If you always caught the green light

Stop. Start. Stop. Start. The bane of city driving is the frustration of intermittent travel. It leads to bad tempers, bad driving, and bad petrol economy.

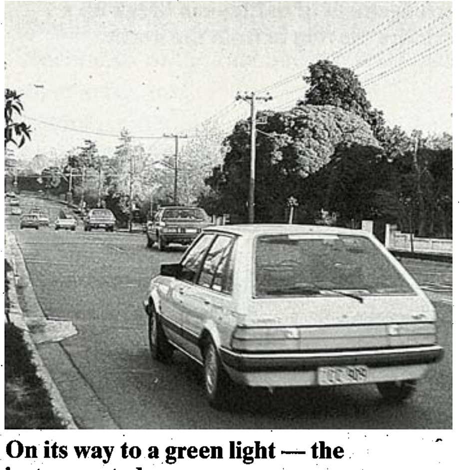
A number of studies point to about 50% of the fuel used in urban driving being consumed in stopping and starting.

Although the flow of heavy peak-hour traffic would be impossible without them, traffic lights play a key part in interrupting the vehicle flow on main roads at less-congested times because of the need to let cross traffic through. Data collected by scientists in the CSIRO Division of Energy Technology suggest that, in this situation, traffic lights are responsible for 10–20% greater fuel use than on a road with no intersections.

Cross traffic fares even worse, as it is much less likely to strike a green light. Data here show that vehicles in light cross traffic can be forced to stop at about 70% of the traffic lights they encounter. Considering the entire suburban network, the cars consume perhaps 20–40% more fuel than in the ideal case — every driver's wish — where they always catch the green light.

The good news contained in this story is that the ideal is not a fantasy — it can be closely approached using a simple scheme that the CSIRO team is currently evaluating. Head of the project, Mr Mike Wooldridge, believes that the scheme offers an easy, attractive way of improving urban fuel economy by at least 10% and at least halving the number of stops — all without interfering with the current traffic-light arrangements.

The key is to make use of a presently unused resource: the driver's nous and his innate aversion to stop lights. What we do is inform the driver that he should travel at x km per hour in order to catch the green at the next set of lights.



On its way to a green light — the instrumented car.

The simplest way of doing so is to place a sign, displaying electronically controlled digits, at the side of the road about a hundred metres past the earlier set. The sign is connected to the set ahead and, from knowledge of how many seconds will elapse before these turn green, the electronic controls compute and display an appropriate speed, x.

Advisory speed signs have worked well in Dusseldorf for 25 years.

Of course, the speed shown is advisory. The complying driver is rewarded with a green light; non-conformists will most likely meet with a red. That set of circumstances becomes a very powerful teacher, as experience with such a system has shown in Dusseldorf, West Germany: there, practically all the drivers comply with the posted speed.

Obviously, the speed posted increases as time elapses — until a speed greater than the legal maximum would be necessary to catch the end of the present green cycle. At this point the screen goes blank, to be soon followed with the speed that will get the driver to the first seconds of the next green phase. So the sign will advance from, say, 30 km per hour through progressively higher speeds to an appropriate maximum, say 80 km per hour.

Its effect will be to aggregate cars together into 'platoons' that will pass through series of green lights without stopping. Similarly, cross traffic will pass through in compact groups while a red light is showing to through traffic.

This scheme considerably increases the traffic-carrying capacity of a road network. It should be an improvement on either 'adaptive' traffic signal controls, where lights alter to favour the heaviest traffic, or the earlier co-ordinated lights, which favour traffic travelling at a particular speed. The weakness here is that traffic invariably tends to disperse (spreading out in speed and distance), resulting in some traffic always being forced to stop.

Advisory speed signs actively work against this dispersal, and herein lies the key to improved traffic flow. The scheme works for heavy through traffic, traffic travelling in the opposite direction, and cross traffic.

The net effect combines smoother traffic flow, more relaxed and less competitive driving, increased safety, and reduced petrol use and exhaust pollution. Access for side traffic (such as from car parks) also becomes easier.

Pluses and minuses

If it's so good, why wasn't it introduced years ago? Well, in Germany a simpler system has been working well for 25 years, but no detailed evaluation of its performance has been made. It was intended to smooth flow and reduce stops and this it does nicely.

