Mathematics of Planet Earth
Managing Traffic Flow On Urban Road Networks

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keeping victorians connected

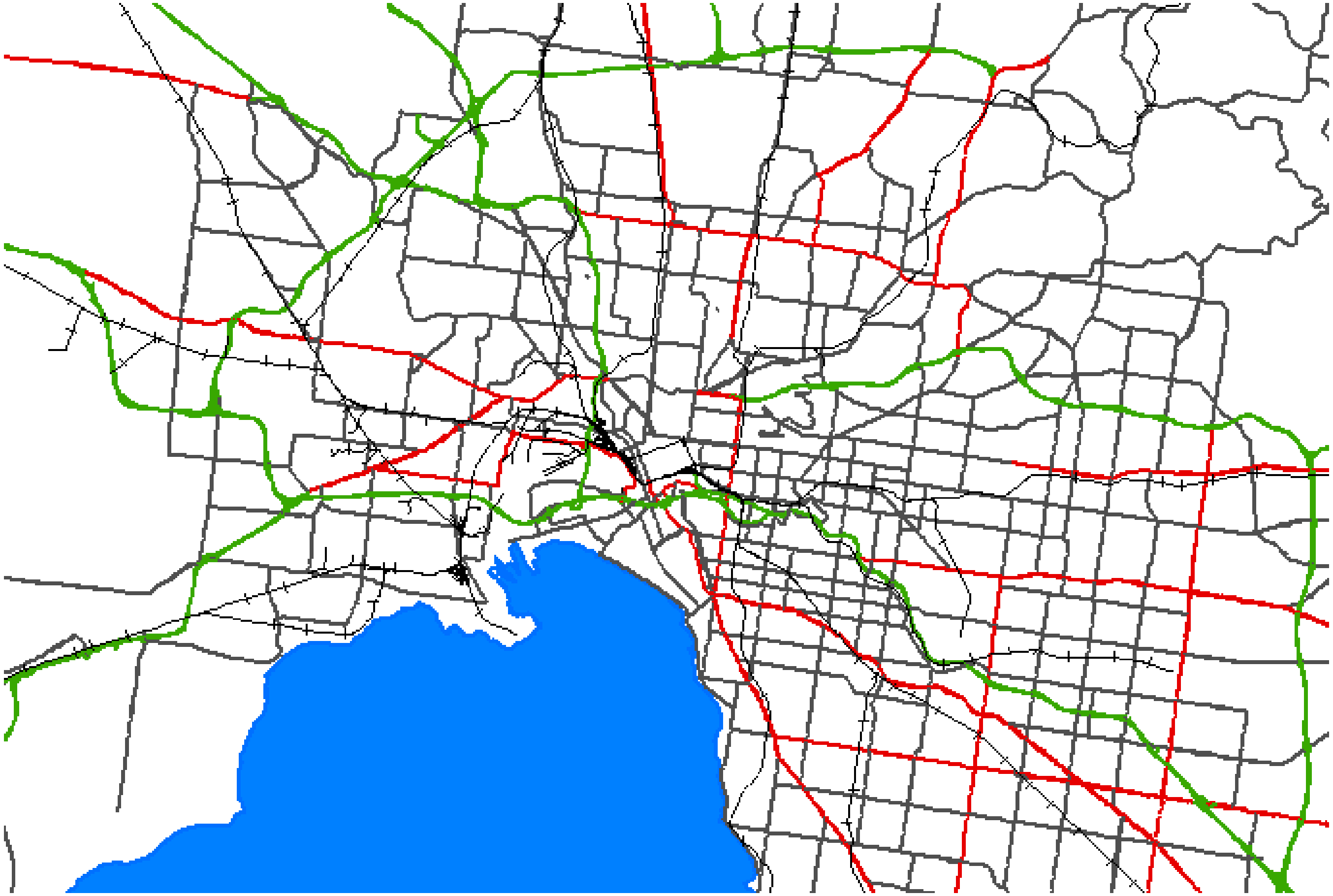
Melbourne's transport demands are growing

5m people by 2030 / Freight doubling by 2030 / Public transport +30% over 5 years
Cars +6% over 5 years

Complexity – The Building Blocks

Network shape

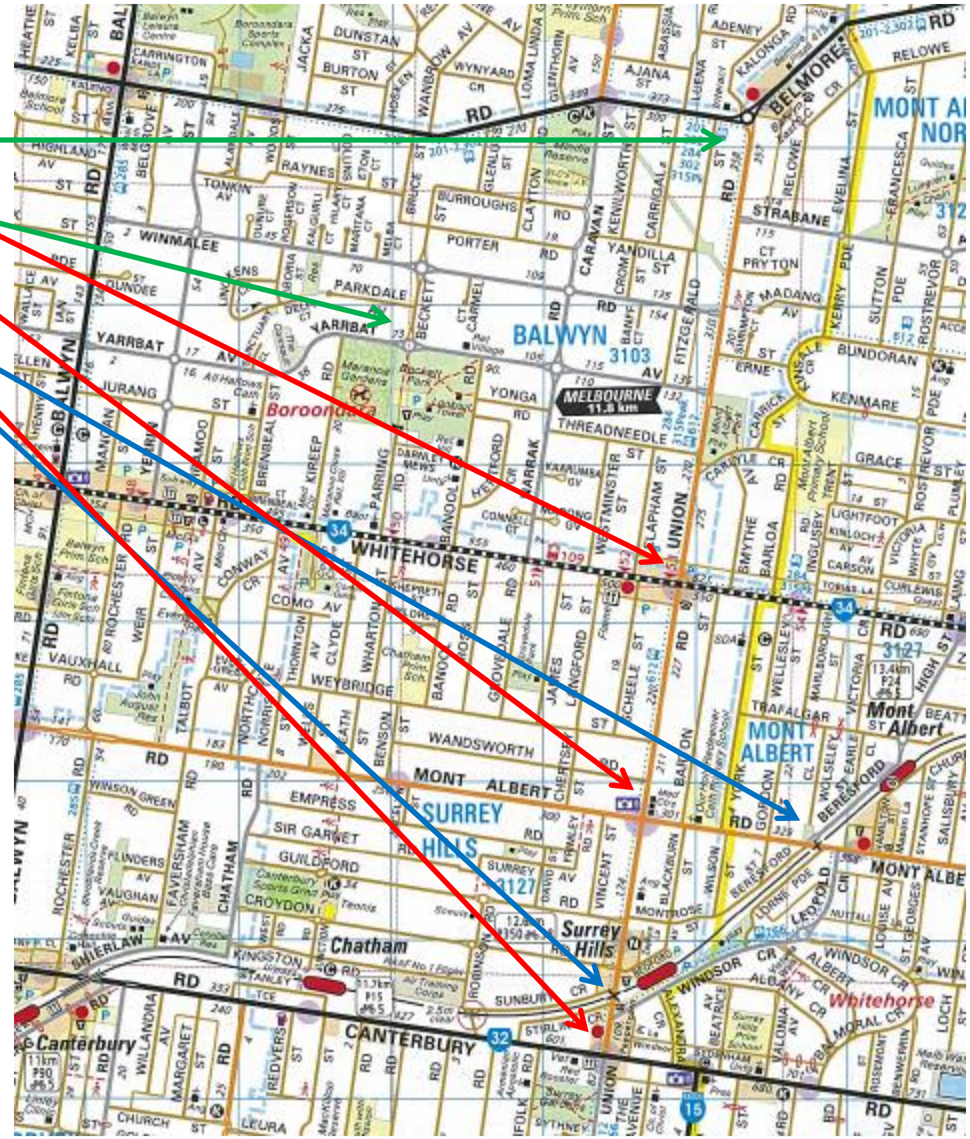
- Intersections and Links
- Intersections control network behaviour and performance
- Melbourne is both grid like and radial



