited braking => double headway
- Same capacity
- Longer station ramps
Same capacity without standees
Coupled vehicles

- Coupled in station
- Decouple in switches to different destinations
- Safe distance between couples
- 2 x line capacity at departure
- Average 1.5 en route
Vehicle pair can safely split apart

- Can serve different destinations
- More load with two destinations
- Each vehicle goes non-stop
Larger vehicle?

- 24 passengers including standees
- 6 sec headway
- Couple 2 x 6 seated has same capacity
- ...and can split up en route
Coupled vehicles better than big

- Can serve 4 destinations
Electronic or mechanical coupling
Ride-sharing plus coupling

- 13 200 passengers carried evening (10 800)
- 5 mins waiting (11)
- Better – but still too much waiting
Sharing to 2 destinations

- 26 % of departures for 2 destinations
- 58 % of passengers matched (48)
- 13 300 passengers carried
- 3.5 mins waiting (5)
Second destination before or after

- Detours within 20 %
Allow boarding to same destination

- When stopped to drop off
- Waiting passengers to same destination
- Destination sign over vehicle
- No reason not to allow boarding
Ride-sharing patterns

- Same O & same D
- Two destinations
- Allow boarding
Sharing to 3 destinations

- 59% of passengers matched
- 1.2 destinations average
- 13,400 passengers carried
- 3.3 mins waiting (3.5)
Adding a third destination

- Before, between or after
Matching many-to-few

- Evening demands more difficult to match
- Multiple pick-ups to common destination (transfer)
- First passengers determine destinations and route
- Stopping en route to pick up for same destinations
Stop en route to pick up

- Route fixed to one or two destinations
- Check waiting passengers en route
- Pick up for same destinations
- No passenger makes more than two extra stops
Stop to pick up

- Picking up 2 000 passengers out of 13 400
- 0.3 intermediate stops per passenger
- 4.5 passengers per vehicle (3.9)
- All vehicles full (6) on max link
- 2.9 mins wait (3.1)
- +10 % ride time
Ride-sharing patterns

- O
- D1
- D2

- Same origin & destination
- Two destinations
- Allow boarding
- Stop to pick en route
Network high/low speed + train
Animation 10 x real speed

- Empty vehicle
- 1 passenger
- 2
- 3
- 4 or more
- Load/unload
- Couple
13,400 trips evening peak (6,000 link)
910 vehicles (1800 vph on link)
Less waiting with more ride-sharing

![Graph showing waiting minutes and vehicle load for different ride-sharing scenarios.](image)
All strategies combined

- Up to 1,800 vph on link (average coupling 1.5)
- Up to 6 passengers per vehicle
- Up to 6,000 pph on link, 13,400 in network
- 85% of vehicles running with passengers
- 8% running empty
- 7% in stations
APM for same capacity

- Stopping on-line => double travel time
- Can only serve 30 out of 50 stations
- Minimum headway 90 secs (40 deps/h)
- To achieve link flow 6 000 pphpd
- Needs to load 6000 / 40 = 150 passengers
APM or LRT

200 pass / 90 sec * 75 % load = 6 000 pph corridor

PRT

6+6 pass / 3 sec = 14 400 pph (all paired & full)
Case 6 000 on link, 13 400 in network
Conclusions

• Apply ride-sharing and pick-ups during peaks
• On demand, almost non-stop (0.3 extra stops)
• Slightly longer trips (+10 %)
• Can handle mass transit flow
  – 6 000 pph on link, 13 000 in network
• Not always Personal, but very Efficient
• Mass Rapid Transit, but faster & cheaper