Designing the Layout

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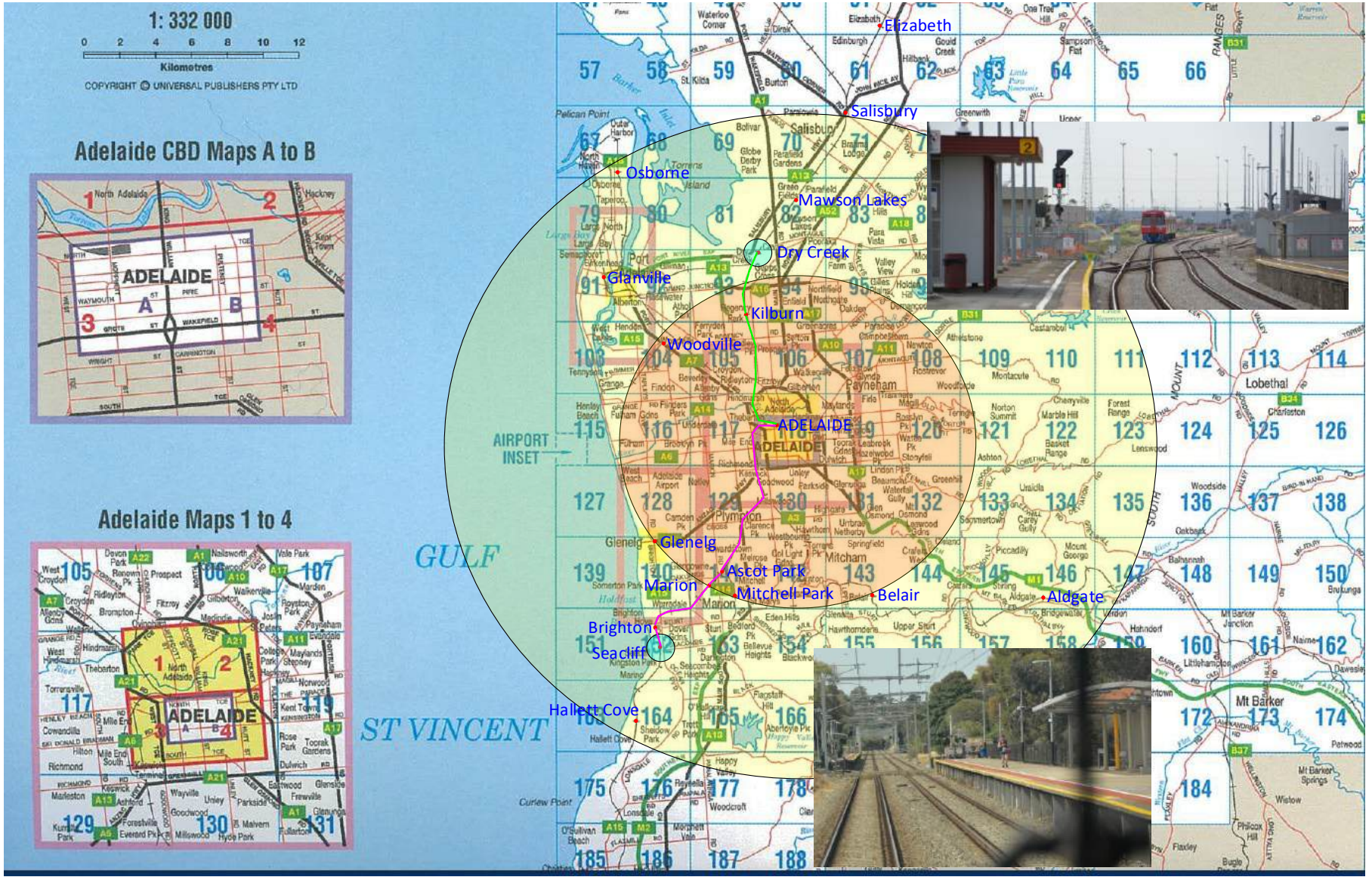
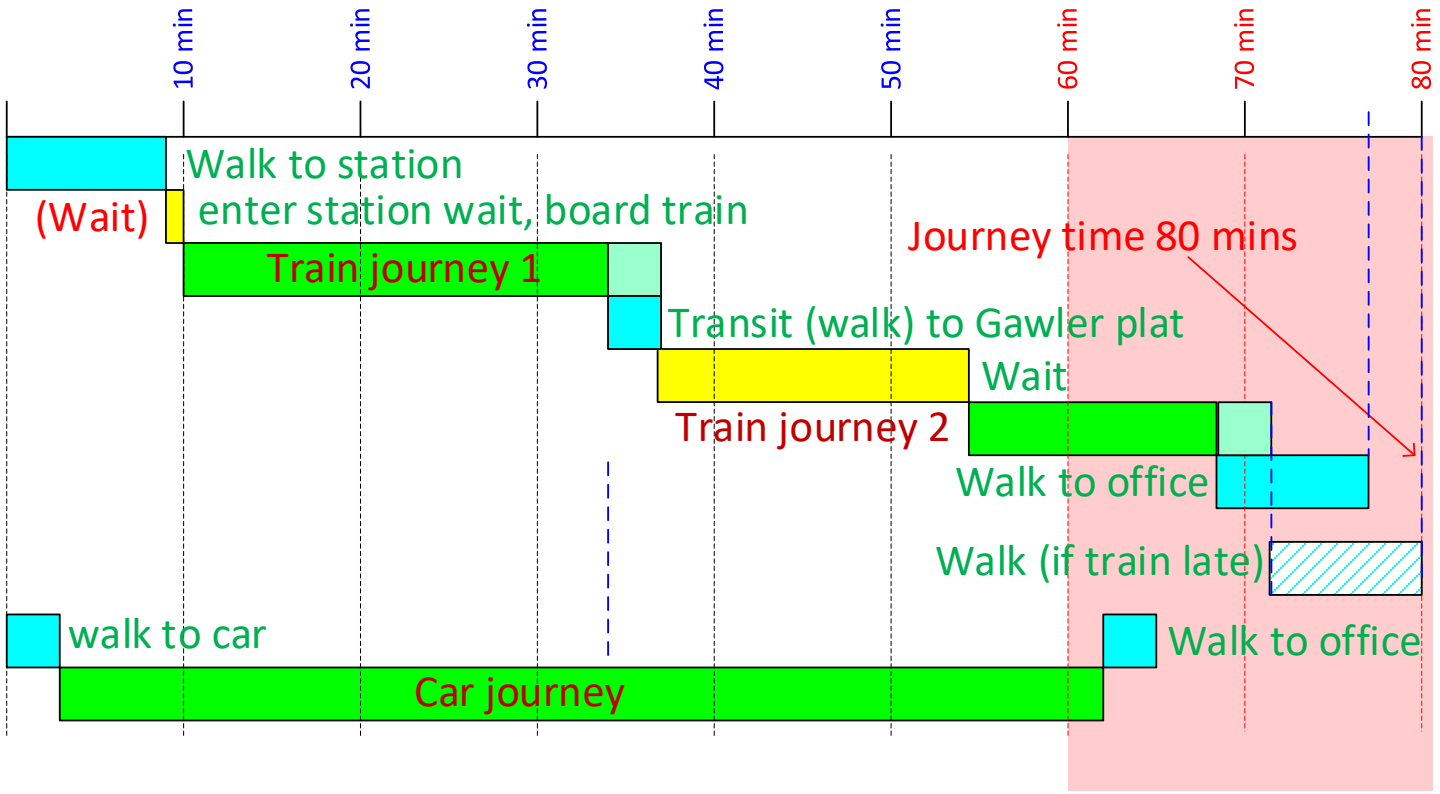
Overview

