Traffic light optimisation

A green WAVE REPRIEVE

Blaise Kelly

Energy of movement

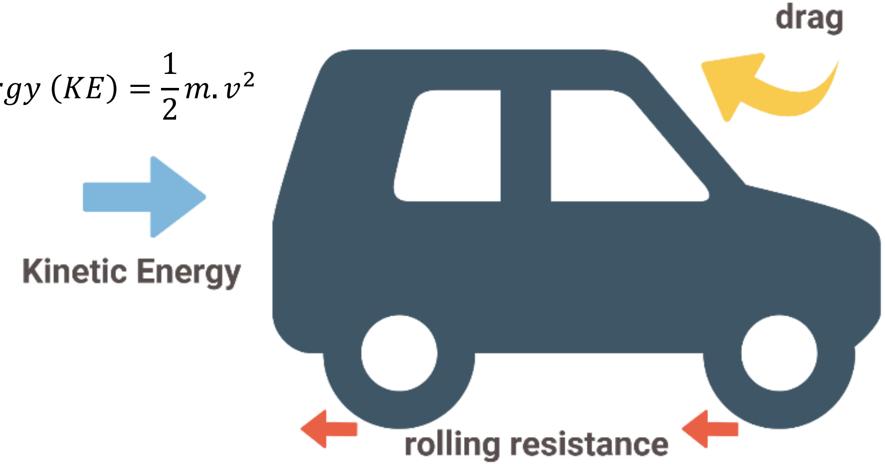
Weight 890 kg
Cd 0.37
Frontal Area 1.95 m^2
Rolling Resistance 0.015
Theory
Combustion
Energy to 30 24.9 Wh
100 Wh
Power at 70 4.5 kW 18.2 kW
Braking energy 20.7 Wh

Weight 1410 kg
Cd 0.32
Frontal Area 2.73 m^2
Rolling Resistance 0.020
Theory
Combustion
Energy to 30 40Wh
160 Wh
Power at 70 9.3 kW 37.1 kW
Braking energy 32.7 Wh

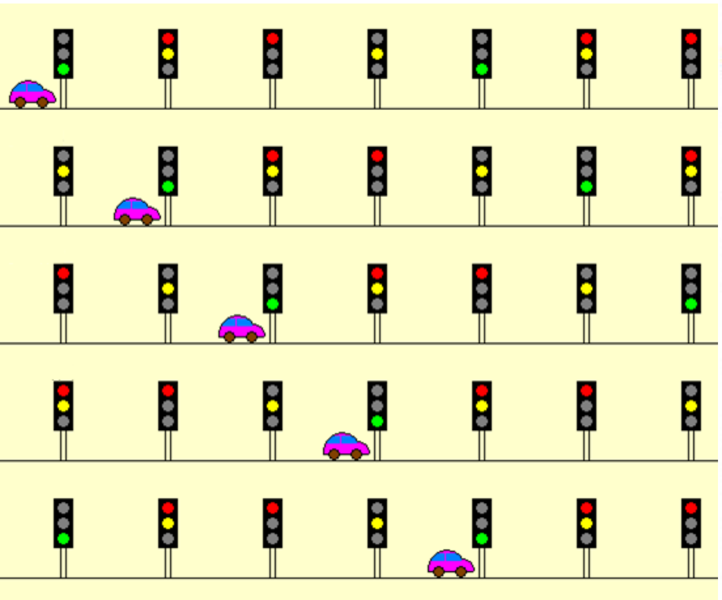
Energy of movement

$$Drag\ (DE) = \frac{1}{2}\rho.CdA.v^3$$

$$Kinetic\ Energy\ (KE) = \frac{1}{2}m.v^2$$



$$Rolling\ resistance\ (rr) = Crr.g.m.v$$



What are 'Green Waves'?