A few experimental and demonstration systems have been set up in America, England, and Holland. However, hard data on the scheme's costs and benefits are lacking.

Another point working against its adoption is the fact that its cost (including maintenance) would have to be met by government bodies, yet the main benefits would accrue to the individual driver — in the cost of petrol, most tangibly. Schemes that involve public cost and private gain often have some difficulty in getting off the ground.

On the other hand, the cost of fuel has risen, and the value of the system's fuel savings should now be much higher. Similarly, pollution abatement is now a more important concern. And the cost of computing and displaying digital information has fallen considerably.

The key is to make use of the driver's nous and his innate aversion to stop lights.

The main aim of the CSIRO researchers is to evaluate in detail the system's pluses and minuses, in particular using computer simulations to gauge the magnitude of its impact. They are also looking at ways to optimize the arrangement, and are examining the limits of its usefulness.

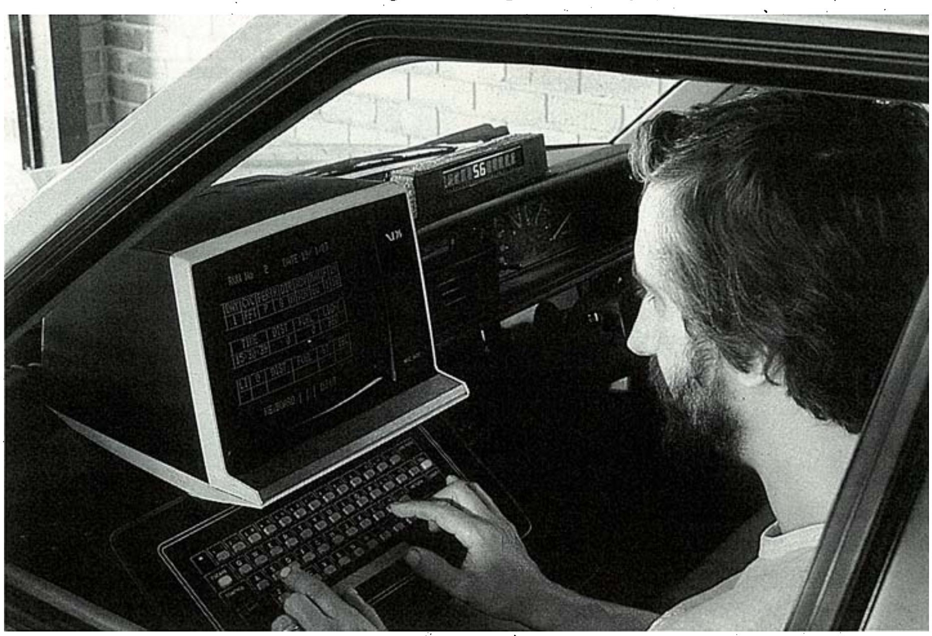
The scientists involved in the work — Mr Wooldridge, Mr Ros Trayford, Mr Bruce Doughty, and Dr Julian van Leersum, of the Division of Energy Technology, Dr Peter Gipps of the Division of Building Research, and Mr John van der Touw of the Division of Mathematics and Statistics — have made progress in the 2 years they have examined the problem. Some of their experiments have been conducted in actual Melbourne traffic conditions. This article will look at some of the findings to emerge so far.

A rough costing casts favourable light on the scheme's potential. At least $2000 million a year is spent on petrol consumed in driving on traffic-light-controlled (arterial) roads in Australia's cities (one-third of the total petrol consumption). If petrol economy could be improved by 10%, that would be worth $200 million.

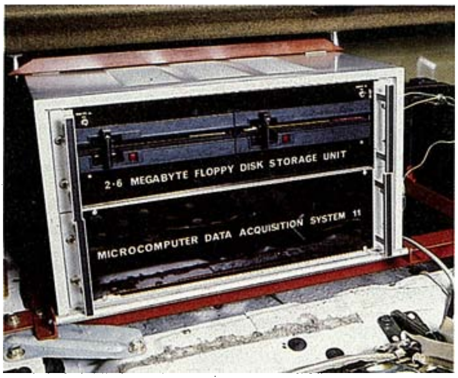
To implement an advisory speed system we would need an illuminated speed sign installed near each of the 5000 or so traffic lights that regulate arterial traffic flow. At a cost of $25 000 each (compared with about $50 000 for a set of traffic lights), that adds up to a bill of $125 million.