Complexity – The Building Blocks

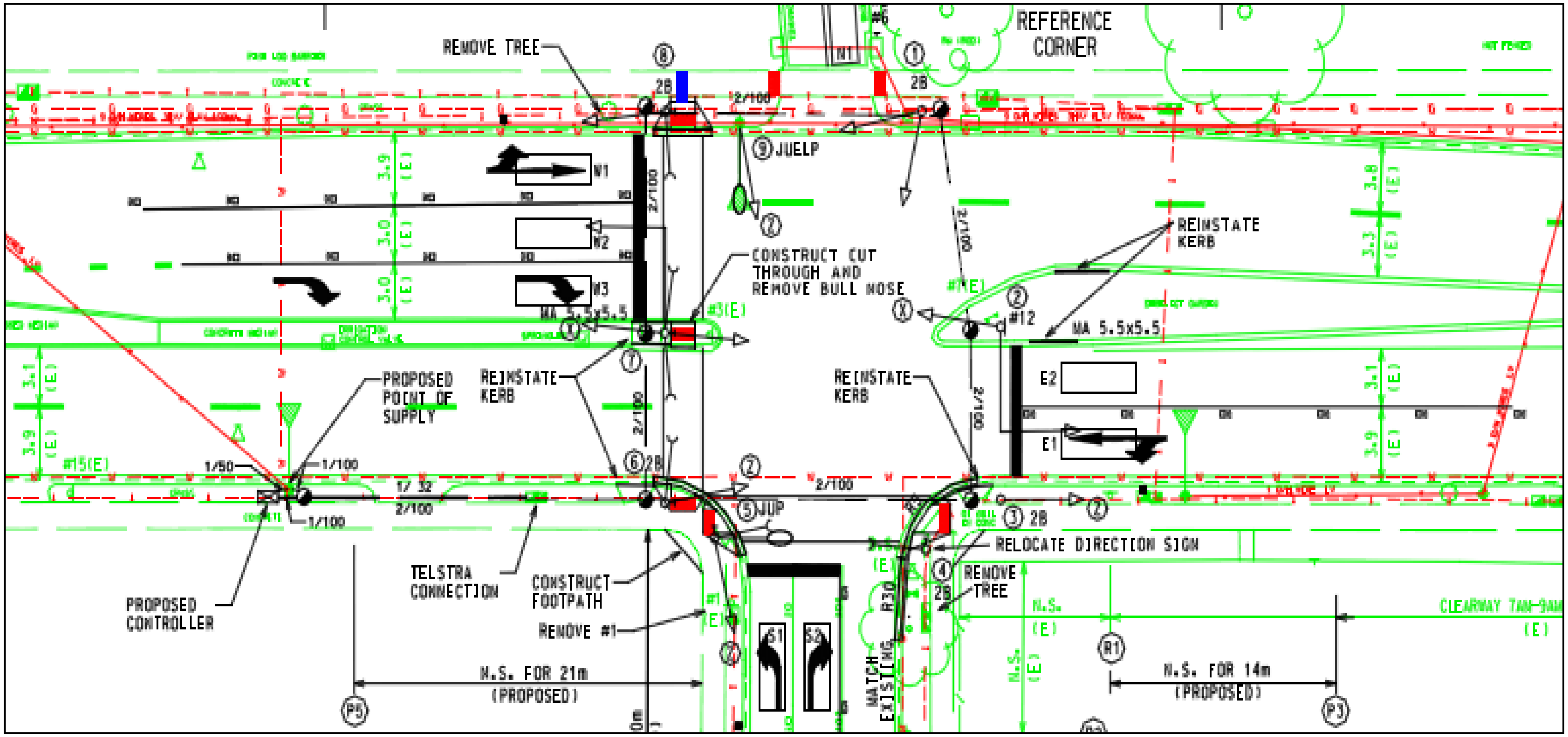
Intersection control
- Traffic signals
- Roundabouts
- Priority control
- Rail Level Crossings

Signalised intersections control everything!



Complexity – The Building Blocks

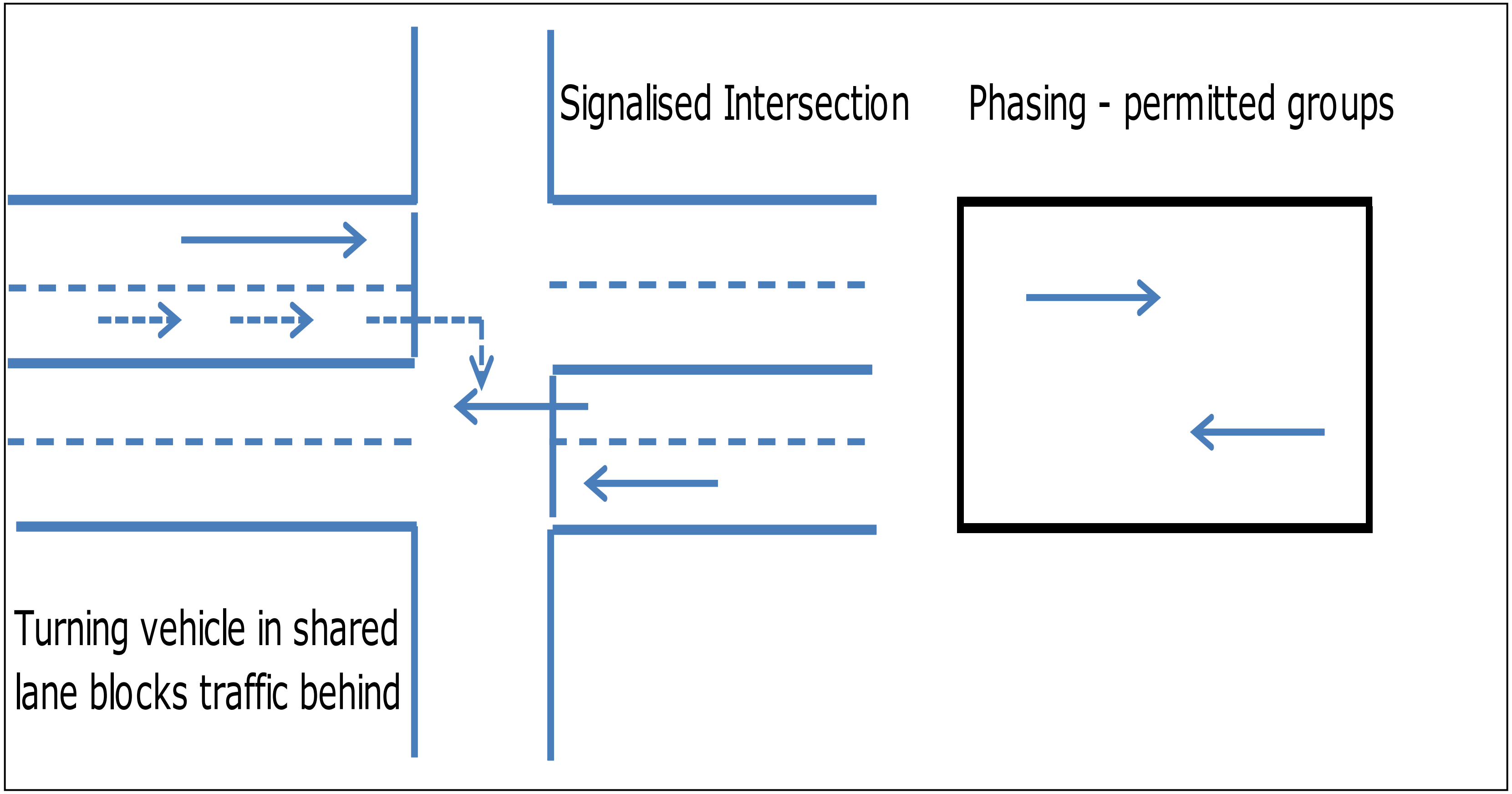
Lane configurations
- L, L+T, T, T+R, R, LTR, U
- Unoppposed movements with lane detection gives high control
- now detectors in left turn slip lanes



Complexity – The Building Blocks

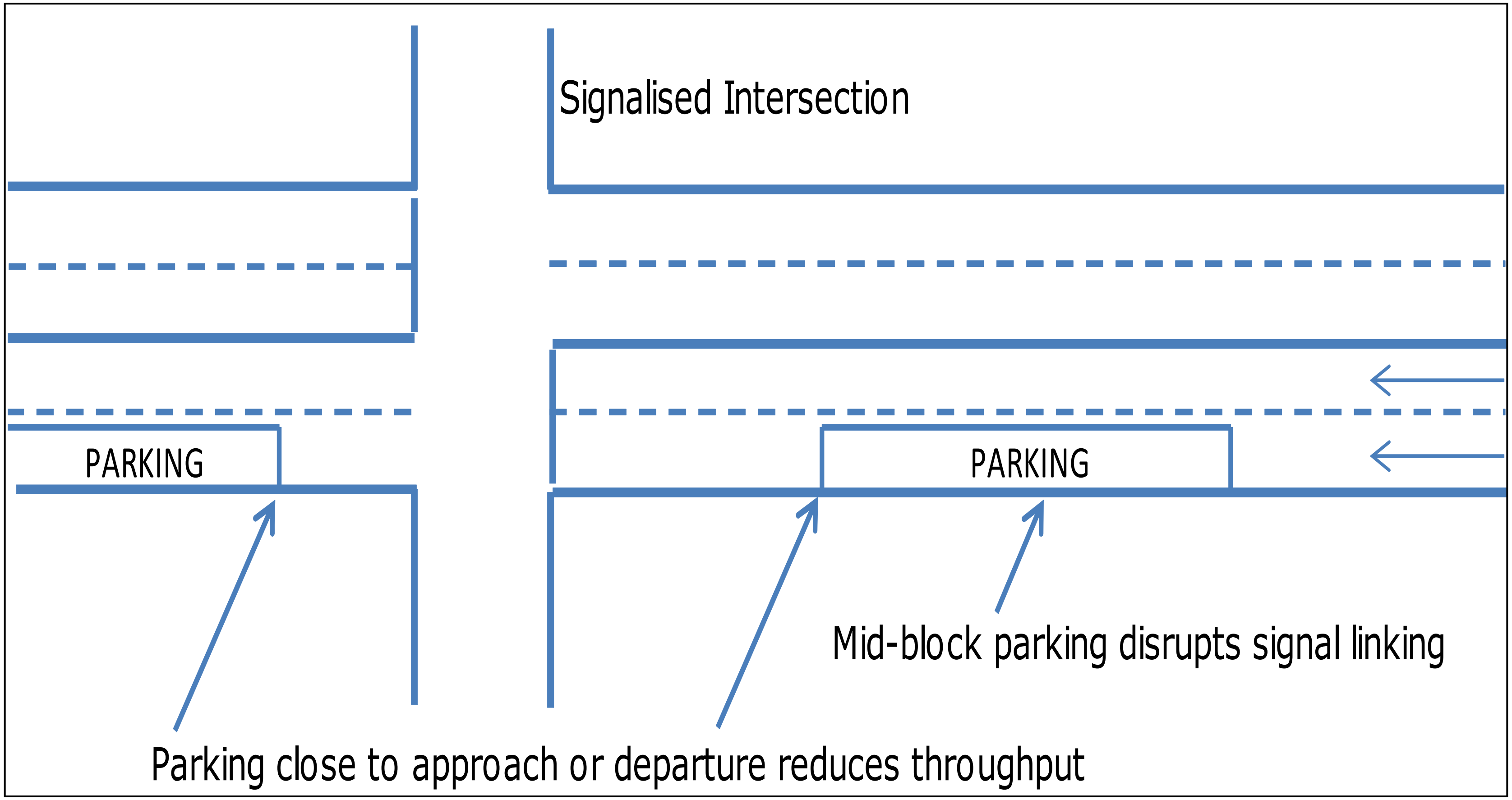
Lane configurations

- Opposed movements in shared use lanes are troublesome
- common problem on undivided 4 lane tram routes