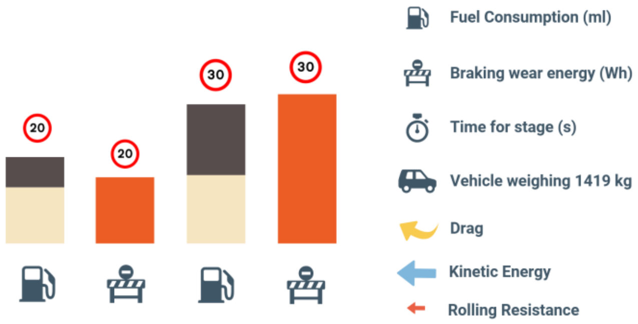
- Receiving consecutive green signals
- Control speed, calm traffic and reduce fuel consumption
- General assumptions in the UK traffic industry:
  - Cars at side roads will be left stranded
  - Cannot be used on two roads that intersect
  - Will not work in both directions
  - Suitable only for US style grid street layouts
  - Intelligent control systems are required to operate them

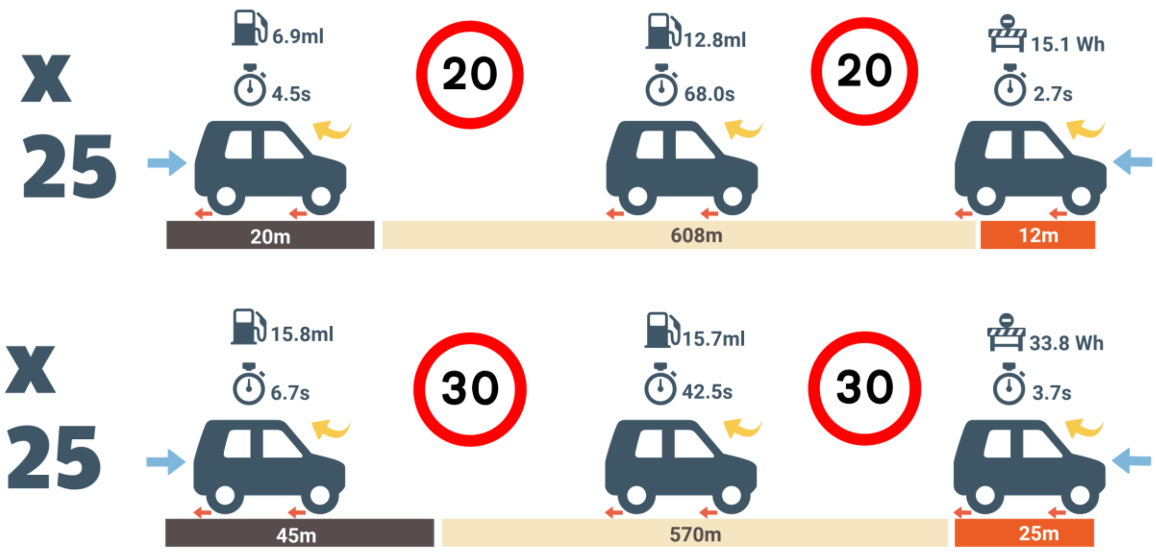
- Aim of study: to model 'green wave' setup and compare with status quo. Specific focus on emissions and fuel consumption.

FUEL & SPEED

BREAKDOWN OF THE FUEL USE OF A JOURNEY AT 20 MPH vs 30 MPH

A typical 16km commute across a city with 25 starts and stops can be broken down into acceleration, cruising and braking energy and the subsequent fuel consumption of each. The extra time spent accelerating to 30 MPH doesn't seem like much, but it needs 8 times the energy per second of cruising, hence it hugely increases fuel use.