Computer simulations and on-road experiments by the CSIRO team have shown

The computer in the CSIRO test car provides instructions to the driver and gathers data used to evaluate the benefits of advisory speed signs. The computed advisory speed is displayed above the dash, on the right.



In Dusseldorf, you just 'float' along with the traffic; there's no desperate manoeuvering, no anxious overtaking.



Not many cars have a computer in the boot!

substantial fuel savings that suggest the system could pay back its cost in less than a year! Assuming 100% compliance, the simulations suggest savings of 5–20%.

Computer simulations

Mr Doughty enlisted the help of Dr Gipps to make use of the latter's traffic simulation model MULTSIM (described in *Ecos* 28). Briefly, MULTSIM simulates traffic flow by modelling the behaviour of individual cars along a given stretch of road. It is very detailed and realistic, although expensive to run for long sections of road.

Mr Doughty simulated 20 minutes of actual conditions prevailing on Military Road, North Sydney, using data collected during CSIRO studies that investigated the relation between traffic flow and fuel consumption (again reported in *Ecos* 28). The results showed that, when all the drivers complied with the advisory speed signs, fuel consumption declined by 7%, the number of stops fell by 48%, and travel time fell by about 10%.

Remember that the calculated savings refer to a system where the lights are already co-ordinated. The CSIRO experiment on Military Road (which is co-ordinated) showed that co-ordinating lights can alone improve fuel consumption by 20–35%. (This figure relates to one-way flow; for two-way flow, the appropriate figure will be half to two-thirds of this.)

As you can imagine, once drivers have 'caught the green wave', their travel time could be made less and less by simply increasing the 'co-ordination speed' of the traffic light system. However, the higher the speed of the green wave, the higher will be the fuel consumption, and a speed setting close to that where a vehicle's consumption is a minimum (near 50 km per hour) is probably most desirable; this speed is the basis of the results reported here.

Simulation of a simple (idealized) one-way two-lane stretch of roadway has confirmed the trade-off between time savings and fuel savings. The computer results here indicate that advisory speed signs can improve fuel consumption by more than indicated by the Military Road simulation. Typically, a figure of some 14% appears — and that is over and above the simple co-ordination advantage. In older isolated light systems, advisory speed signs could reduce petrol consumption by 30%.

Traffic engineers need no convincing of the value of co-ordinated lights, and most of Sydney's major arterial systems are co-ordinated. Melbourne has four or five arterial roads co-ordinated and an active conversion program under way, while other cities are commencing such programs.

Dr van Leersum has used another computer model, TRANSYT, which simulates an interconnected road network of five traffic light junctions. Instead of tracing the movement of individual vehicles, TRANSYT uses a mathematical function that defines the distribution of traffic density along a road. The function changes with time to model the movement of traffic, including its dispersion. The dispersion figure becomes zero when the effect of advisory traffic signs is introduced.

The complying driver is rewarded with a green light; non-conformists will most likely meet with a red.

Dr van Leersum found that the signs reduced fuel consumption by between 10 and 20% over and above the case when the lights were co-ordinated. In contrast to the MULTSIM results, he found little effect on travel time, even though the number of stops was, again, markedly reduced (by about 40%). Both MULTSIM and TRANSYT show that the system's benefits vary more or less in proportion to the percentage of complying drivers.

