

Traffic Advisory Leaflet 3/97 March 1997



Detectors

100m

# The "MOVA" signal control system

40m

### Introduction:

The MOVA signal control strategy was researched and developed by TRL (Transport Research Laboratory). It is a more efficient form of control able to deliver substantially reduced delays without the need for regular re-setting of the signal timings.

This leaflet is intended to draw the attention of highway authorities (in Scotland, roads authorities) to the advantages of this method of signal control for uncoordinated road intersections. New facilities have been introduced into MOVA recently and on-going research should deliver further improvements in the future.

If applied at all 5,500 isolated signal sites in the UK, it is estimated that delay savings worth some £220M per year would be made (based on a cost of £8/vehicle-hour of delay). This would include about £30m in reduced fuel (net of tax and duty). These figures are updated from an unpublished TRRL internal Working Paper TG 88/1 "Some costs of road traffic operations in Britain in 1986" (Ref. 1).

# Microprocessor Optimised



Actuation

# Background

Vehicle-Actuated control (VA) has been the standard method of signal control in UK since the second World War. VA is a simple method for allocating the green times to different traffic movements, between preset minimum and maximum limits. Vehicles detected during the green phase extend the green period until a gap exceeding a critical value is found or the maximum is reached. Variations on this basic gap-seeking control logic are widely used throughout the world, with various detector sizes and lavouts: however. the basic principles remain substantially the same. The only major development has been the change from pneumatic tube detectors to inductive loops, and latterly to much improved detector electronics. Until MOVA, there had been no substantial advance in control strategies over a period of some forty years.

VA has considerable merit compared with fixedtime signal control, but is prone to extend the green phase inefficiently, particularly when there are long queues waiting at red signals. It is also difficult to set maximum greens effectively, and this can seriously degrade performance if they are poorly-related to the balance of flows in conflicting traffic streams. Thus, if performance is not to deteriorate by ageing, it is necessary to measure traffic flows at regular intervals in order to reset maximum greens. This places a considerable burden on traffic engineers and is often neglected. In the mid-eighties, TRL developed a control strategy to overcome these problems - MOVA.

MOVA signal timings vary widely in response to traffic conditions. This innovative method of signal control can reduce delays and accident levels. Detector failure is one of the main problems associated with existing vehicle actuated signals. MOVA has an effective back-up system that allows the worst effects of detector failure to be avoided. MOVA also has effective reporting facilities for detector failure, as well as a range of other failures. As an additional benefit, the system also provides information on traffic flows at the junction, which can be accessed either on site or remotely.

MOVA has been approved by the Department of Transport and is widely used in UK and overseas.

#### Costs and Benefits

The costs and benefits of converting sites to MOVA control have been evaluated during a comprehensive, country-wide trial at 20 sites (Ref.2).

TRL/Department of Transport (DOT) trials have shown that MOVA reduces delays by an average of 13% compared to the earlier, vehicle actuated system. Benefits are likely to be largest when compared with vehicle actuated signal control that has not been recently validated. There is also evidence that MOVA reduces injury accidents at signals on high speed roads. It has the additional advantage that it is no longer necessary to install speed discrimination or speed assessment detectors and equipment; this was needed with the earlier vehicle actuated system in order to minimise high-speed vehicles running through red signals at the end of green.

T able 1 below shows the annual benefits arising from reduced delays, and the installation costs. The costs include staff time for planning and commissioning the sites as well as all the direct installation costs. The third column shows the payback time in weeks. The figures are presented for small, medium and large junctions. The data are taken directly from TRRL Research Report RR 279 (Ref.2), at 1989 prices.

These figures take account of delay benefits only. No attempt has been made to include any safety benefits that may accrue from conversion to MOVA control.

Injury accident records from the initial 20 MOVA sites have been compared for the three years prior to MOVA installation and three years after. The results showed a small overall reduction, which was not statistically significant. However, when major, high flow, high speed junctions were examined as a separate group, a 30% reduction in injury accidents was found, with 90% confidence.

The potential for safety benefits at large highspeed sites is supported by MOVA trials at two major trunk road sites; these showed reductions in red-running equivalent to 50,000 fewer vehicles per junction jumping the lights per year, compared with the previous VA plus speed-assessment control. As this class of junction is also the prime group for conversion on delay grounds, there is the possibility of substantial safety benefits to add to the delay/congestion benefits.

# Table 1 - Annual Benefits Using MOVA

	Av 12 hour throughput (vehicles)	Benefits (£)	Cost (£)	Payback time (weeks)
Small	23,700	30,000	12,200	21
Medium	34,800	60,000	12,200	11
Large	49,700	141,000	19,800	7

# How MOVA Works

MOVA is a sophisticated strategy using the computing power of microprocessors to assess the best signal timings, given the physical layout of the junction, the signal stages available and the traffic conditions at the time (Ref.3, 4). MOVA is extremely flexible, and the signal timings can vary widely as the traffic conditions change.

Once a MOVA site has been set up successfully, the system will generate its own signal timings cycle-by-cycle, varying continuously with traffic conditions, both in the short term (hour to hour, day to day) and in the long term following annual trends and longer term traffic growth.

MOVA has two operational modes; the first deals with uncongested conditions, the second with situations when the junction becomes overloaded/congested with large queues on one or more approaches. MOVA determines which mode is appropriate and which approach(es), if any, are overloaded.

In the uncongested mode, MOVA seeks to disperse any queue which has built up on red, and then carries out a delay-and-stops minimising procedure every half second. If there would be a benefit from extending the green, then the green would continue and the calculations repeated. If no benefit were predicted, the signals would change to the next stage.