Problems of Stop-Start traffic

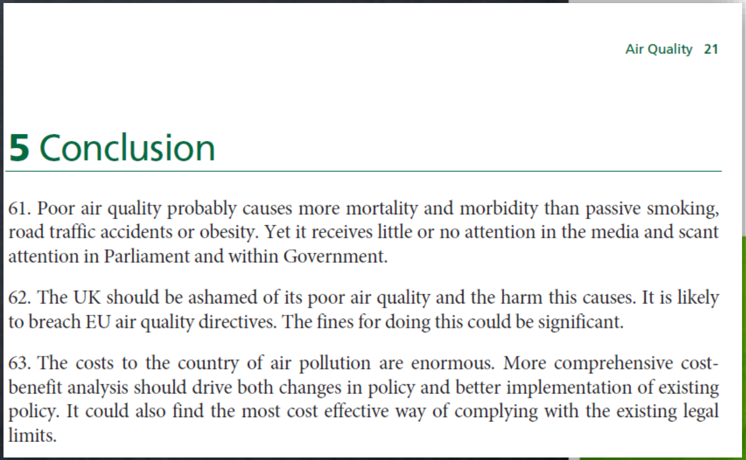
Acceleration is the most energy intensive and braking the most wasteful stage of driving, both increase:

- Noise
- Air pollutants
  - Combustion products from fuel and oil: NOx, CO_2, O_3
  - Wear products from tyres, brake systems, bearings, and road construction materials
  - Re-suspension of soil and road dust
  - Wear and tear of vehicles, energy to manufacture and replace worn parts
- Fuel consumption

UK has still not met the EU pollution targets that came into force in 2004

200,000 premature deaths every year in UK as a result.

In 2009 27% of total UK energy consumption was from burning of oil derivatives for road transport



Air Quality 21

5 Conclusion

61. Poor air quality probably causes more mortality and morbidity than passive smoking, road traffic accidents or obesity. Yet it receives little or no attention in the media and scant attention in Parliament and within Government.

62. The UK should be ashamed of its poor air quality and the harm this causes. It is likely to breach EU air quality directives. The fines for doing this could be significant.

63. The costs to the country of air pollution are enormous. More comprehensive cost-benefit analysis should drive both changes in policy and better implementation of existing policy. It could also find the most cost effective way of complying with the existing legal limits.

Less Congestion = Reduced Journey Time = Lower emissions

Emissions (mg/sec)

	Idle	Accelerating	Decelerating	Cruising
NO	0.05	1.5	0.4	0.8
HC	0.17	0.7	0.28	0.5
CO	1	30	9	15
CO_2	1800	6200	3000	4200

Fuel Consumption (ml/sec)

	Idle	Accelerating	Decelerating	Cruising
Diesel	0.17	1.61	0.16	0.62

Traffic Department

Current priorities

Reducing journey time	50
Minimising congestion	50
Emissions	?

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EXAMPLE

Stop Start

Total real life time

4 min 55 sec

Green Wave

Total real life time

19 min 55 sec

Car waiting for green wave for

14 min

Pollutant	Stop Start	Green Wave	Savings
NO	264 mg	175 mg	36%
HC	141 mg	226 mg	-59%
CO	5339 mg	3288 mg	39%
CO_2	1304 g	2235 g	-71%
Diesel	256 ml	256 ml	0%

“As part of the campaign to become Britain's Greenest City Manchester is committed to reducing the City's carbon emissions. One of the main contributors to CO_2 emissions in Manchester is from vehicle exhaust”

(Manchester City Council, 2009)

