

IMPLEMENTATION OF TRAFFIC CONTROL MEASURES SYSTEMS AS AN INTERIM LABOUR-BASED ALTERNATIVE TO INTELLIGENT TRANSPORT SYSTEMS

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ABSTRACT

This study investigates the traffic control measures system (TCMS) currently implemented at Gillooly's Interchange and assesses its potential as an interim labour-based alternative to Intelligent Transport Systems (ITS). The Ekurhuleni Metropolitan Police (EMP) initiated the TCMS in August 2002 in an effort to alleviate the morning peak congestion at Gillooly's. The TCMS is implemented by EMP officers who manually alternate the right of way to two traffic streams at the start of the weaving section where the off-ramps from the R24-W and the N3-S merge. The system is operationally similar to a combination of manually implemented mainline metering and freeway-to-freeway metering found elsewhere in the world, but implemented using manual labour and low-cost canalisation aids instead of electronic technology.

The TCMS was investigated on a very broad basis – operational, safety-related and monetary aspects all being reviewed and studied. The similarities it displayed with certain ITS applications were also investigated. Based on the literature reviewed and the field observations made, it was found that the TCMS implemented at Gillooly's Interchange was not a form of ramp metering.

The results of this study indicated that the manually operated TCMS currently implemented at Gillooly's Interchange provided operational and economic benefits similar to those provided by an ITS application when compared to a scenario where no TCMS was implemented. Travel time savings of more than R1,5 million/annum and a benefit-cost ratio of 40,4 were realised compared to a scenario where no TCMS was implemented. Furthermore, the TCMS is in line with Government policy for the promotion of labour-based projects and is a unique example of how the principles of first-world traffic management practices can be integrated with third-world development constraints in a way that is beneficial to all concerned.

1. BACKGROUND

This study investigates the traffic control measures system (TCMS) currently implemented at Gillooly's Interchange and assesses its potential as an interim labour-based alternative to Intelligent Transport Systems (ITS). The lack of available data for certain attributes of the study area necessitated the aim of the study to be restricted to a first order assessment of the potential benefits of TCMS and it is therefore not a detailed quantitative assessment. The findings of the study are based on empirical measurements as well as results obtained through modelling.

The Ekurhuleni Metropolitan Police (EMP) initiated these measures at the time of the World Summit held in Johannesburg in August 2002 in an effort to alleviate the congestion typically experienced at the interchange during the morning peak period.

The control measures in force involve the regulation of the following traffic streams:

- Traffic originating east of Gillooly's Interchange (Johannesburg International Airport, Kempton Park, Witbank, etc.) and travelling on the R24-W, turning in a northern direction along the N3-N with Roodepoort, Buccleuch Interchange, Pretoria, etc. as a destination
- Traffic originating north of Gillooly's Interchange (Roodepoort, Buccleuch Interchange, Pretoria, etc.) and travelling on the N3-S turning in a westerly direction along the R24-W towards Central Johannesburg, Eastgate, Bruma Lake, etc.

The South African National Roads Agency Limited (SANRAL) did not endorse the TCMS when it was initially implemented. SANRAL did, however, assist the EMP with the erection of directional control devices in the form of marked plastic poles during October 2003 in order to improve the overall safety of the system. It should be noted that SANRAL is currently engaged in studies for the improvement of the general operations at Gillooly's Interchange. Details of these studies could not be obtained in time for inclusion into this study.

Apart from the current traffic problems experienced at Gillooly's Interchange, other factors prompted an investigation into the operation of the TCMS:

- A rare phenomenon regarding general traffic operations was observed during implementation of the TCMS. When the traffic control measures are implemented by EMP traffic officers, the weaving section functions as a signalised intersection with interrupted flow characteristics, prioritised movements and time allocation. When not implemented, the weaving section functions as a normal freeway weaving section with uninterrupted flow characteristics.
- The TCMS was originally viewed as a form of ramp metering, which justified further investigation.
- Some EMP traffic officers claimed that the traffic control measures improved traffic operations at Gillooly's Interchange and reaped safety and monetary benefits. These claims needed to be quantitatively investigated.
- The "labour-based" approach to traffic management as a manifestation of South African Government policies on job creation as an effective alternative to specialised imported resources needed confirmation.