Complexity – The Building Blocks

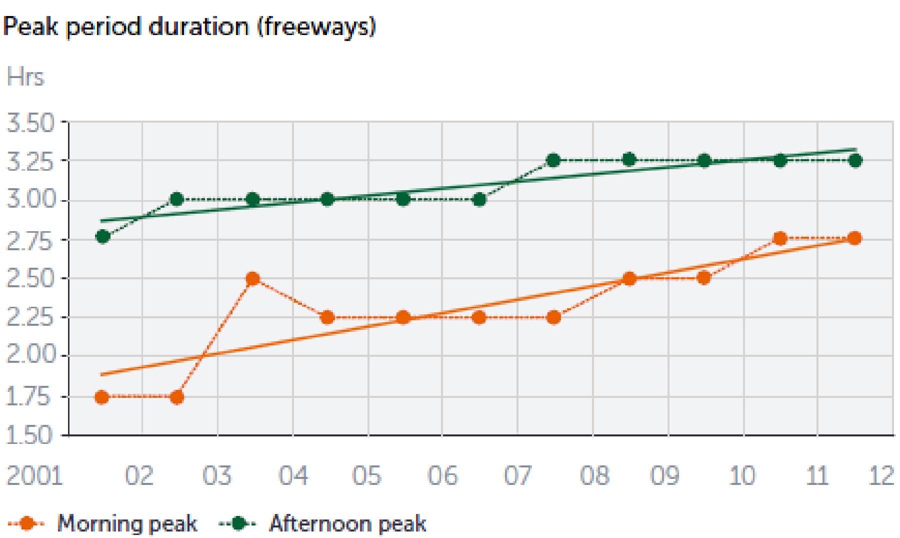
Parking
- along the route (strongly impacts travel time)
- near signalised intersections (strongly impacts throughput)

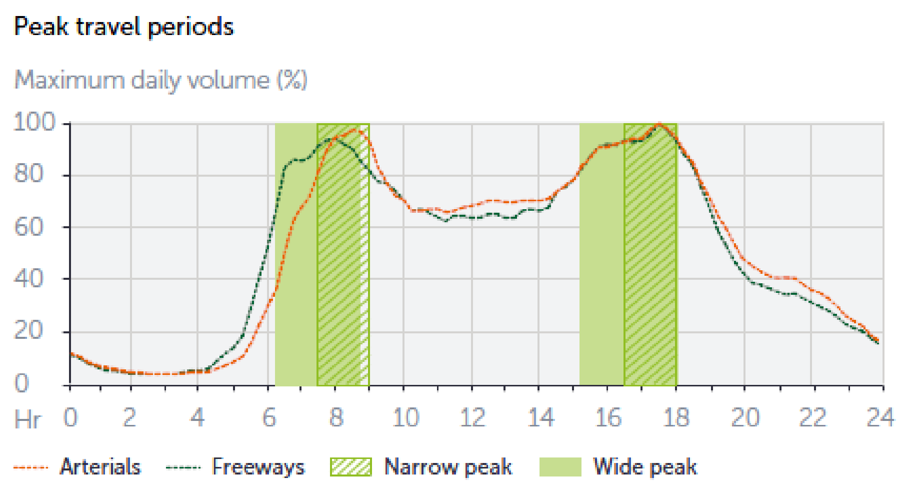


Complexity – The Building Blocks

Traffic composition
- cars + trucks + trams + buses + bicycles + pedestrians
- exclusive use lanes enable priority to preferred streams

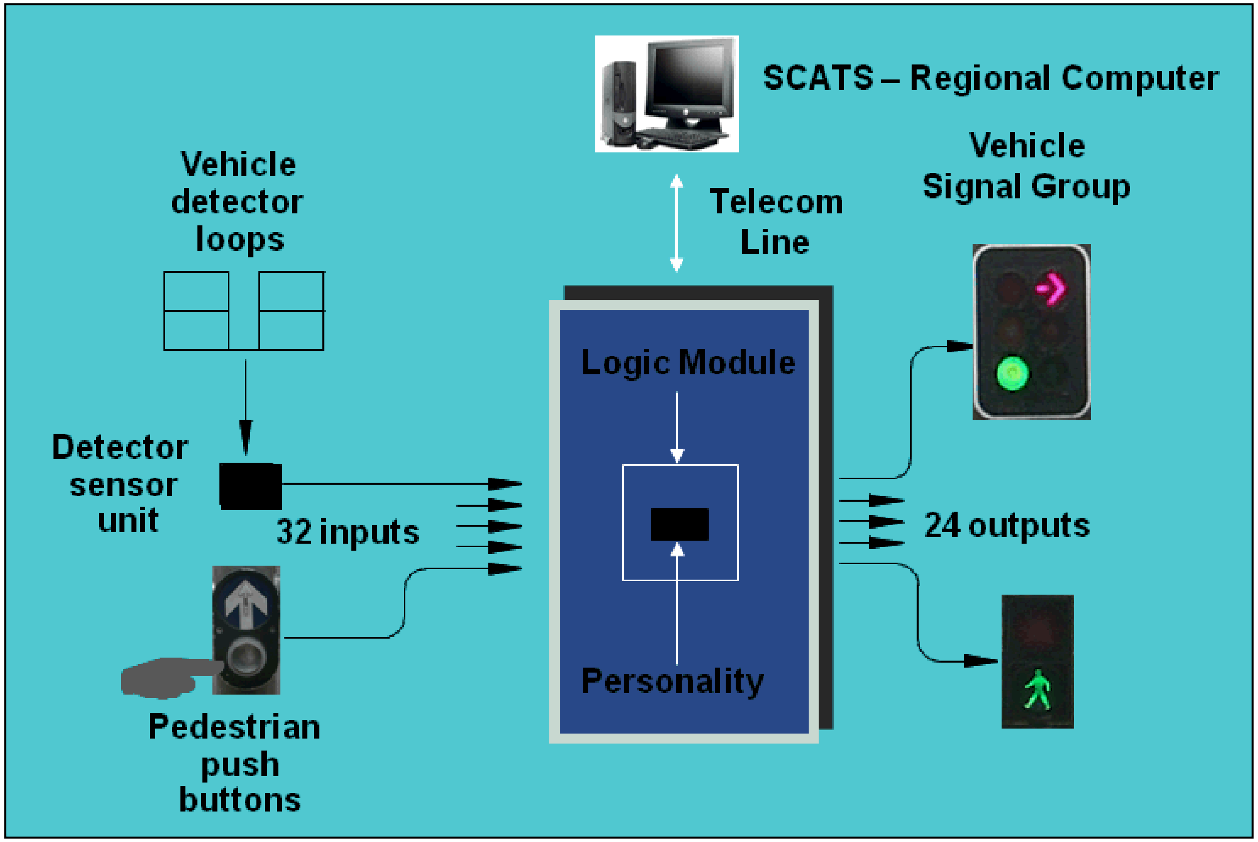
Traffic profile
- Control system must be agile to react to changes e.g. AM peak
- In oversaturated conditions (common), must analyse the build-up and dissipation of queues – steady state analysis is not adequate