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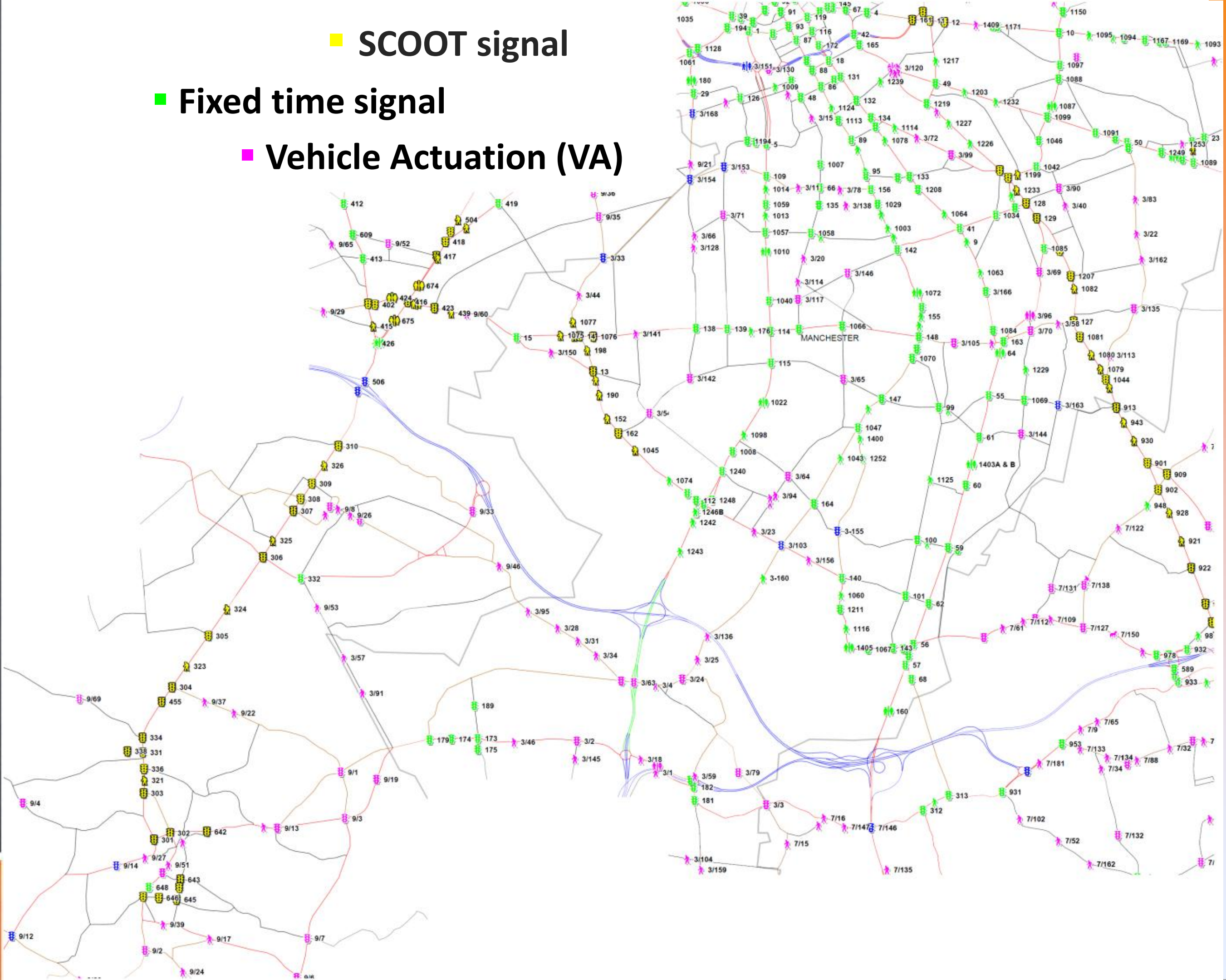
Manchester

- Every signal controlled from UTC HQ. Runs SCOOT system on over 60 signal installations
- DfT says SCOOT and green wave never been compared
- Greater Manchester Traffic Unit (GMTU) is second largest traffic control department in country after London.
- Build a Paramics model of Chorlton, Manchester
- Use ASTRID and Survey data for traffic flows
- Setup one model with signals as they are and second model for green wave
- Compare both models using PHEM emissions module

Manchester Network

- **SCOOT signal**
- **Fixed time signal**
- **Vehicle Actuation (VA)**



Due to the complexity and secrecy of SCOOTs operation it was not possible to model the current setup accurately

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The majority of the signals in Manchester are not co-ordinated/ synchronised and not on SCOOT

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The unsynchronised model is still representative of much of Manchester and the UK

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SCOOT Network

SCOOT Zones highlighted in Purple

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Separate SCOOT zones are not synchronised with others