- What makes a high performing railway?
  - The importance of passengers
  - Concept of “Nodes” (stations) and “Roads” (tracks between stations)
  - The importance of Signal Engineers
- Saturating Roads and Saturating Nodes
  - Dry Creek (off peak) example
    - Old world operation case
    - Current operation
  - Switzerland
  - Importance of Running On Time
- Clifton Hill Loop Example
  - Headway concepts
  - Importance of Running on time
  - Benefit of flyover
- London Northern Line Example
  - Importance of integrating operation with infrastructure
- Way Forward

Train Controller's Trip (Adelaide)



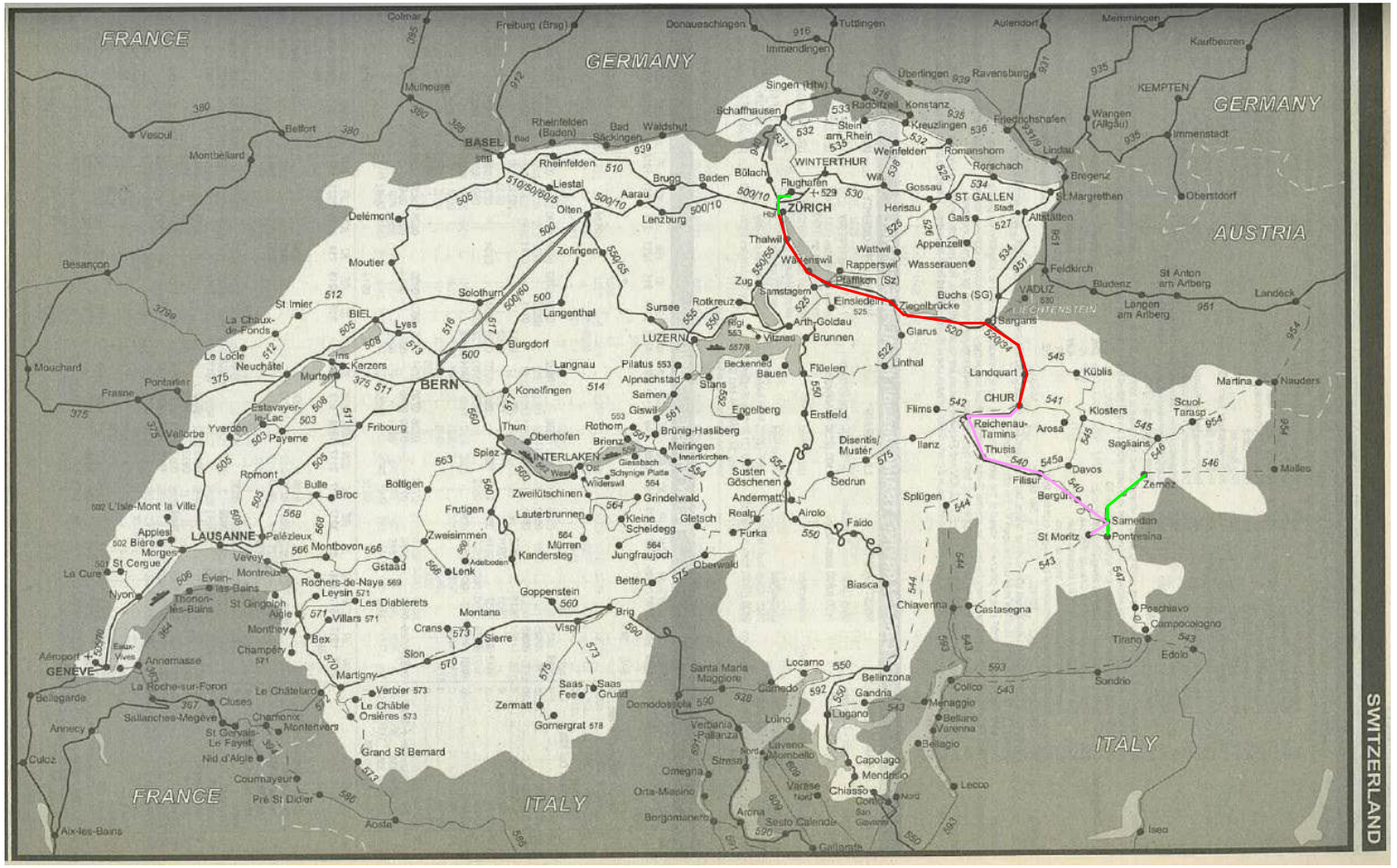


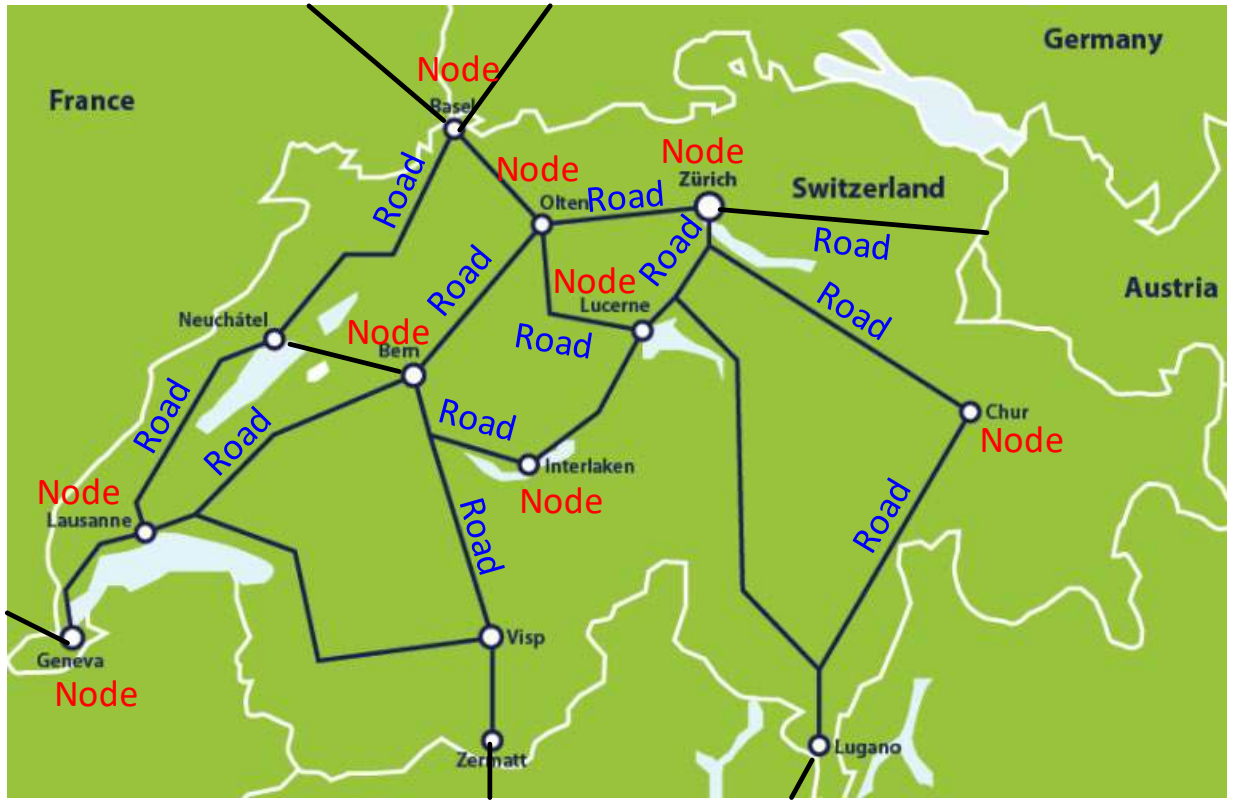
Why not catch the train?

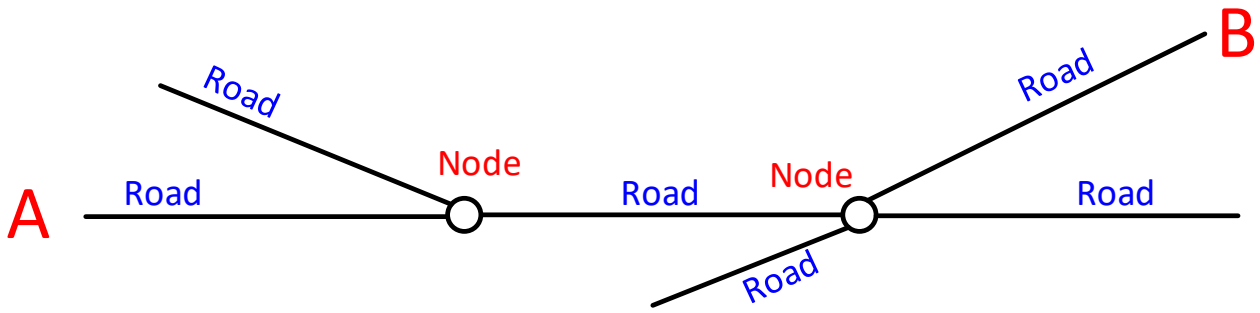
- By Train (based on 10pm)
  - 8.8 minute walk from home to station (approx. 700m at 1.33m/s [Transport for London standard rate])
  - Train scheduled every 30 minutes
  - 24 minutes train to Adelaide
  - Change trains to Gawler line train (departs 20 minutes after Seaford line train arrives)
  - 14 minutes train to Dry Creek. Train can run late.
  - 8.8 minute walk to office
- By Car
  - 5 minutes get car out of garage
  - 55 minutes (Google estimate, but vaties with traffic) drive to Dry Creek.
  - 5 minute walk from carpark to office
- Car is faster and more reliable at that time of day

Travel in Switzerland

- Can get from anywhere to anywhere quickly and with no fuss
- Left Pontresino 9am. In Zurich for lunch (3 separate train services involved)
- Works differently from a Metro (“saturating the roads”)
- Uses concept “saturating the nodes”.