The abovementioned factors were investigated to gain insight into the management of traffic operations at one of the busiest and most important interchanges in South Africa.

The main objectives of the study were to:

- investigate the system of traffic control measures implemented at Gillooly's Interchange during the morning peak hours and gain a good understanding of its history, the way it functions and the way it influences the operational characteristics of Gillooly's Interchange;
- do an in-depth study of ramp metering applications in order to fully understand what ramp metering comprises, and to assess whether the implemented traffic control measures system can be described as a form of ramp metering and, if not, whether it can be described as another form of metering; and

- investigate operational, safety-related and monetary aspects of the traffic control measures system, and compare it with scenarios where no system or an automated (signalised) system is implemented, in order to determine the benefits (if any) of the system in its current form.

2. TCMS FUNCTIONING

The TCMS is implemented by EMP officers who manually alternate the right of way between the two traffic streams at the start of the weaving section where the off-ramps from the R24-W and the N3-S merge. This section describes the functioning of the TCMS.

2.1 Functioning During System Implementation

When the TCMS is implemented, the general characteristics of the relevant section change from that of an uninterrupted flow weaving section, to that of an interrupted flow section controlled by a traffic signal.

The EMP traffic officers placed at the beginning of the weaving section regulate the movements entering the weaving section as follows:

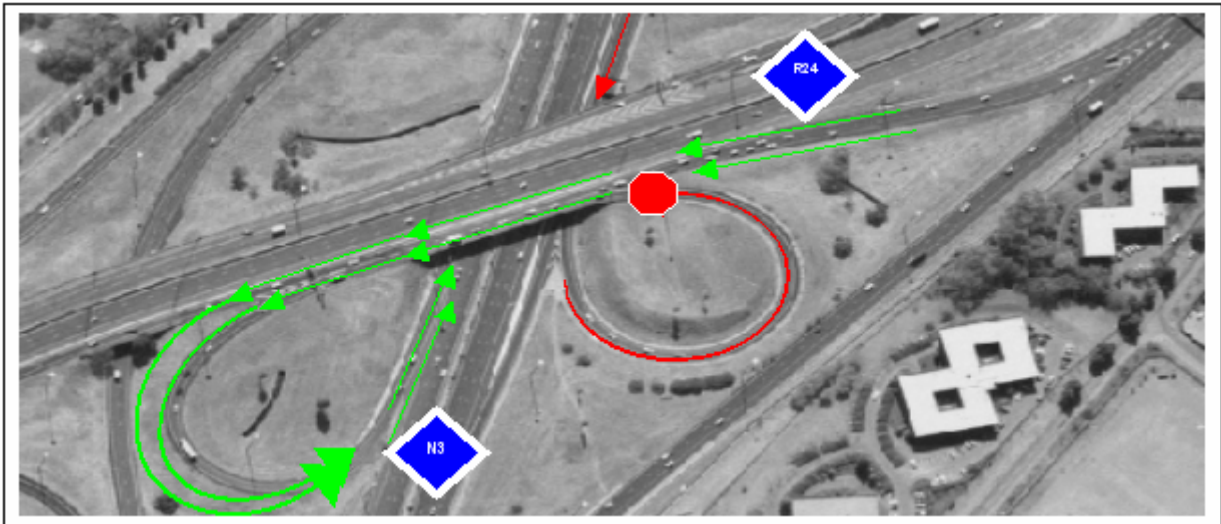
- *Phase 1:* Vehicles from the N3 are stopped whilst vehicles from the R24 are permitted to proceed.
- *Phase 2:* Vehicles from the R24 are stopped whilst vehicles from the N3 are permitted to proceed.

During periods when the system is active, marked plastic poles are strategically placed to organise the vehicles from the R24 into two separate traffic streams. The flow of traffic is governed by the officers' visual assessment of traffic operations in the study area.