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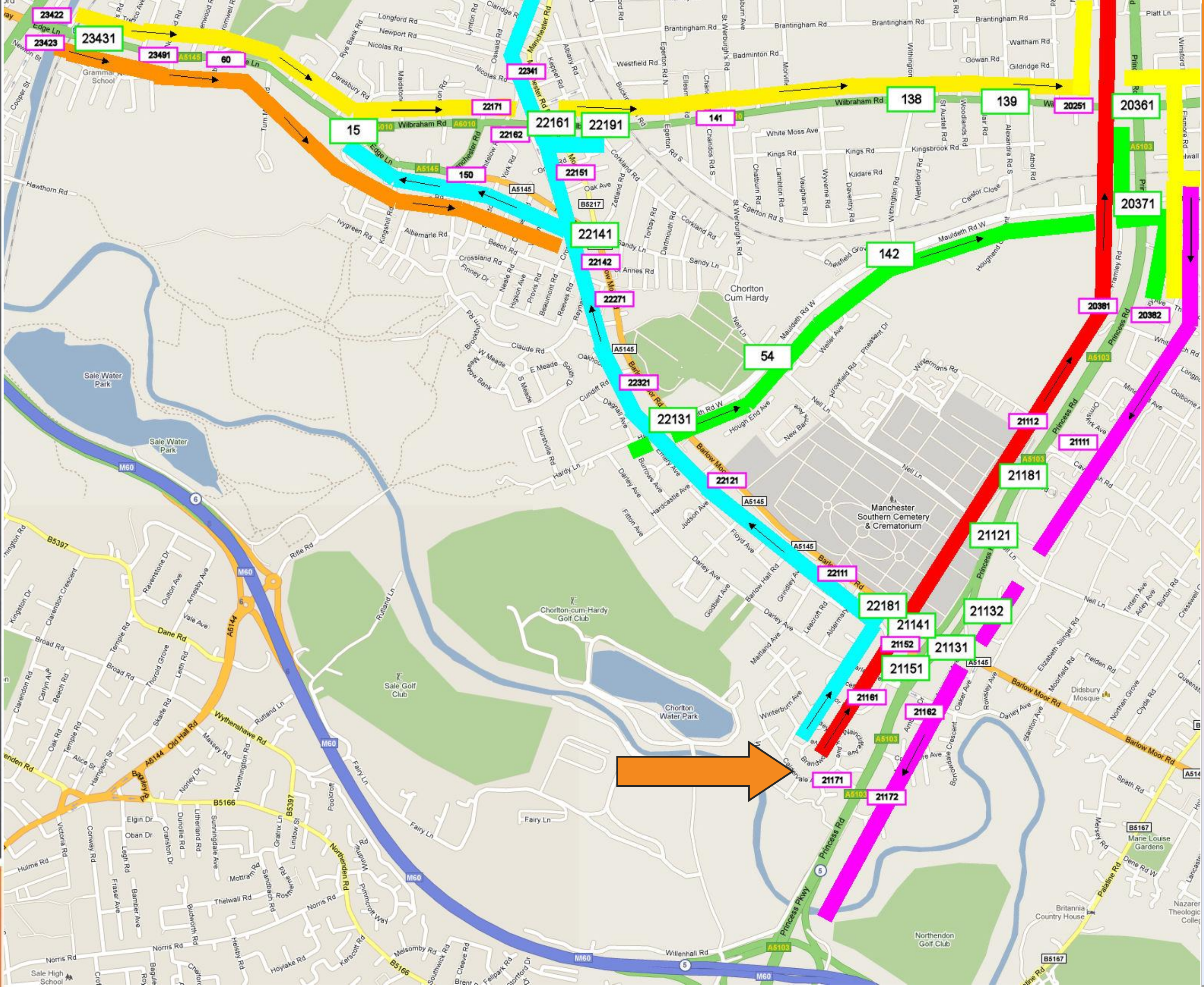
Signals in orange area are fixed time or VA and not connected or synchronised with each other

Green wave routes



6 Separate 'Green Waves' setup

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Offset based around Junction 21171 as highest flow into network

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Completed in a few hours by observing cars in Paramics

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Opposite directions possible on Dual Carriage way and some sections of single