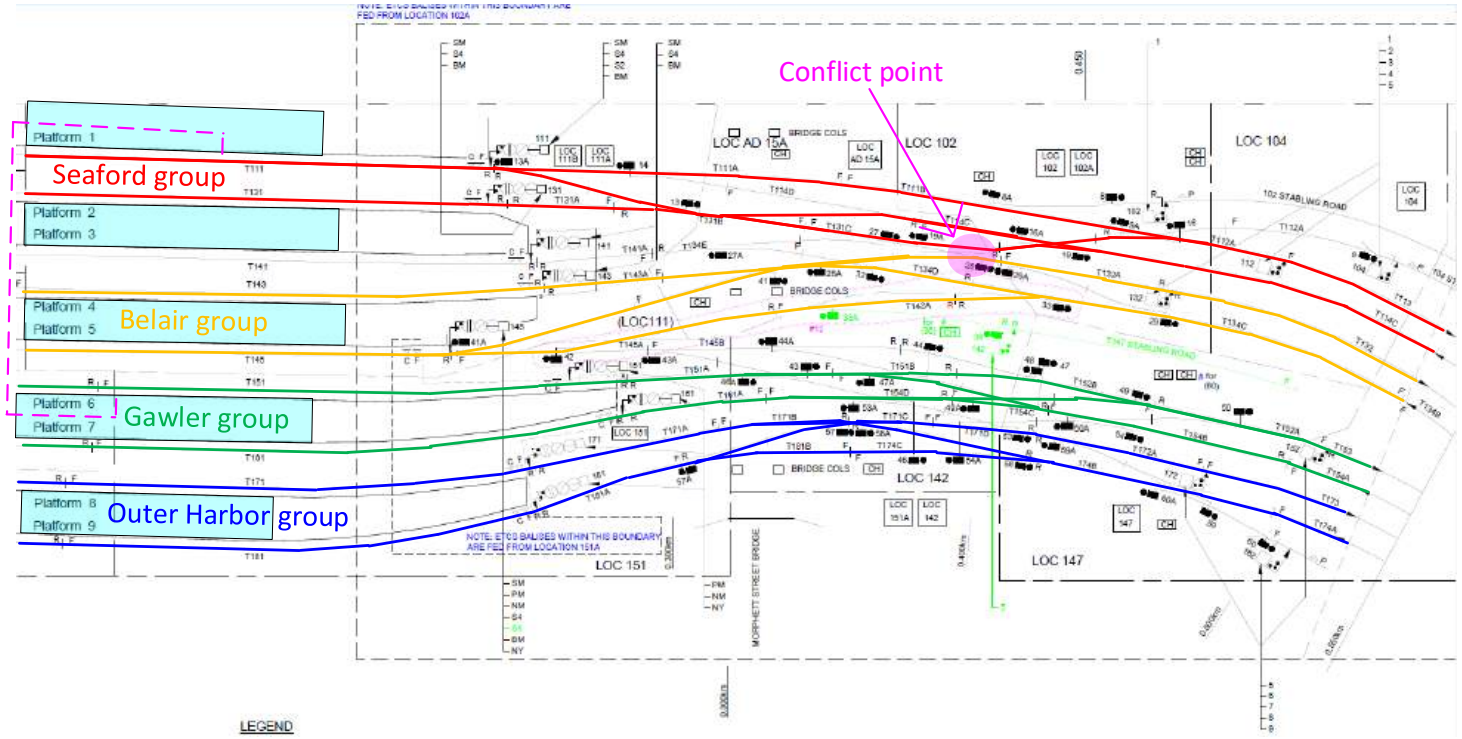




Saturating the Nodes (Switzerland)