Driver compliance

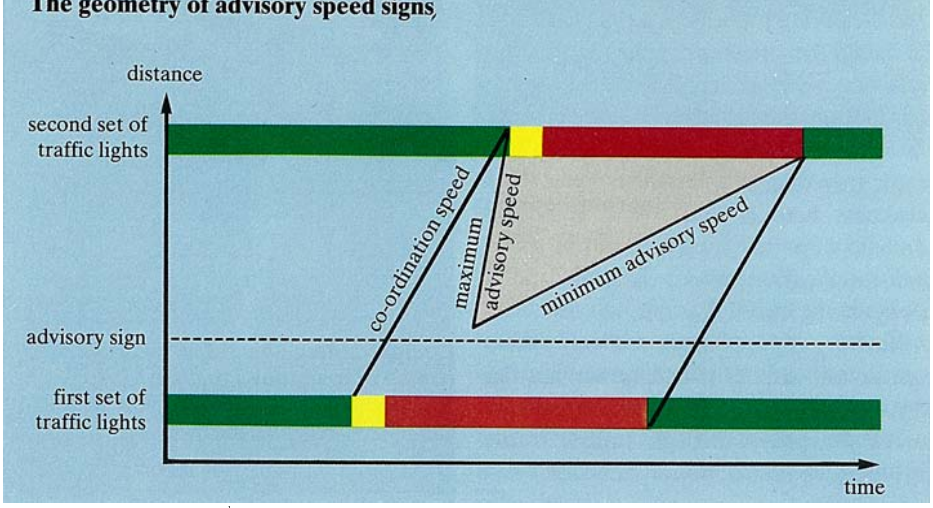
Obviously, the higher the degree of driver compliance rises, the better the system works, and its implementation then appears more worth while. German drivers comply very well, but it's more difficult to tell how Australian drivers would behave.

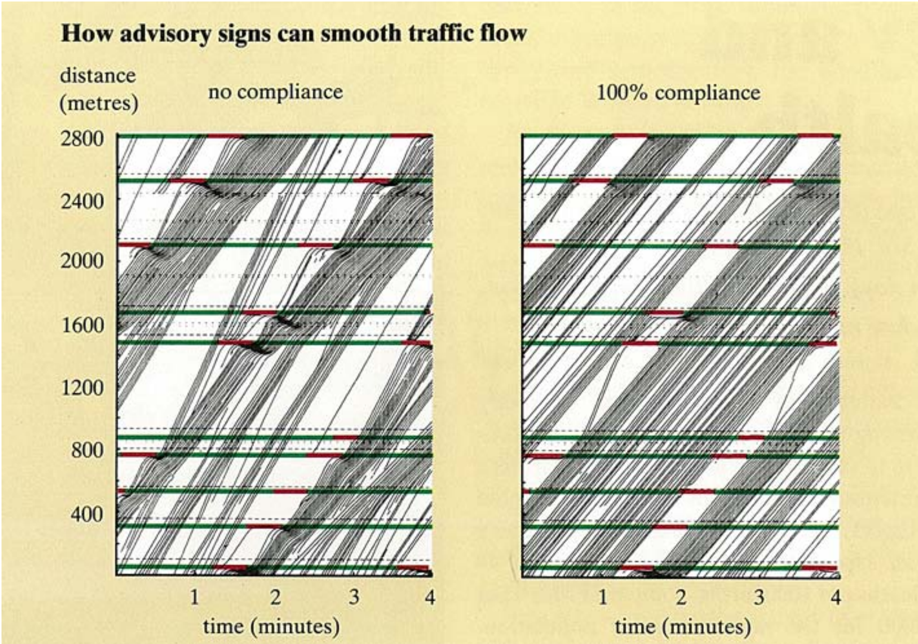
Some people may not be prepared to drive slowly (according to the sign) when they see an open road ahead. It's a bit easier if you are not a platoon leader, as you will tend to be restrained by the complying drivers ahead. It will be pointless to change lanes, overtake, and speed ahead because you will only be brought to a halt by a red light. Indeed, the reduction in lane-changing, and the low speed difference between cars, should significantly lower the accident rate.

The only problem that may arise concerns drivers who realize that, when the sign goes blank, they must catch up with the platoon ahead if they are to just make it through the green (or amber). Drivers who 'run the red' are always a danger, and Mr Trayford thinks that advisory speed signs won't make things any worse. One way of dealing with the problem is to install red-light cameras, which automatically take photographs of vehicles going through red

Advisory signs keep vehicles out of the grey area — where confrontation with a red light is almost inevitable — by recommending appropriate speeds.

The geometry of advisory speed signs





Each diagonal line represents the path of a vehicle. This computer simulation of Military Road, heading towards Sydney, shows how advisory speed signs (at positions shown by single dashed lines) nearly always prevent a vehicle coming up to a red light. The double dashed lines represent intersections without lights.

Computer simulations suggest the system could pay back its cost in less than a year.

lights. Offenders are traced through licence-plate numbers. The cameras are common in Germany and are already making an appearance in Melbourne.