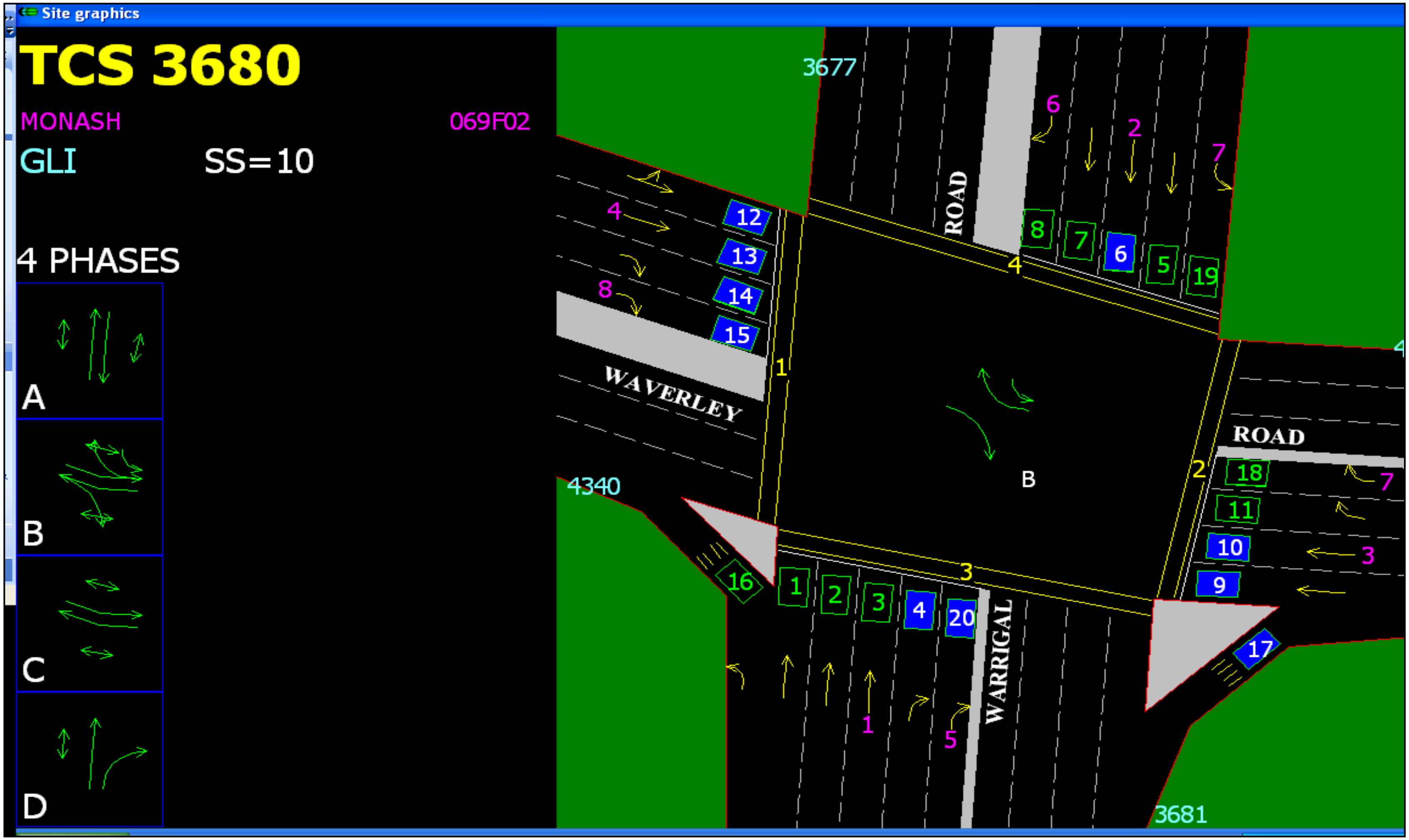
Complexity – The Building Blocks

Control System – in Melbourne - SCATS
- Isolated / Time of Day / Adaptive



Complexity – The Building Blocks

Control System – in Melbourne - SCATS
- Detectors / Phases / Groups



Complexity – The Building Blocks

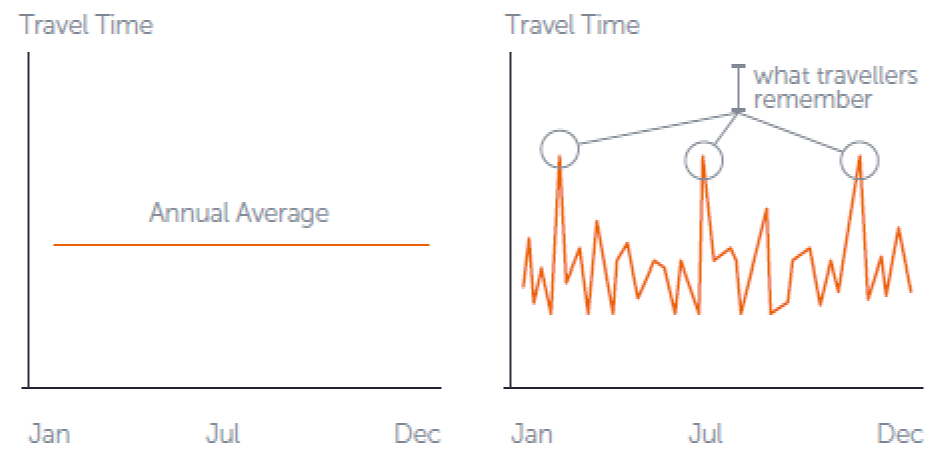
Performance Measures

- Throughput
    - not just vehicles, people

- Travel Time (delay)
    - road users want certainty – reduced variability

- Queues are not a primary measure for SCATS

In Melbourne, approx 85% of arterial and freeway trips occur within +/- 20% of mean travel time – but will this change as the network gets increasingly congested

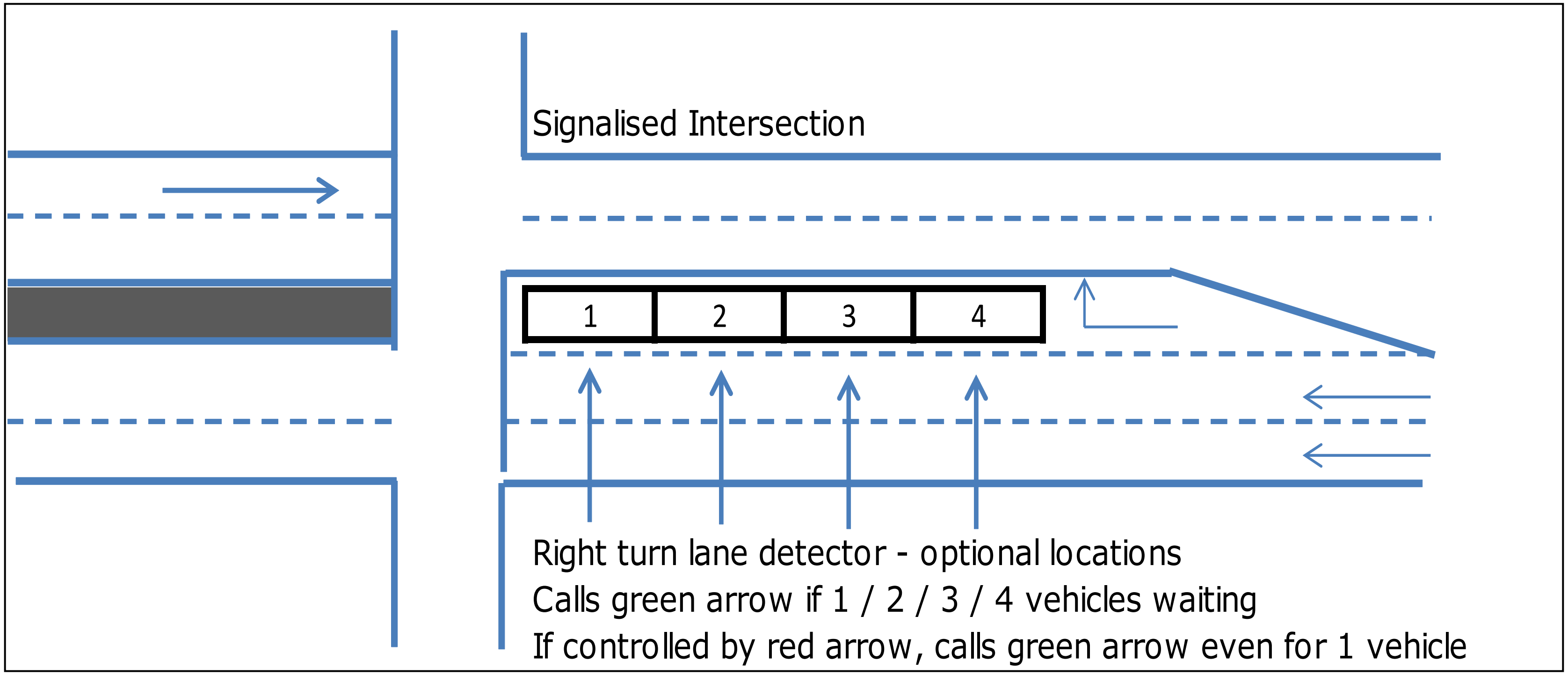


Source: Federal Highway Administration (2006)

Control – What We Do

Intersections
- phasing sequence + group control
- generally service every movement during a phase cycle

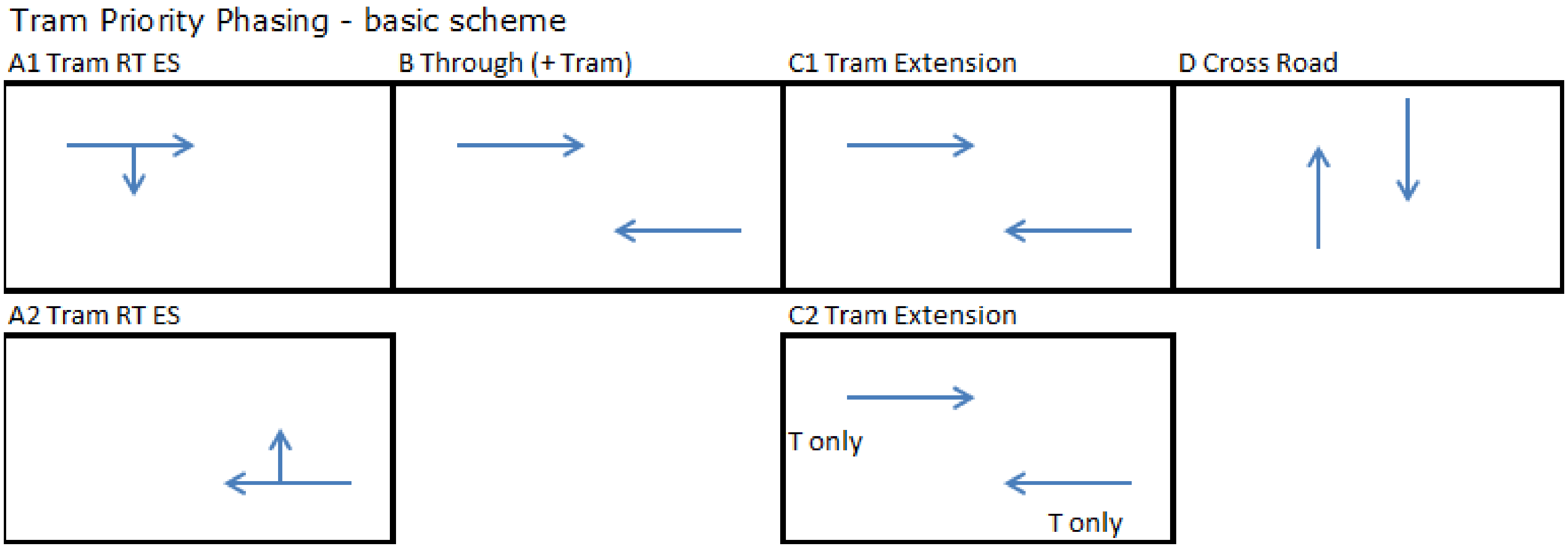
Flexibility is paramount
-skip phases if not enough waiting, or wrong time, or wrong direction
- full control (red arrows) prevents phase skipping