The officers give priority to the heavier traffic from the R24 and permission for this traffic stream to proceed will be given when at least one of the following conditions are observed:

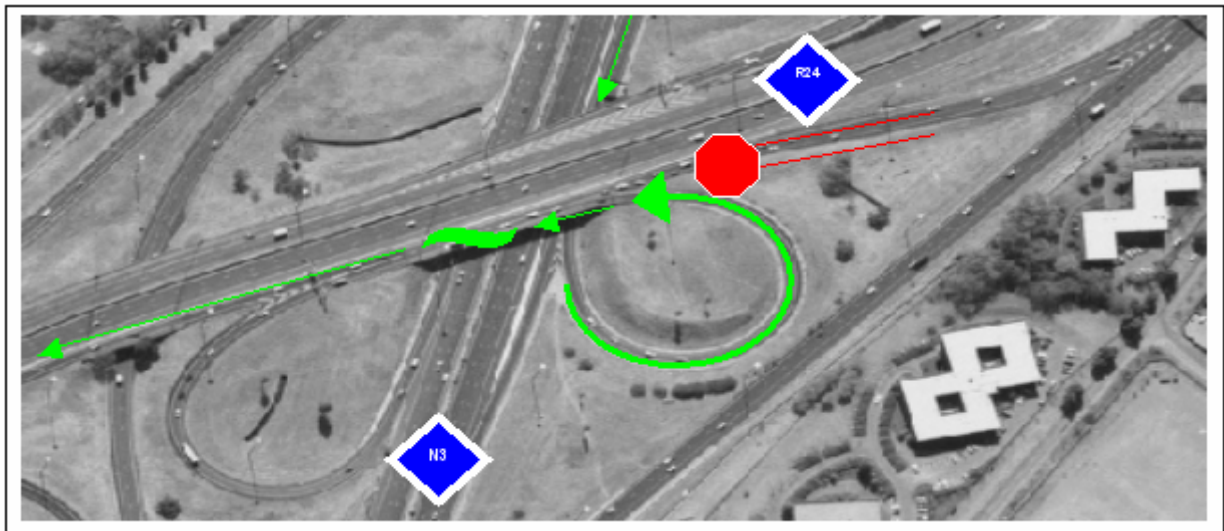
- The loop feeding the flow from the R24 onto the N3-N is no longer at maximum capacity and spare stacking capacity is available (downstream control).
- The stacking of vehicles on the approach of the R24 starts to interfere with the traffic making use of the on-ramp from the R24 onto the N3-S (upstream control).

As can be seen from the governing conditions, the TCMS exhibits a real-time response to fluctuating traffic operations in the study area. Cycle times measured during field observations confirm this as they are by no means fixed but rather linked to the assessment of the traffic situation by the traffic officers. According to EMP officials the system is typically implemented from 6:30 to 8:30 on weekdays. However, field observations show that the system usually starts later. Figures 1 and 2 contain graphic representations of the functioning of the system, green arrows indicating permitted movements and red arrows indicating unpermitted movements.



Adapted by author from photograph provided by AFRICON (Information and Land Systems Division)

Figure 1. System functioning during phase 1.



Adapted by author from photograph provided by AFRICON

Figure 2. System functioning during phase 2.

3. OVERVIEW OF THE STUDY

The final benefit-cost analysis was preceded by creating traffic simulation models in VISSIM. VISSIM is a time-step and behaviour-based simulation software suite that models urban traffic and public transport operations. It enables modelling on a microscopic level and was hence used to provide a representation of the expected traffic conditions for certain scenarios from which required results could be obtained. The creation of the simulation models and the results they produced were necessary since no data is currently available from field observations for the scenarios where no system or an automated signalised system is implemented. These results from the simulation models could then be utilised in the final benefit-cost analysis to compare the current implementation of the system with scenarios where no system, or an automated signalised system, is implemented. Three different scenarios for the relevant section in terms of operational, safety and monetary aspects were to be investigated.

The three scenarios were the following:

- *Scenario 1*: A simulation modelling the traffic operations of the morning peak period at Gillooly's Interchange without implementation of the current traffic control measures system;
- *Scenario 2*: The current implementation of the traffic control measures system at Gillooly's Interchange; and
- *Scenario 3*: A simulation modelling the traffic operations of the morning peak period at Gillooly's Interchange with the implementation of an automated signalised system.

The simulation models were calibrated by considering the actual measurements of travel times and queues. Furthermore, the models were validated by field observations that occurred either before implementation of the system or were independent of the TCMS. This included the breakdown of flow on the weaving section at about 6:20 and the congestion on the N3-N reaching Gillooly's Interchange at about 7:00.