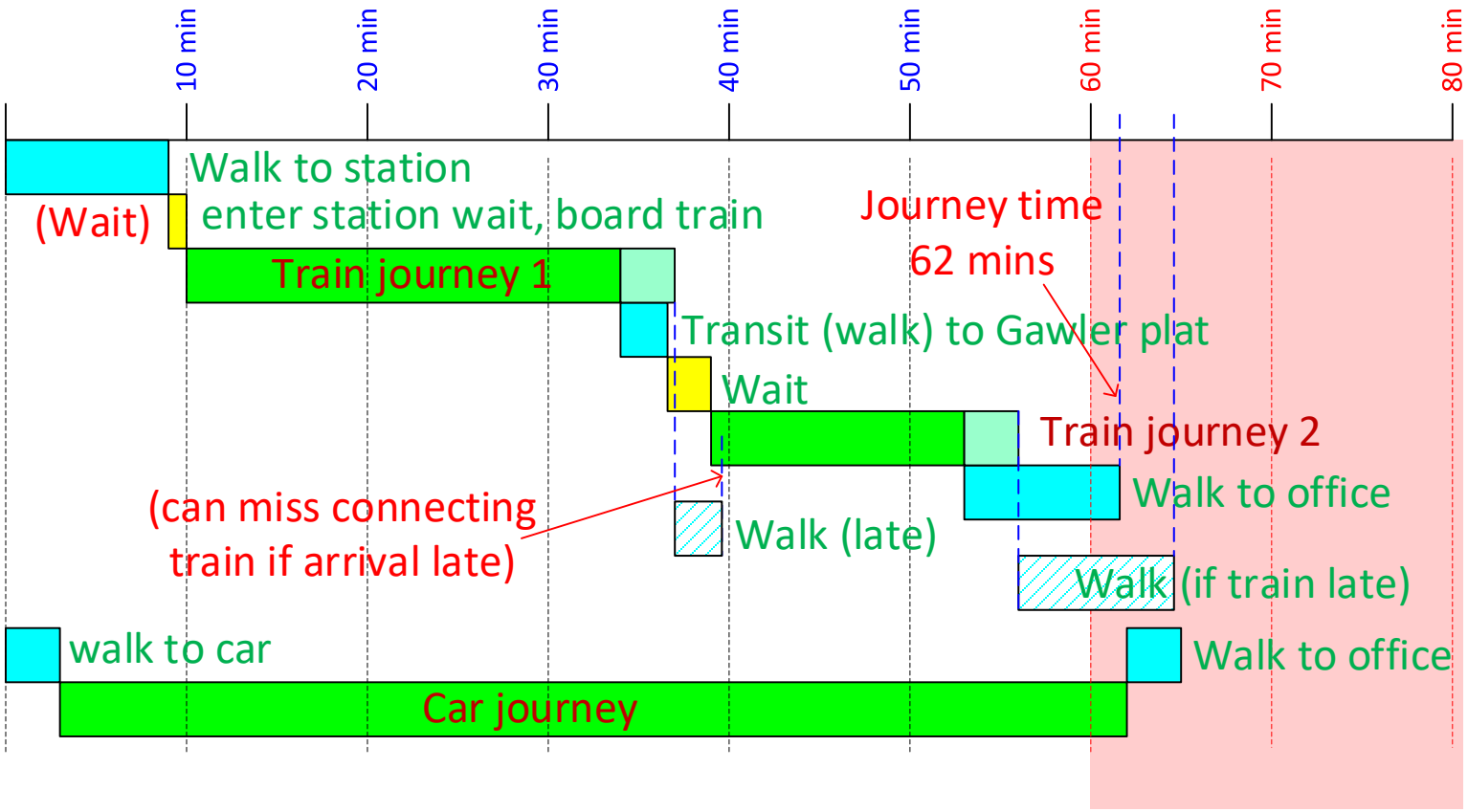
- Classically, trains from all locations arrive at the station simultaneously
- Trains stand-over at station long enough for every passenger to interchange from any arriving service to any departing service
  - Allow for doors to open, time to get off the train, then walk time along station, then across to station where departing service is waiting.
  - Allow for degree of late running permitted by Operations
  - Prefer “cross platform” interchange where large numbers of passengers are likely to interchange
- In practice, network infrastructure constraints prevent true simultaneous operation in many cases
  - Network infrastructure constraints need to be understood and impact included in TT

Saturating the Nodes (Adelaide)



- 4 separate operating groups
  - Note conflict point between Seaford and Belair groups.
- Walking between arriving service and departing connecting service via concourse
  - Longest interchange walk 2.7 minutes at 1.33m/s.
  - Interchange across single island platform less than 20s
- Clockface service in evenings at 30 minute interval
  - 6 minutes standard minimum layover (for “change ends”)
  - 5 minutes between Seaford schedules arrival and Gawler scheduled departure
  - 3 minute allowance provided without arriving train being designated “late”

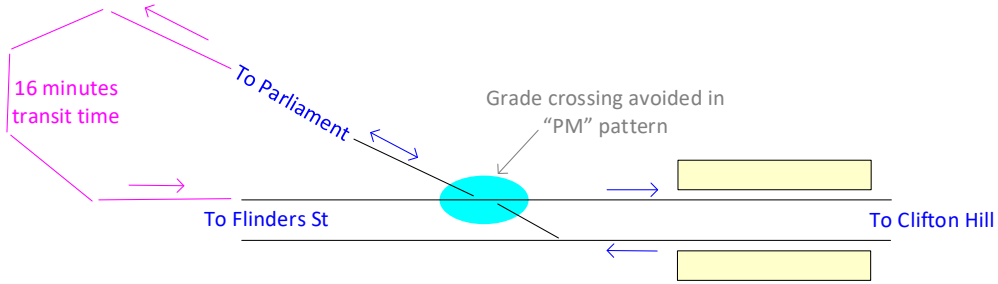
Controller's trip with current timetable