Control – What We Do

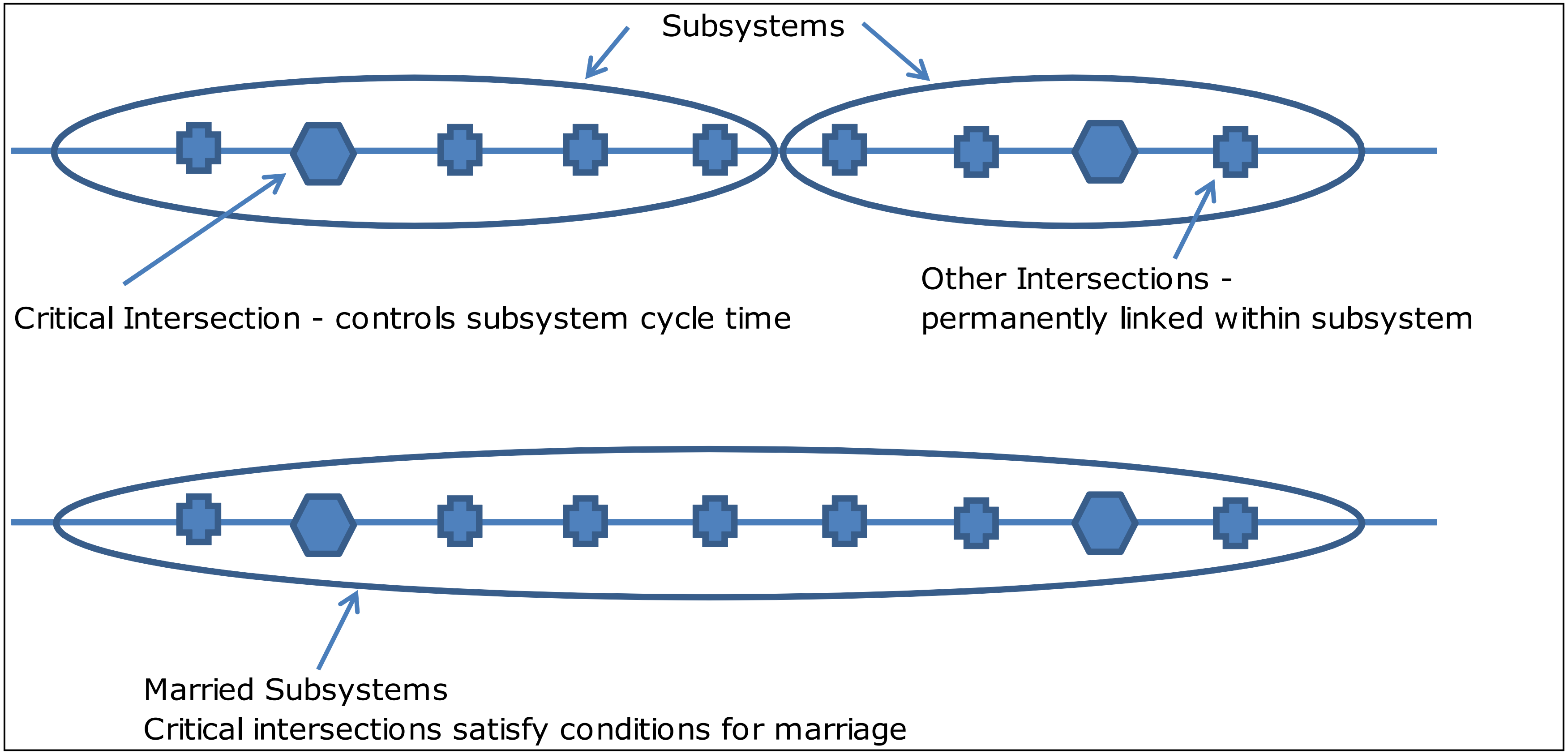
Intersections
- Priority phasing – highly reliant on priority vehicle detection
- In Melbourne, tram priority since the 1980s

Right turn phases are called to clear traffic in front of the tram (A1 or A2), and through phases can extend if trams have not yet cleared the intersection (C1 or C2)



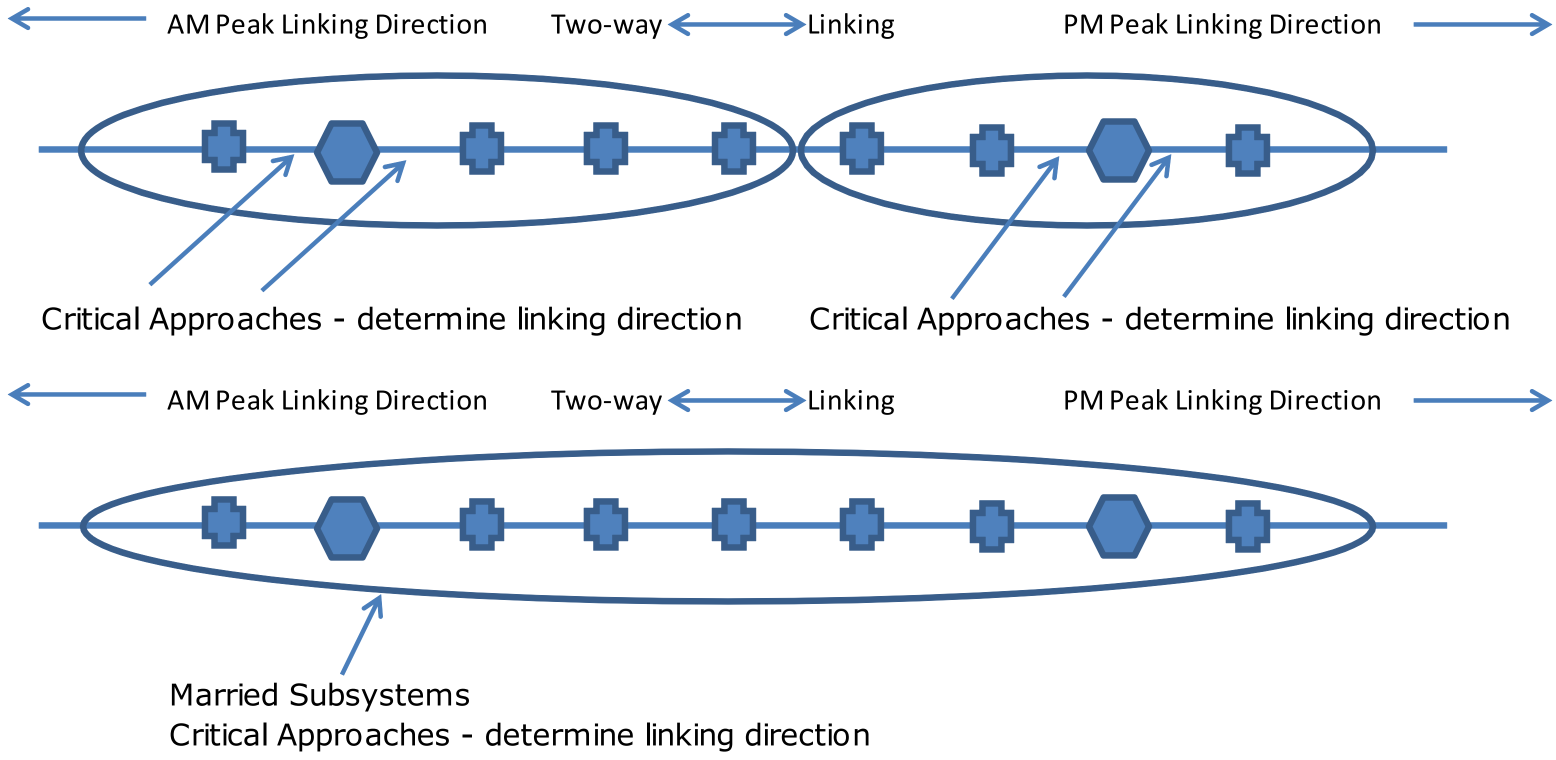
Control – What We Do

Critical intersections within subsystems control cycle length
- critical approaches control linking direction
- marry and divorce subsystems if conditions are met
- similar cycle length for 3 out of last 4 cycles
- alternatively, directional volume exceeds a typical peak threshold