On the other hand, we can always expect a few drivers who want to travel slower than the signs indicate. Stopping buses, pedestrians, and other obstacles may also upset system timing, but only where lane-changing is difficult (in heavy traffic).

Further refinements of the system could include extra signs (say half-way and three-quarters of the way to the next lights) to correct any mis-timings and to keep the platoon compact. Leading drivers should find that the lights turn green just when they would otherwise have needed to brake for the red. Adding signals that respond to traffic flow would create the ultimate in smooth traffic flow.

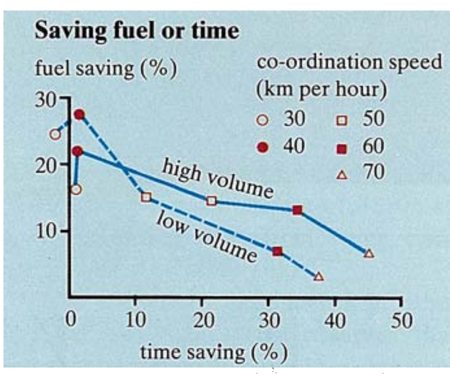
The degree of compliance is obviously a critical variable in achieving the desired results. The concept pays handsome dividends when everybody complies, and generally the benefits are proportional to the percentage of complying drivers.

However, under some conditions the degree of compliance enters as a non-linear factor and, according to the MULTSIM model, more than 75% compliance is required for significant gains in travel time at high co-ordination speeds. Similarly, the best co-ordination speed (for minimum fuel consumption) depends on the degree of compliance.

The minimum speed displayed will also be governed by how well drivers obey a call for 'slow coach' speeds. Below a certain speed, compliance is likely to disintegrate, and a safety risk could appear if a large speed difference emerged between those who choose to comply and those who don't.

Human factors

Hazarding a guess based on a perceived notion of the Australian character is unscientific, and Mr Wooldridge believes 'human factors' research is necessary to put numbers on the expected compliance at various speeds. This aspect will be looked at



Computer simulation of an idealized stretch of road shows that advisory speed signs can be made to save mainly fuel or time, depending on the co-ordination speed setting of the traffic lights (the speed required to get from one set of lights to the next at the same point in its cycle).

in a later phase of the project now that the potential benefits of the system have been established. The results should prove enlightening, particularly if they show that apparent differences between drivers in different cities are real!

At present the CSIRO group is carrying out on-road experiments on the fuel-saving effects of advisory speed signs. Using a single instrumented car (a Ford Laser) driven along a section of Malvern Road, Melbourne, by a number of drivers, the scheme reduced fuel consumption by 16% and nearly halved the number of stops. Travel time stayed about the same.

Engineers from the Road Traffic Authority of Victoria helped by setting traffic signals for the experiment and gave expert advice on traffic behaviour.

Instead of road-side signs, a computer on board the car, synchronized to the lights, calculated the requisite speed. Malvern Road allowed reasonable freedom of movement, enough to allow one car to provide an indication of how a full-scale system would work.

However, if you really want to be convinced of how well the scheme works, Mr Trayford suggests you go for a drive in Dusseldorf. As he found in a visit in 1982, you just 'float' along with the traffic; there's no desperate manoeuvering, no anxious overtaking.

Advisory speed signs make you feel a part of an intelligent, co-operative network, and allow you to accept your time-frame — here and now — as being the best possible.

Andrew Bell

More about the topic

Fuel savings and other benefits of dynamic advisory speeds on a multi-lane arterial road. R.S. Trayford, B.W. Doughty, and M.J. Wooldridge. *Transportation Research*, 1984, **18A** (in press).

Fuel economy investigation of dynamic advisory speeds from an experiment in arterial traffic. R.S. Trayford, J. van der Touw, and B.W. Doughty. *Transportation Research*, 1984, **18A** (in press).

Simulation of the effects of dynamic advisory speed signs on travel time, stops and fuel consumption. B.W. Doughty and R.S. Trayford. *Papers, Fourth Conference of Australian Institute of Transport Research, Macquarie University, December 1982*.

Urban energy savings through dynamic advisory speeds: the progress of a research project. M.J. Wooldridge, R.S. Trayford, and B.W. Doughty. *Proceedings, Ninth Australian Transport Research Forum, Adelaide, May 1984.*