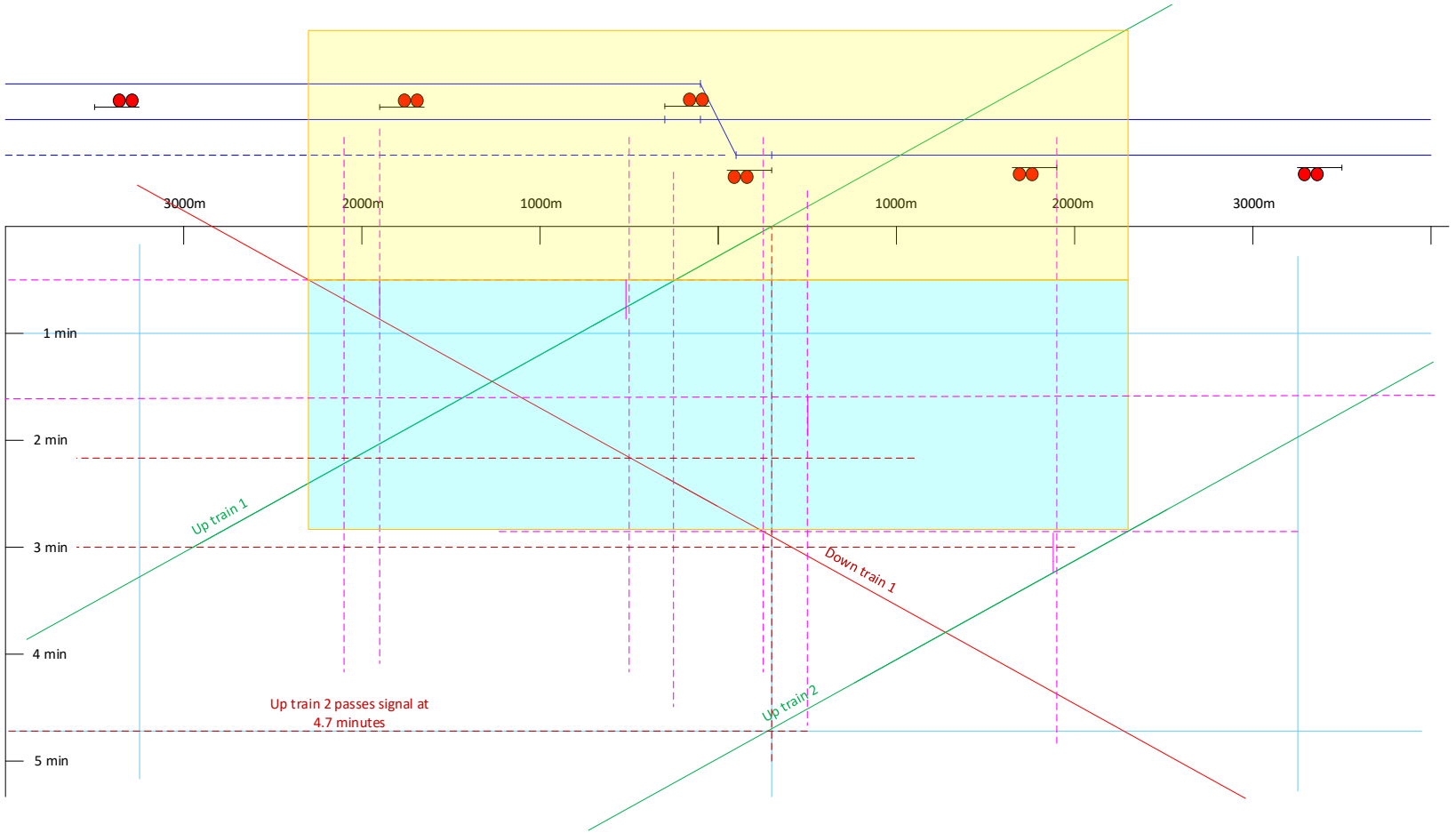
- By Train (based on 10pm)
  - 8.8 minute walk from home to station (approx. 700m at 1.33m/s [Transport for London standard rate])
  - Train scheduled every 30 minutes
  - 24 minutes train to Adelaide
  - Change trains to Gawler line train (departs 5 minutes after Seaford line train arrives, takes 3.2 minutes to walk between platforms and interchange)
  - 14 minutes train to Dry Creek. Train can run late.
  - 8.8 minute walk to office
- By Car
  - 5 minutes get car out of garage
  - 55 minutes (Google estimate, but vaties with traffic) drive to Dry Creek.
  - 5 minute walk from carpark to office
- Car and train take the same time, but which is more reliable?

Timetabling over junction with conflict 1

- Clifton Hill Loop (as start point for example)
  - Plan was to timetable 20 trains per hour.
  - Simulation showed only 15 trains per hour possible when direction of travel included conflict
  - Solved by not using that direction of travel (conflict eliminated)
  - Represents “hydrogen case” for conflict
- Basic parameters for layout
  - 65km/hr for all movements.
  - Station stop not considered
  - 16 minute timetabled transit time includes adjustable standover time at Flinders St
- Desired to timetable trains at 3 minute interval
  - 2 minute signalled headway chosen
  - “Headway” at a signal is the minimum time between a train passing that signal unrestricted by the signal and the time when, in the normal course of operations, a second train may pass that signal similarly unrestricted”