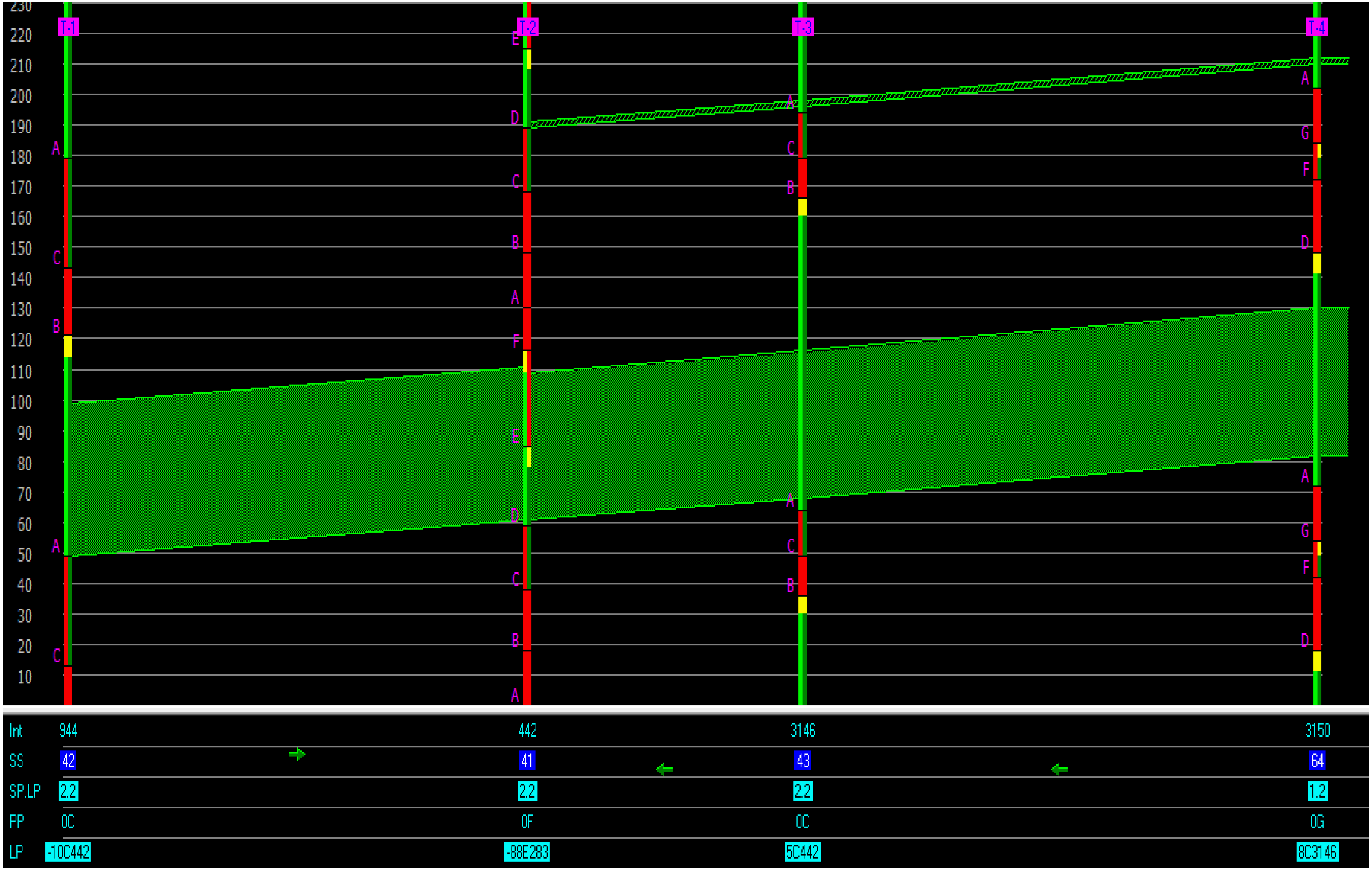
Control – What We Do

Critical approaches control linking direction
- typically 4 out of last 5 cycles with same peak directional bias
- avoid frequent change of linking direction (need to wait for subsystems to get in link – can be very inefficient)



Control – What We Do

Linking offsets based on speed and distance to reference intersection



Challenges

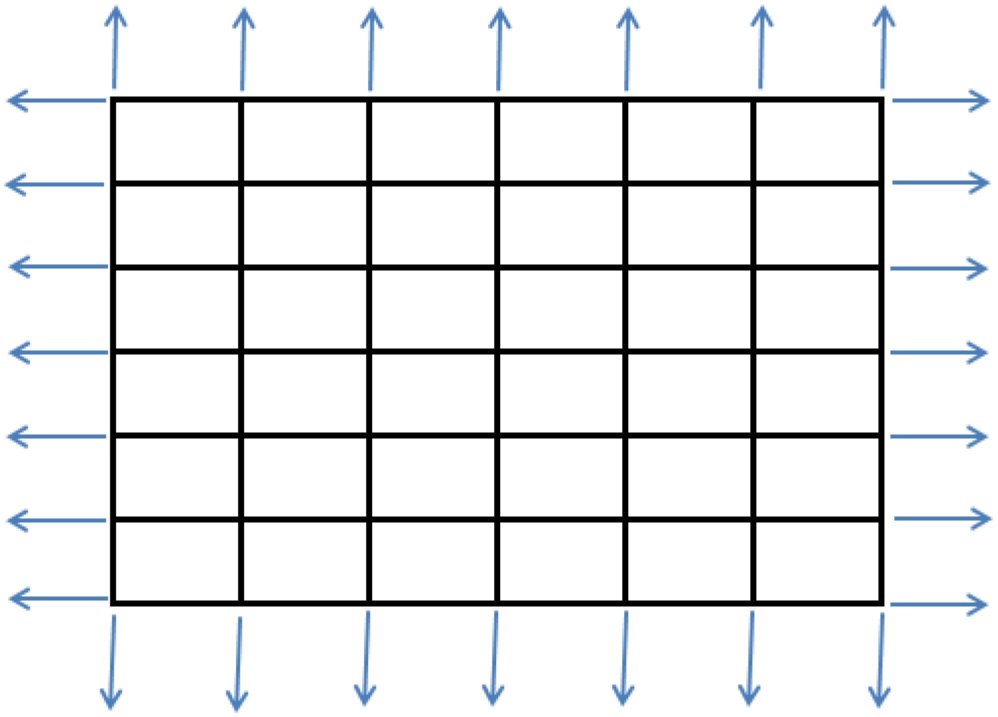
Previous studies

-10% to 30% reduction in travel times

1. SCATS is ideally suited for linear linking
   - does this maximise throughput?
   - would an alternative method give more throughput?

From outside looking in, each cycle pumps out traffic. But linking means some streams progress through while others are trapped in the grid – stored. So linking may provide little throughput increase, but reduced travel time. How does this relate to storage within the grid?

What impact would longer cycle times have on storage in the grid?



Challenges

2. Long Cycle Times

We typically run cycle times of about 120s to 140s during peak periods, with only one or two large multi-leg intersections running 160s to 180s. Recent trials on highly congested routes showed that longer cycle lengths of 160s appeared to be far more efficient.

Longer cycle times should be more efficient as they run less cycles per hour, so less time is lost between phase changes.

What efficiencies can be gained at long cycles of say 180s?

How can those long cycles be integrated with nearby linked smaller intersections?

How can longer queues that result longer cycles be managed?

Challenges

3. Strategic Management - SmartRoads

Previously - all movements treated as equitably as possible.

Under heavier traffic this just leaves everyone unhappy.

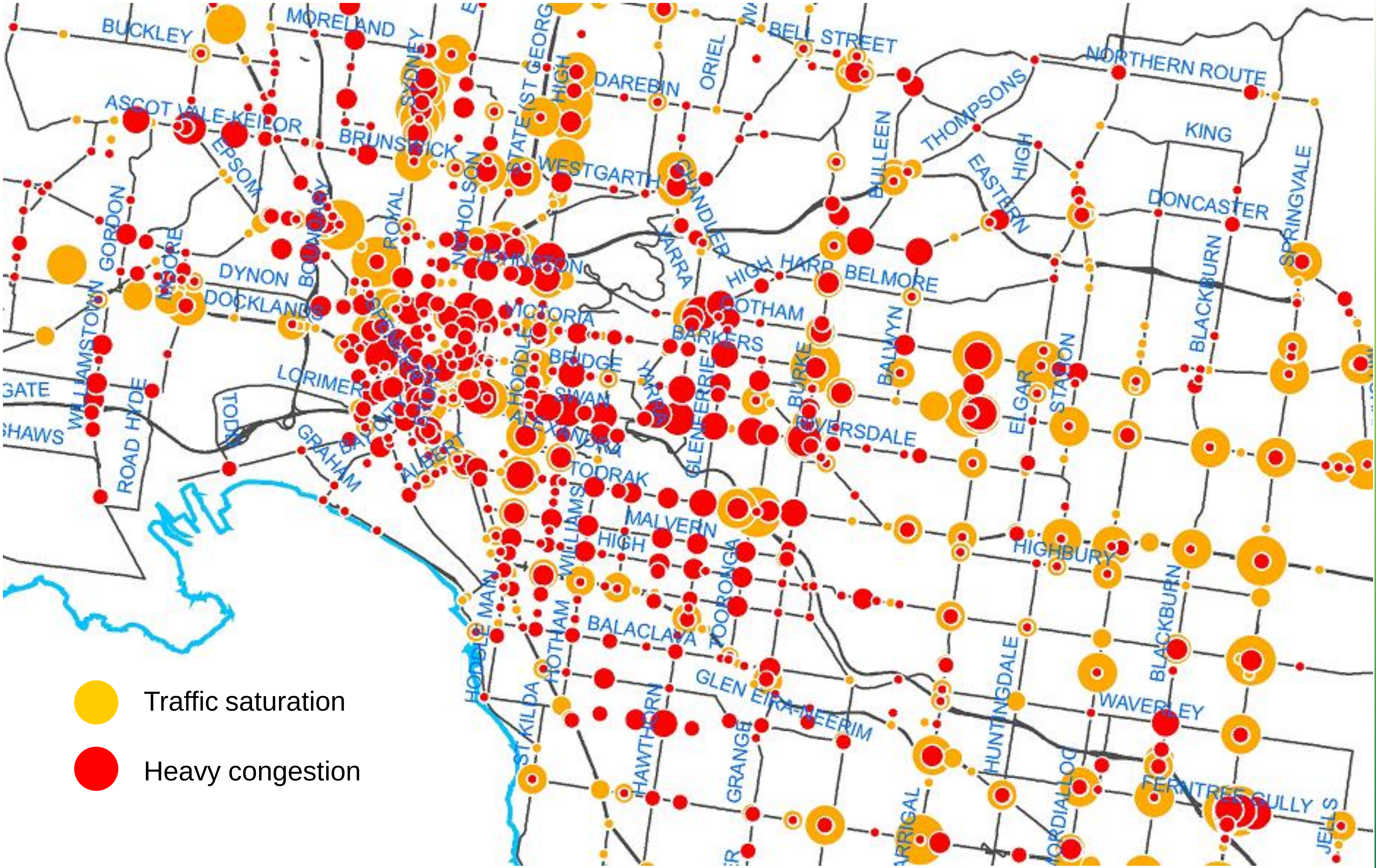
SmartRoads identifies priority movements based on:

- road importance

- time of day

- efficiency of transport (e.g. bus versus private car).

Challenge – Managing Traffic Congestion in Melbourne



SmartRoads – a plan for how the road network needs to operate

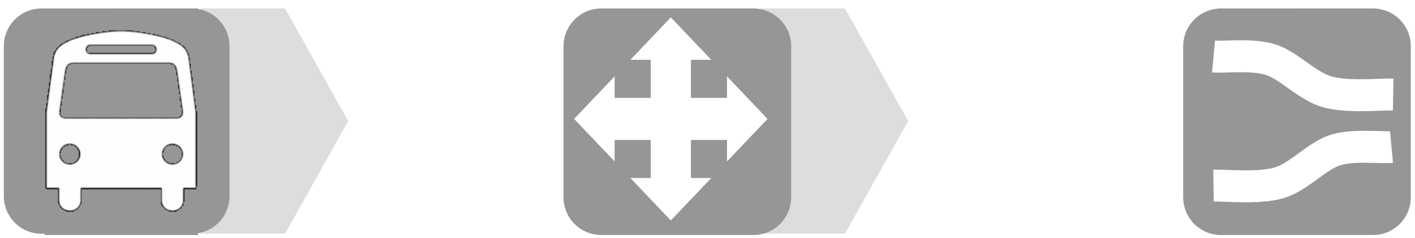
- Better manage use of roads
- Links transport to land use
- Encourages walking and cycling
- Emphasis on moving people and goods
- Balances competing demands for road space

SmartRoads uses a simple 3 step framework

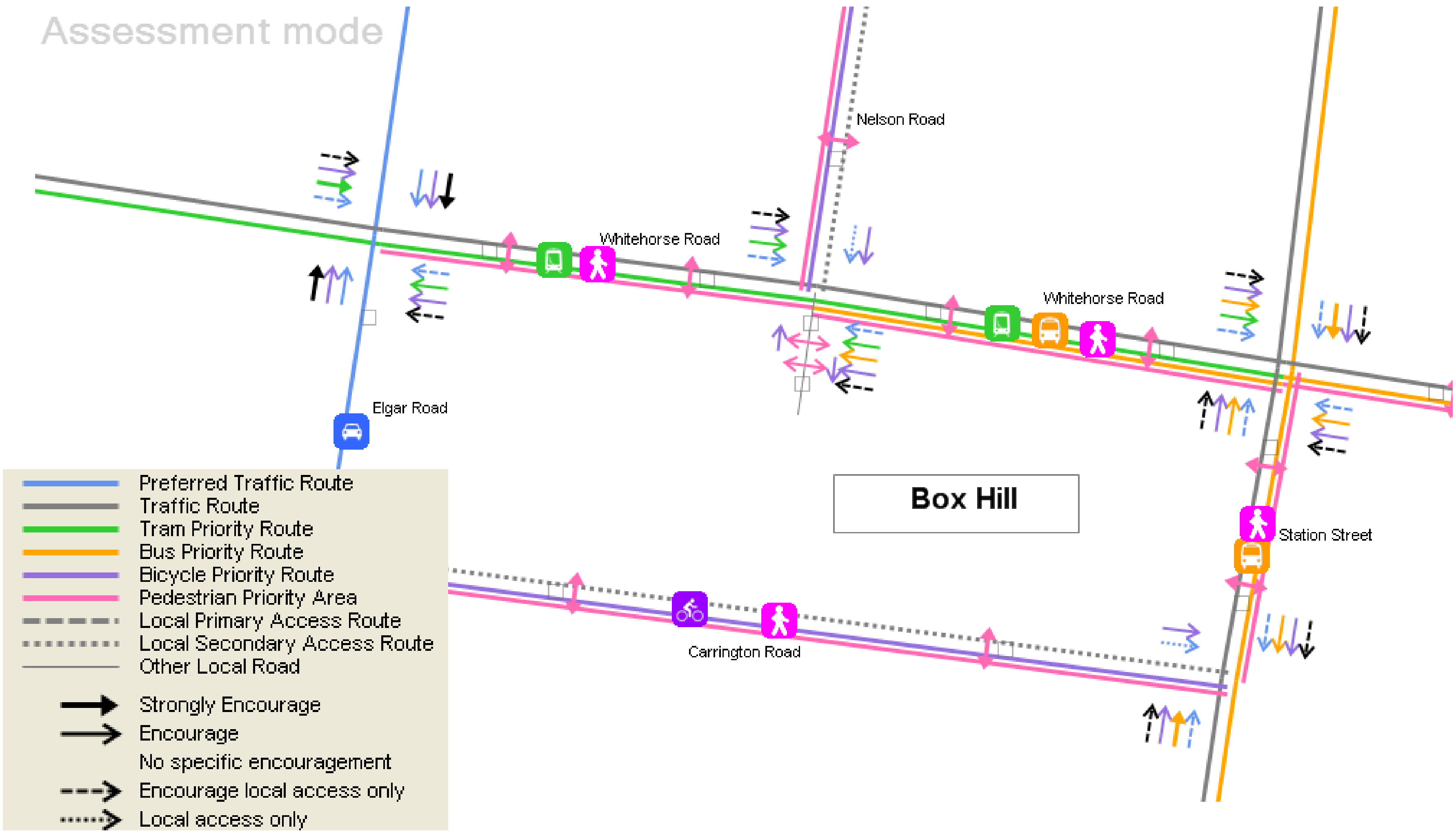
Road Use Hierarchy

Network Operating Plan

Network Operating Gaps



There are network operating plans covering all of Melbourne over 4 time periods



Challenges

4. Getting Ahead of the Congestion

Some Possible Strategies

A.
Look upstream - extend the cycle time before the heavy traffic arrives

- use detectors in an upstream subsystem (early warning), or

- marry the downstream subsystem when traffic gets heavy.

B.
Run the system slightly over-supply instead of just-in-time – avoid occasional oversaturation caused by traffic platoons or minor disruptions

Challenges

5. Smart Priority

Current priority – detect the tram or bus – run the priority

Smart priority

- detect the tram or bus
- check the schedule
- no priority if early or on-time
- strong priority if late