Once all the relevant data were acquired and the required results drawn from the calibrated simulation models, the final benefit-cost analysis could be concluded. The values used to quantify costs were based on values recommended by SANRAL and the Water Research Commission (Mullins, 2002) for economic studies relating to infrastructure development in South Africa. The goal of the analysis was to compare *Scenarios 2 and 3* with *Scenario 1* in order to gain a first-order estimate of the benefits (if any) that are provided in terms of operational, safety-related and economic aspects by implementing either a manual or an automated traffic control measures system. The assessment of safety-related benefits was, however, excluded from this analysis since information available on the subject was inadequate. This analysis assessed only the sections of Gillooly's Interchange relevant to the TCMS during the critical analysis period (6:30 to 8:30).

The primary costs were identified as:

- *Capital costs*, which included installation costs of an automated signalised system as well as capital costs incurred for all necessary equipment;
- *Maintenance and operations costs*, which included electricity costs of operating an automated system as well as the wages for traffic officers currently operating the system; and
- *User costs*, which included vehicle operating costs (the cost of operating a vehicle in terms of fuel, maintenance, etc.) and travel time costs (the cost of time spent travelling instead of being productive).

In the case of capital costs, the future value of the investment was calculated and then converted to a uniform annual value in order to make an assessment with 2004 as the base year. Benefits were defined as those benefits provided by *Scenarios 2 and 3* in terms of savings on user costs with respect to *Scenario 1*. The benefit-cost ratio provides a guide to the attractiveness in economic terms of a given scenario and thus quantifies its benefits.

4. RESULTS OF THE STUDY

Gillooly's Interchange is traversed by a total of 12 possible routes. Each of the four directions of approach therefore provides three different options in terms of the course that a road user can follow through the interchange. Initially the 12 routes were identified and numbered in a certain order to simplify the measurement of travel times.

For the purposes of this study, however, only the following numbered routes are relevant and the rest of this section refers to them as they are described here:

- *Route 11*: Entering on N3-S; exiting on R24-W
- *Route 12*: Entering on R24-W; exiting on N3-N.

4.1 Operational Aspects

In order to determine whether the implementation of the traffic control measures system (either manual or automated) provides any operational benefits as opposed to no implementation, it is necessary to compare the results produced by the two simulation models with the data obtained by field measurements. Only results obtained during the critical analysis period (6:30 to 8:30) for the routes relevant to the implemented TCMS have been considered. Table 1 contains a comparison of these results.

Table 1. Results comparison for simulation models.

Parameter (6:30 - 8:30)	Results for relevant routes in terms of scenarios					
	<i>Scenario 1:</i> No system implemented		<i>Scenario 2:</i> Current manual system implementation		<i>Scenario 3:</i> Automated system implementation	
	Route 11	Route 12	Route 11	Route 12	Route 11	Route 12
Volume of vehicles (<i>Percentage improvement in respect of Scenario 1</i>)	1059 (0%)	1775 (0%)	1627 (54%)	1832 (3%)	1075 (2%)	2426 (37%)
Average travel time in seconds (<i>Percentage improvement in respect of Scenario 1</i>)	288 (0%)	485 (0%)	156 (46%)	403 (17%)	285 (1%)	391 (19%)
Average total delay as seconds per vehicle (<i>Percentage improvement in respect of Scenario 1</i>)	551 (0%)	294 (0%)	318 (42%)	71 (76%)	362 (34%)	274 (7%)
Average queue length in metres (<i>Percentage improvement in respect of Scenario 1</i>)	1174 (0%)	293 (0%)	99 (92%)	95 (68%)	466 (60%)	117 (60%)

The results indicate the following in terms of comparison of the different scenarios:

- *Volume*: The generally higher volumes that *Scenario 2* display in respect of *Scenario 1* indicate that the currently implemented TCMS facilitates the passing of more vehicles through the interchange along the relevant routes due to the fact that congestive conditions are alleviated somewhat by controlling the way traffic flows through the interchange. This is particularly applicable to Route 11, whilst Route 12 only improves slightly in terms of volume. *Scenario 3* also displays improvements in respect of *Scenario 1*, but that the bulk of the benefits are manifested in terms of Route 12.
- *Average travel time*: The improvement in travel times presented by *Scenario 2* over *Scenario 1* is to be expected, based on the previously mentioned alleviation of congestion that the control measures provide. The same is true for the improvements that are displayed by *Scenario 3*.
- *Average total delay*: The average delay is based on the average travel time, therefore the discussions of the average travel time are also of relevance here.
- *Average queue lengths*: Both *Scenarios 2* and *3* show vast improvements in terms of queue lengths. The queue lengths of *Scenario 2* which were obtained by means of field measurements vary significantly from the other scenarios.