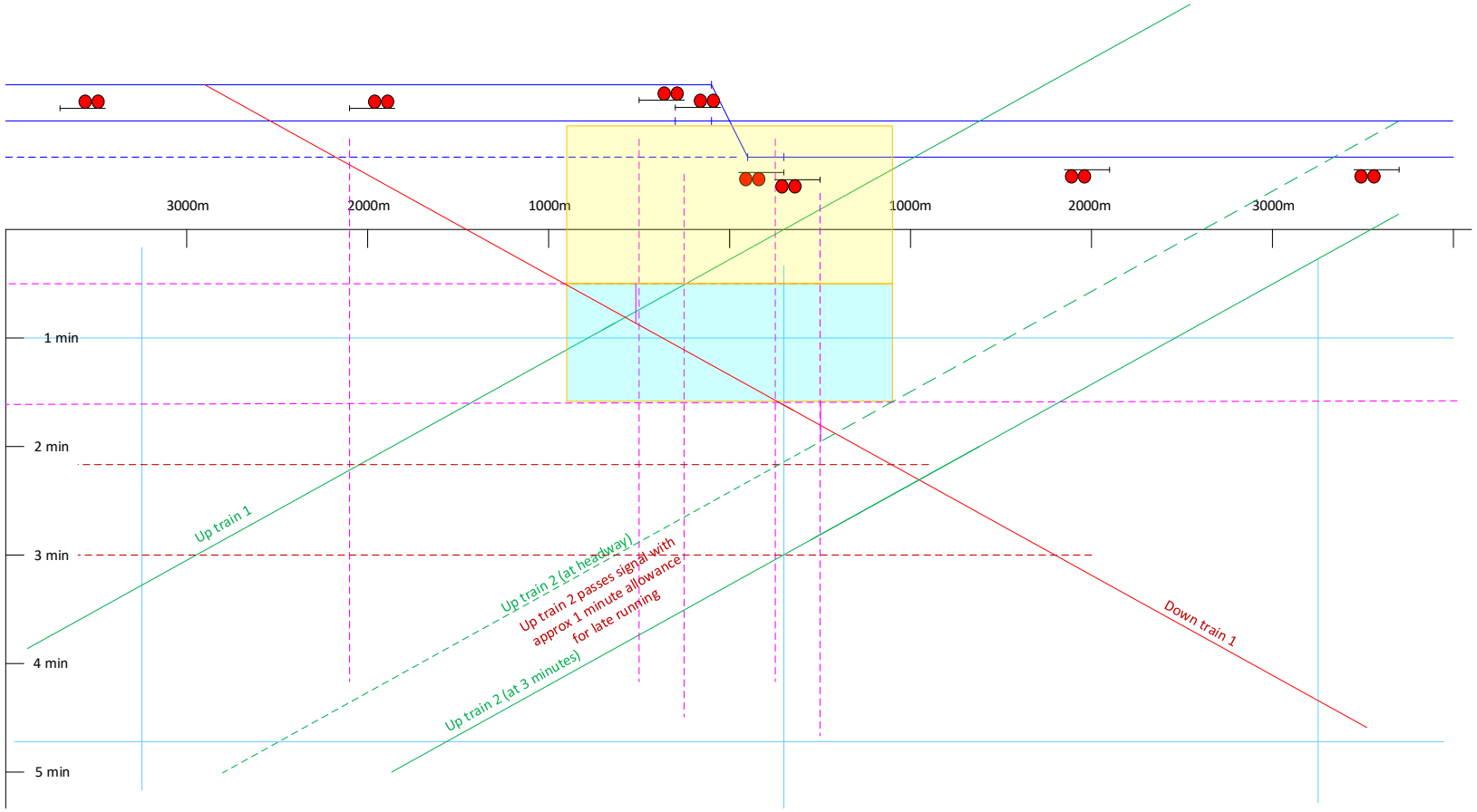


Train Graph (“2 minute” headway?)



- Designer designs without considering conflict
  - 2 minute headway gives 1600m signal interval
  - Actual headway (recognising that all up trains must return as down trains) calculated at 4.7 minutes.
  - No allowance for late running. Nothing less than 6 minute timetable interval could be considered.

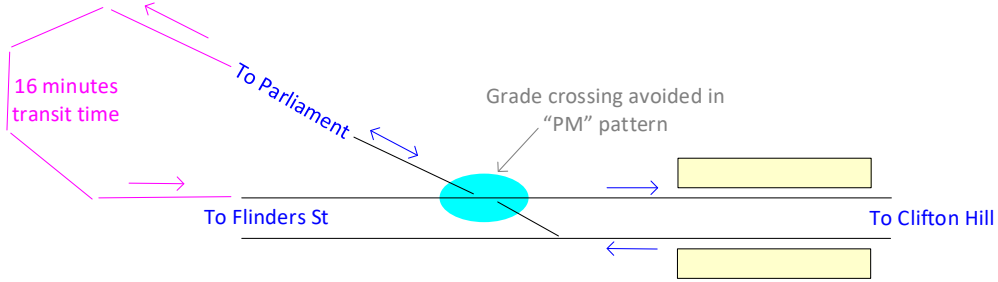
Train graph (short headway)



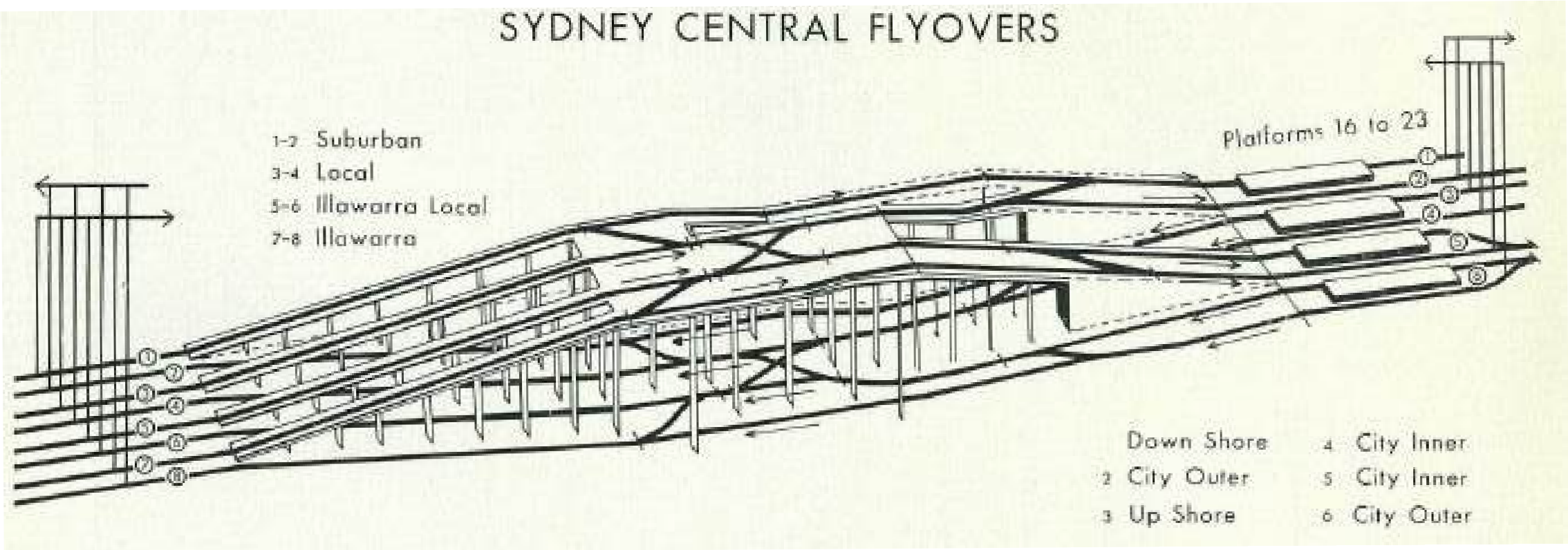
- Designer implements minimum signal spacing to protect junction, 2 minute interval elsewhere
  - 127s headway calculated across junction for this case
  - 3 minute timetable interval (20 trains per hour) if train running within 1 minute of TT
  - 4 minute timetable interval (15 trains per hour) if train running within 2 minutes of TT
  - Trains are permitted to be 3 minutes behind TT without being registered late
  - Simulator output depends on input assumptions about what proportion of trains run how late.
- Loop transit time dependency
  - Transit time must deliver train to conflict zone at the time which achieves scheduled gap between trains.
  - 16 minute loop transit assumes trains to TT
  - 17 minute transit allows for within 1 minute.
  - If 4 minute service interval and 16 minute loop transit, 100% of trains would conflict.