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Signal Timings

Offset			Time between junctions	Offset	
Junction number				Junction number	
Stage number	Stage number	Stage number		Stage number	Stage number
Stage Length	Stage Length	Stage Length		Stage Length	Stage Length
Cycle time				Cycle time	

Greenwave

Offset	Junction number	Stage 3	Stage 2	Stage 1	Cycle time	Time between junctions
15	21171		50	50	100	20
29	21161		40	60	100	7
41	21151		40	60	100	7
1	21131	50	20	30	100	25
74	21121		50	50	100	9
56	21181	9	50	41	100	12
85	21112		40	60	100	25
10	20381		40	60	100	35
55	20371		50	50	100	21
76	20361	30	50	20	100	

Unsynchronised

Offset	Junction number	Stage 3	Stage 2	Stage 1	Cycle time	Time between junctions
0	21171		15	33	48	20
29	21161		15	33	48	7
27	21151		28	68	97	7
0	21131	62	7	22	91	25
0	21121		21	51	72	9
9	21181	16	25	56	96	12
21	21112		15	33	48	25
46	20381		20	28	48	35
0	20371		21	75	96	21
0	20361	39	40	17	96	

Results

	NO_x (kg)	PM_{10} (kg)	Carbon Dioxide Equivalent (CO_2(e) tonnes)	Total Network Time (hours)	Total Distance (km)	Vehicles	Average Network Speed (mph)	Average Journey Time (mins)
Unsynchronised	45.29	1.20	15.89	2020.5	43956.6	21584	13.52	5.62
'Greenwave'	41.89	1.15	14.69	1309.7	43949.7	21461	20.85	3.66

CO_2 equivalent emissions reduced by over 1 tonne

Distance travelled nearly identical

NO_x and PM_{10} lowered

Total network time and average journey time almost halved

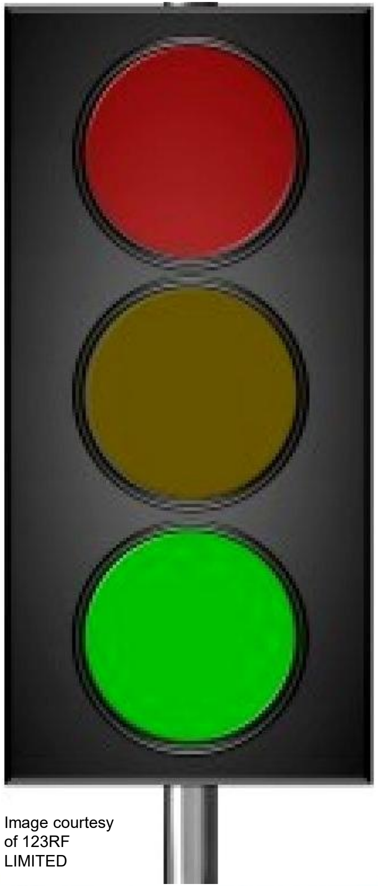

Image courtesy of 123RF LIMITED

Improve origin/destination and route data

Model current control methods accurately i.e. SCOOT with SCOOTLINK

Optimise model based on emissions i.e. Paramics adapts to information received from PHEM

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IMPROVEMENTS TO STUDY

Conclusions

Cars at side roads will be left stranded

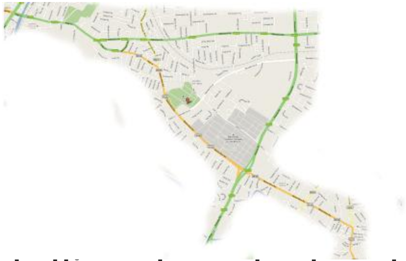
Side road traffic and Pedestrians more green time

All main roads in network synchronised

Cannot be used on two roads that intersect

Both directions possible in some situations

Will not work in both directions



Suitable only for US style grid street layouts

Intelligent control systems needed to operate them

Money better spent on traffic data collection

Huge potential to save energy and reduce emissions

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Acknowledgements

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ANY QUESTIONS?

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