As is evident from the relevant comparisons, both the manual and automated systems provide operational benefits for the affected traffic streams. This is mainly due to the elimination of weaving on Gillooly's bridge as well as the traffic responsive nature of the TCMS that enables adaptability to fluctuating traffic conditions. Furthermore, by maintaining optimal use of the stacking capacity on the loop feeding the flow from the R24 onto the N3-N, the absorption of this flow by the N3-N is maximised at all times.

4.2 Safety Aspects

When assessing the road safety aspects of an existing traffic facility or traffic control device or measures, a three-pronged approach should be followed which includes the analysis of accident statistics, conducting a safety audit and engaging in a conflict study. As stated earlier, the safety aspects could unfortunately not be properly assessed due to a lack of adequate data and hence only a road safety audit could be conducted.

4.3 Monetary Aspects

In terms of this study, the benefits are defined as the savings in user costs displayed by *Scenarios 2* and *3* in comparison with *Scenario 1*. The user costs include the vehicle operating costs as well as travel time costs. Benefit-cost ratios are defined as the relationship between these benefits and the sum of the relevant capital costs and maintenance and operation costs. Table 2 contains a summary of the relevant benefit-cost ratios of *Scenarios 2* and *3*.

Based on the results of the benefit-cost analysis, it was concluded that both traffic control measures systems (manual and automated) provide economic benefits above a scenario where no system is implemented. Although the manual system provides more benefits in terms of user costs, its relatively high operating costs reduce these benefits. However, it is significant to note that an automated system with fixed-time settings is not as efficient as the more adaptable real-time human controlled and traffic responsive system as is evident from the improved benefits in terms of user costs. Under current Government policy on promoting labour-intensive projects, the high operating costs may be acceptable due to the fact that it comprises mainly the wages of the traffic officers.

Table 2. Benefit-cost ratio analysis results.

Benefit-cost parameters	Benefit-cost analysis results		
	<i>Scenario 1:</i> No system implemented	<i>Scenario 2:</i> Current manual system implementation	<i>Scenario 3:</i> Automated system implementation
Capital costs	None	R3 100,00	R5 700,00
Maintenance and operating costs	None	R39 000,00	R160,00
Total costs	None	R42 100,00	R5 900,00
Vehicle operating costs	R835 400,00	R729 300,00	R778 200,00
Travel time costs	R5 888 700,00	R4 292 300,00	R5 120 300,00
Total user costs	R6 724 100,00	R5 021 600,00	R5 898 400,00
User costs benefits (compared to <i>Scenario 1</i>)	None	R1 702 500,00	R825 600,00
Benefit-cost ratio (compared to <i>Scenario 1</i>)	None	40,4	140,4

5. CONCLUSION

With regard to the initial study objectives certain conclusions were drawn and are briefly discussed below.

- Interviews were conducted with a variety of interested and concerned individuals in order to understand the system's background. The TCMS was investigated on a very broad basis, operational, safety-related and monetary aspects all being intensively reviewed and studied. It was concluded that this study in itself was proof of the first objective being met.

- Based on the literature reviewed and the field observations made, it was further concluded that the traffic control measures system implemented at Gillooly's Interchange was not a form of ramp metering, but rather a combination of manually implemented mainline metering and freeway-to-freeway metering.
- Based on the results of this study, it was concluded that the manually operated control measures system currently implemented at Gillooly's Interchange provided operational and monetary benefits compared to a scenario where no system was implemented. In addition to this, an automated (signalised) system also proved effective and could even provide increased economic benefits. However, it is not as efficient as a human controlled system that is responsive to fluctuating traffic conditions.

This system is in line with Government policy of promoting of labour-based projects and is a unique example of integrating the principles of first-world traffic management practices with third-world development constraints in a way that is beneficial to all concerned.

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