In the congested mode, MOVA operates a capacity-maximising routine. This routine takes into account which approaches are overloaded, the efficiency of green use, the amount of use made of any local flaring of the carriageway, and determines the signal timings which will maximise the junction throughput under the actual flow conditions prevailing.

Figure 1 shows the effect of using flared areas, expressed in terms of 'bonus green' and capacity. 'Bonus green' is the extra green time the main lanes only would need to discharge vehicles using the extra space created by the flaring. When the 'bonus green' is small (i.e. little use of the flared area), then capacity increases as cycle time rises. When the 'bonus green' is large, then capacity increases as cycle time reduces. The optimum cycle is a product of junction geometry and lost time, flows and turning movements. MOVA continually monitors conditions during oversaturated periods and will, when appropriate, select and enforce the cycle time which maximises capacity.





A typical MOVA Installation: Prime candidates for conversion to MOVA control are junctions with some or all of the following features:-

- High flows
- Large, complex junctions
- High speed sites with Speed Assessment/Speed Detection
- Sites suffering from prolonged periods of congestion
- Sites with unpredictable periods of high flows e.g holiday routes.

All the usual signal features can be accomodated - early cut-off, late release, fully signalled right turns, pedestrian phases, double greens and flared approaches. MOVA has special logic to decide how best to control the use of flares.

MOVA uses an advanced detector layout to provide traffic data to the control logic. In urban areas, each lane will have one vehicle detector about 100m before the stopline, and a second at approximately 40m. The diagram at Figure 2 shows a typical detector layout for an urban site.

For high speed inter-urban sites, the detectors would be positioned further from the junction, to give 8 - 10 seconds warning of the arrival of vehicles. Some junctions require extra, special-purpose detectors, to control an early cut-off right turn facility, for example. Pedestrian crossings with pushbutton control can also be accommodated. Full details of the required detector layout are given in TRL Application Guide 10 (Ref 5).





*Where MOVA can be used:* MOVA is suited to most independently controlled (non-linked) signalled junctions. In general, MOVA appears to give above average benefits when applied at major, high flow junctions with speed asessment/speed detection, or at smaller heavily congested junctions. It will also perform particularly well, reducing the need to monitor and adjust the signal timings, at junctions where it is difficult to predict traffic patterns - for example junctions on busy holiday routes where traffic patterns are more dependent on seasonal factors and the vagaries of the weather than on the time of day.

Heavily loaded, congested junctions offer the best return on the costs of installing MOVA, and should be considered first as prime sites for conversion. Conversely, there is little point in converting quiet, lightly loaded junctions. MOVA should, in general, be used for all new signal installations, as its costs are similar to those of the less efficient earlier system.

Further details of the installation requirements are fully detailed in MCH 1542 "Guidelines for the implementation of MOVA using "add-on" equipment" (R ef .6).



# Installation of MOVA

MOVA is available either integrated into a new signal controller, or as an additional unit which can be added to any existing modern controller. In the case of the ëadd-oní unit, MOVA controls the signals via the standard urban traffic control (UTC) interface. MOVA has built-in fault monitoring and reporting, but limited to the MOVA system and its detectors.

Some site data needs to be measured - saturation flows (by lane) and cruise speeds. Software for the purpose is available for use on laptops.

The site data required by MOVA is prepared using special-purpose software. The program is designed to make data-set preparation as straightforward as possible. The program is fully documented, with detailed guidance for the user, in TRRL Application Guide 11 (Re f.4).

Physical installation requires no additional skills beyond those normally needed - slot cutting, duct work, controller wiring.

As at all signals, good commissioning is essential. Built in test software allows easy checking of connections to detectors and to the controller. Once checked, MOVA is ready to go on line. At this point, the traffic engineer needs to be able to assess performance and modify site data if necessary.

Training Workshops are available to provide users with the knowledge required to specify, set-up and commission MOVA installations.

# **Research and Development**

DOT and TRL are devoting further effort to MOVA. Recently completed research and development work has produced the following new facilities:-

- Automatic stage-sequence selection at junctions with separately-signalled right-turn movements.
- Bus and emergency vehicle priority control
- Control of multiple, separately-controlled pedestrian crossing movements
- Increased maximum number of stages, phases, detectors, lanes, etc which can be accommodated

# **Upgrading MOVA**

Once MOVA is installed and operational, very little further attention is required until traffic conditions change so much that new stages, increased number of lanes etc are required. Should new facilities be required, or if the software needs updating, this can be accommodated by merely changing the MOVA module of the controller. In the case of bus priority, selective detection would have to be installed.

Should the data set require revision, it is prepared on a personal computer by modifying the existing dataset using the 'MOVA SETUP' program.

## References

1. TTRL Internal Working Paper TG 88/1 "Some costs of road traffic operations in Britain in 1986"

2. TRRL Research Report RR279. MOVA: The 20 site trial. Peirce J R & Webb P J.

3. TD 35/91. MOVA System of Traffic Control at Signals. DOT Highways Safety and Traffic Departmental Standard ~ TD 35/91.

4. TRRL Research Report RR170. MOVA: Traffic responsive, self-optimising signal control for isolated intersections. Vincent R A & Peirce J R.

5. TRRL Application Guide 10. MOVA traffic control manual. Vincent R A, Peirce J R & Webb P J.

6. Highways Agency document MCH 1542 "Guidelines for the implementation of MOVA using "add-on" equipment", 1990. J L James

7. TRRL Application Guide 11. MOVA data set-up guide. Lines C J, Vincent R A & Crabtree M R.

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