Timetabling over junction with conflict 2

- Conflict zones must be understood, not ignored
  - For each zone, “resonance” operates to cause forbidden combinations of train frequency and transit time.
  - Where multiple conflict zones are provided on the same line, multiple resonances appear with multiple forbidden combinations.
  - For some layouts, no “delay free” combination may be possible.
  - Where delays are introduced, they should be in infrastructure/timetable at the start, not left for the driver to find at the end.
- The size and impact of each conflict zone depends on the tolerance for late running
  - Enforcing lower “on time tolerance” substantially boosts network capacity (33% improvement for our example).
  - Operations cannot enforce a tolerance the infrastructure (track + signal) does not permit.
- High performance networks eliminate conflict zones by providing flyovers

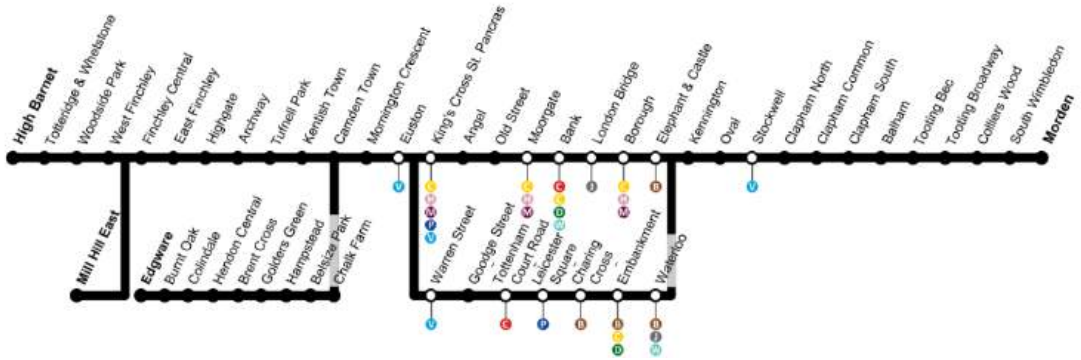


Sample conflict elimination – Sydney 1930



Sample diverge and merge – London Northern Line

- Trains diverge after Camden Town and Merge again by Stockwell Bridge
  - Run time is 24 minutes, either leg
  - Merging trains must merge into an available train running slot
  - When run time is the same on each leg, availability of slot is not sensitive to transit time or train interval
  - Line capacity dependent on tolerance for running behind TT (lower tolerance = higher capacity)
- Run times may differ for each leg (eg 12 minutes via Bank, 24 minutes via Leicester Square)
  - When run times differ, forbidden combinations of transit time and train interval emerge
  - For example, 3 minute interval is feasible, 4 minute interval is forbidden in example.
  - The capacity for fast trains to pass slow trains provides a worthwhile reason to include this class of layout in your railway.
  - Design of layout (track + signals) requires integration with operational plan so as forbidden combinations can be avoided.



Beyond this paper – Keikyu line

- Keikyu line runs between Tokyo and Yokohama
  - Carries 2.4 million passengers per day (2013)
  - Mix of stopping and express trains
  - Links to Haneda airport
  - 2 tracks (up and down) with multiple platform faces
- The need for quadruplification avoided by
  - Controlling tolerance for running behind TT to within 1 minute
  - Multiple tracks through premium stations to allow passing.
  - Maintaining reliability of infrastructure to high levels.
  - Maintaining safety to extremely high levels.
- Those attending ASPECT 2025 may like to try out this line

Conclusion

- A Metro is not the only kind of suburban railway.
- It is people who have journeys, not trains.
- Both “Saturating the Nodes” and “Saturating the Roads” have their place in a high performing network
- Designing the layouts involves integration between an operational concept and the infrastructure (track + structures + signals) which can support that concept
- We have shown:
  - Significant capacity improvement can flow from controlling late running tolerance to minimums
  - Operations cannot comply with late running tolerances the infrastructure does not support
  - The need for costly new infrastructure can be avoided by understanding junction conflict zones; how to remove them (with cheaper infrastructure) or how to control them (operations).
- These are not new lessons for our networks.
  - See schemes in Sydney and Melbourne in 1930s and 1940s
  - See Transport engineering literature from 1960s