Challenges

6. Lane Priority

Wherever possible, separate priority vehicles from general traffic

Challenges

7. Natural Variation

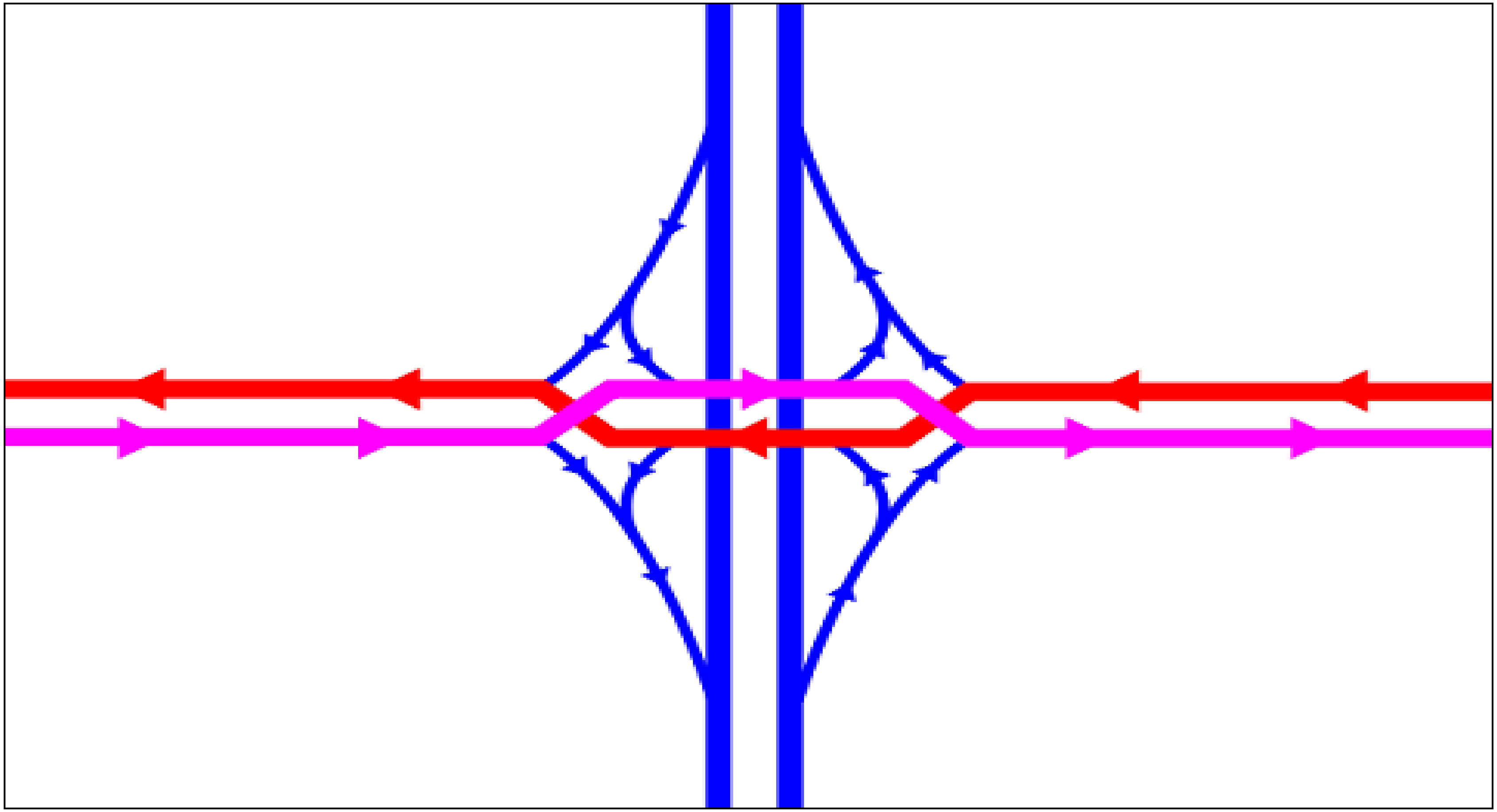
How much variation is there in traffic operation?

A better understanding of this would allow us to know when to respond to variation, and when to recognise the variations of random human behaviour!

Challenges

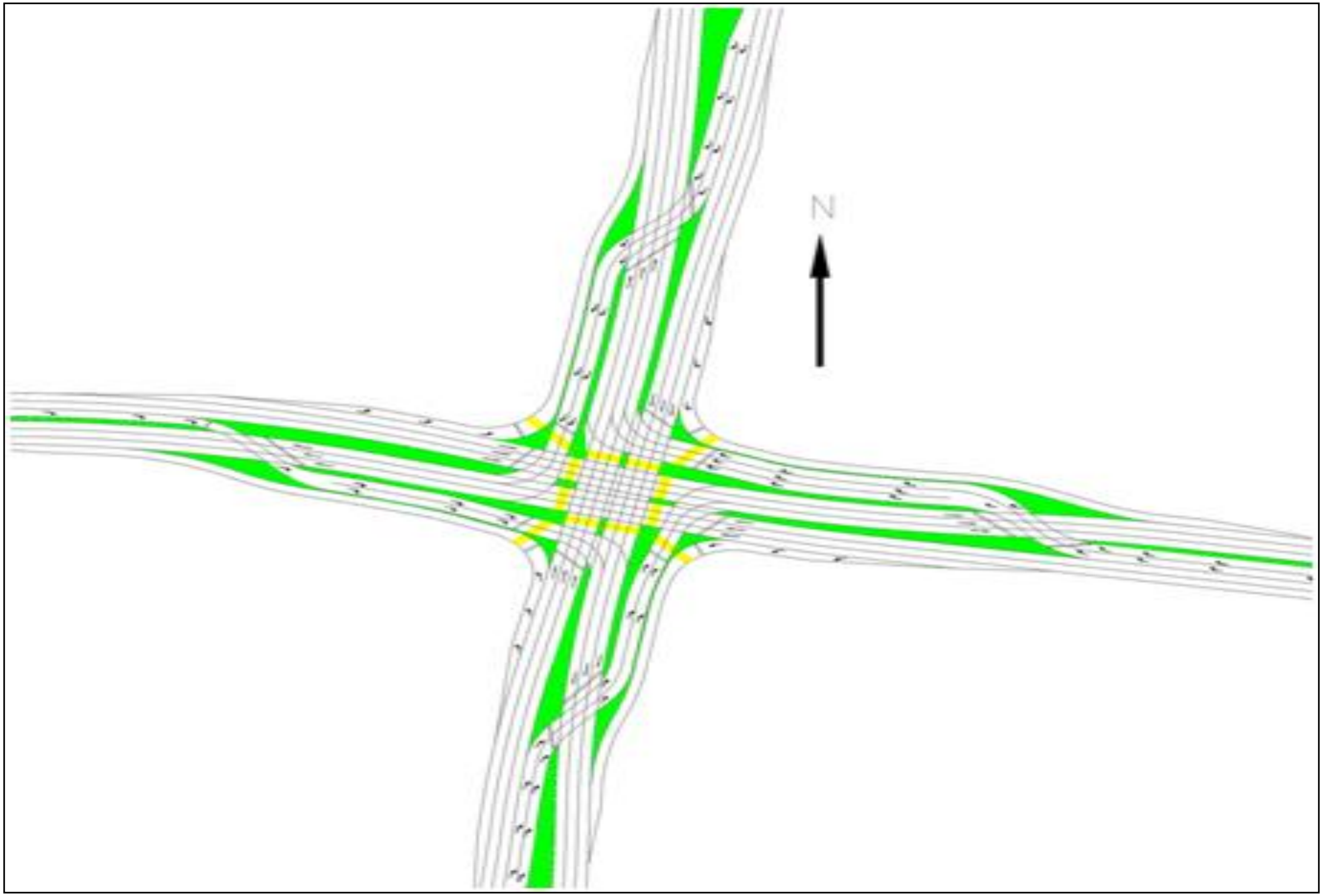
8. Radical Intersections

Using space and complexity to move traffic more efficiently.



Challenges

8. Radical Intersections (cont)



Challenges

9. Network Performance Characteristics

Network management has been something of a black art – since the 1970s we have incrementally developed rules and techniques that appear to work.

Can increased computing power test various networks practices:

- is the current flow bias of 1.5:1 (60% / 40% directional split) the best threshold for changing or retaining linking bias?

- what is the best volume threshold to marry subsystems for extended length linking?

- what influence does speed limit have on network efficiency (there are now many lower speed zones for safety near shop and schools)?

Summary

The urban traffic network is complex.

Many of the network control practices in this area are based on experience:

- we think we have refined our practices

- but the real challenge may lie ahead – with a heavily saturated network

- will our rules and practices work – or is there a better way

- we hope that mathematical and scientific approaches may provide new insights and justification for funding alternative or new systems.

Questions

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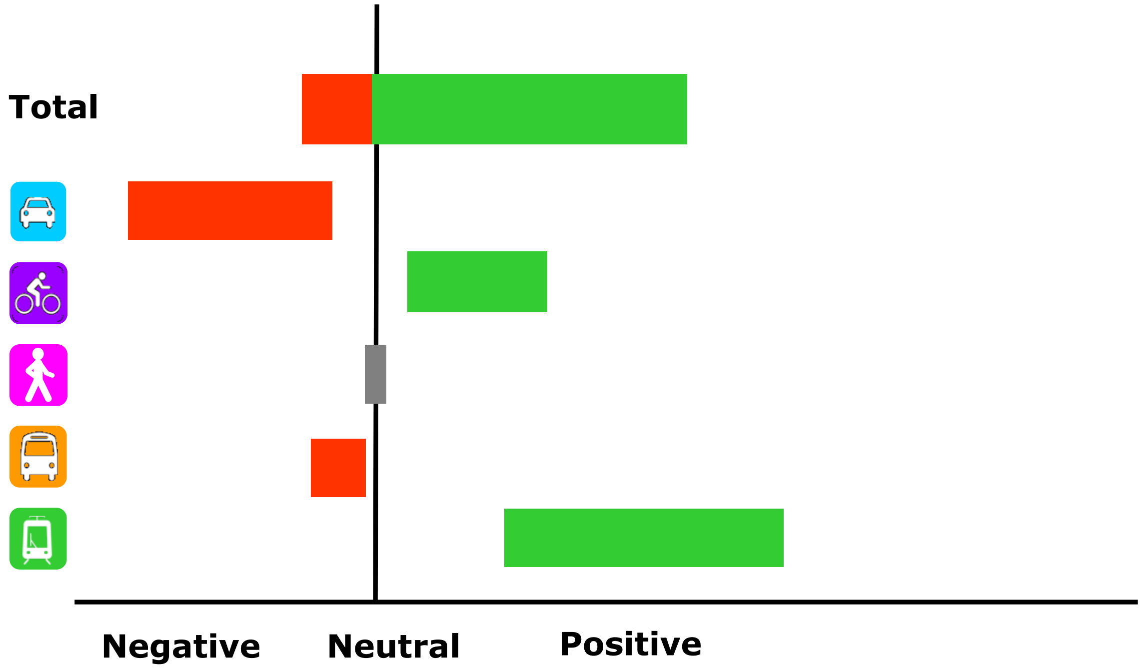
Operating Gaps

Operating Gap

= Performance x Efficiency x Priority x Growth

All proposals are being assessed against the Network Operating Plan

- Covers all proposals which impact traffic operation
- Describes how well a proposal matches the plan
- Assists decision-makers in making trade-offs



Degree of 'fit' to the Network Operating Plan

Route 96 – Nicholson Street