Studying traffic signal phasing in the Stellenbosch Smart Mobility Laboratory

Moving towards smart mobility in Stellenbosch

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ITS deployment is rapidly increasing globally, as well as in Africa. Advancements in communications technologies and the widespread use of technology enablers, such as smartphones, are creating new opportunities in ITS and providing impetus to the deployment of ITS projects. Individuals and vehicles are increasingly being equipped with technologies capable of monitoring their movement, leading to increased understanding of the mobility needs of individuals, and resulting in improvements to transport planning.

BACKGROUND

Traffic gridlock in Stellenbosch has become a common sight, largely owing to the town being an intense trip attractor due to the high number of destinations in the town, including Stellenbosch University, good schools, a bustling central business core and tourist appeal. All routes into Stellenbosch are severely congested during the morning with reverse congestion conditions in the afternoon. The result is significant delay and adverse environmental impact. These are some of the issues that the Stellenbosch Smart Mobility Laboratory (SSML), established in Stellenbosch University's Faculty of Engineering in June 2014, aims to address while fulfilling its vision to provide a platform for the development of innovative and cost-effective transportation solutions for application in developing countries.

This article considers the role of an academic facility such as the SSML in the research and development of new technology and data processing in engineering, and particularly in the field of Intelligent Transport Systems (ITS). The educational benefit of such a facility is considered, and the importance of interaction between industry and academia is discussed.

ITS CONTEXT IN SOUTH AFRICA

Intelligent Transport Systems (ITS) is the application of information and communications technology and data processing to the field of transportation engineering. ITS assists in managing transport facilities more efficiently, and can improve data collection of the operational characteristics of the transport network.

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ingly being equipped with technologies capable of monitoring their movement, leading to increased understanding of the mobility needs of individuals, and resulting in improvements to transport planning.

In South Africa, the 2010 FIFA World Cup had a significant impact on ITS development. In gearing up for the influx of visitors to the country, various improvements to transport systems were implemented. Freeway Management Systems (FMS) were upgraded and deployed on the country's freeways, especially in Cape Town, Gauteng and Durban. Electronic message boards and CCTV cameras were linked to traffic management centres, which were upgraded to serve as transportation operations centres during World Cup activities.

A number of cities in South Africa started to implement Integrated Public Transport Networks, which continue to be rolled out with more routes and services being added. Importantly, decisions were made at national level about service standards and best practices that would be implemented for all integrated public transport services throughout the country. These standards included the utilisation of technology to enhance the service to public transport users. Bus fleets are managed from centralised operations centres, fares are paid using a smartcard, stations and buses are monitored continuously by CCTV cameras to improve public safety, and all activities are monitored and integrated with other transport services at central operations centres.

Other important ITS projects that have been implemented in the last few years include electronic toll systems in Gauteng, and technologies associated with the Gautrain rapid rail system linking Tshwane, Johannesburg and Ekurhuleni. From the diversity of ITS deployment, it is clear that ITS forms an important component of our modern transport system.

With this rapid implementation of ITS projects, we are challenged to ensure the readiness of the supporting industry to meet the ongoing demands for ITS application. The transportation industry requires the tools to coordinate day-to-day operations and maintenance of the systems while developing the technical knowledge to continually improve existing systems. The ITS programme at Stellenbosch University was established for this purpose – to meet the needs of a growing ITS industry with regard to education, training and research.

A SMART LAB FOR MOBILITY STUDIES

The Stellenbosch Smart Mobility Laboratory's core objective is to provide a platform for the research and development of technology solutions that promote sustainable and safe mobility, specifically in developing countries. The SSML emphasises three main principles to achieve this objective:

- Encourage interaction between industry and academia
- Promote multidisciplinary research
- Test mobility solutions in real-world applications, specifically for developing countries.

Industry partnerships

Through interaction between the ITS industry and the university, the SSML provides a unique opportunity to expose students to real-world projects while allowing industry to access research and advisory services. The SSML is in partnership with a number of industry service providers and implementing authorities. Through these partnerships the SSML has been allowed access to extensive traffic management systems and traveller information databases which are being used in current research projects. Through these relationships, the SSML has also been equipped with state-of-the-art facilities, including software for various transportation and simulation programs, and hardware including traffic signal controllers.

This equipment and data are used by students while conducting research into mobility improvements. Additionally, the SSML provides research support to industry for specifically requested applications. Projects include analysis of network capacity constraints, development of traffic monitoring and management methods, information dissemination installations, development and testing of new hardware and software applications, and customising technologies for the developing country market.

Research focus

The SSML promotes the development of postgraduate students in the ITS field by providing a platform for multidisciplinary research. The ITS sector is deeply transversal in nature, and gathers members from a broad range of disciplines. The SSML facility provides the opportunity for a number of research environments, including transportation engineering, electronic and electrical engineering, industrial and systems engineering, Geographic Information Systems (GIS), economics and statistics to work together on common mobility projects. The SSML can therefore stimulate the added value of existing and new synergies by joining diverse core competencies that are distributed across a wide range of departments on the Stellenbosch University campus and industry.

The SSML research focus is aligned with current international trends in ITS, including research and product development in the following key areas:

- **Smart City:** Transport-related Smart City initiatives use data analysis and communications technology to improve infrastructure use and management. Research areas include public transport applications, parking solutions, Travel Demand Management initiatives, and the application of big data to human movement and transport planning.
- **Connected Vehicle / Connected Traveller:** Communications technology is applied to vehicles and transport facilities to improve interaction between users. Research is specific to the developing world context and the use of probe data.
- **Freeway management:** ITS allows the optimisation of transport infrastructure through the monitoring and management of freeway incidents and data gathering, for example from Open Road Tolling.
- **Traffic control optimisation:** Research is conducted into improvements of intersection control and traffic signal operation.

Test-bed environment

The SSML provides a practical test-bed environment in Stellenbosch. ITS applications are first modelled using traffic simulation software in the lab, and are then implemented and tested in a real-world environment while the effects on the transport system are monitored from the SSML. This allows projects to be tested in a developing-world environment while also resulting in improvements to the Stellenbosch transport situation. The lessons learned through implementing and testing the effects of SSML research projects will be used to inform development of ITS projects in other towns and cities of South Africa, and other developing countries.

Traffic congestion in Stellenbosch

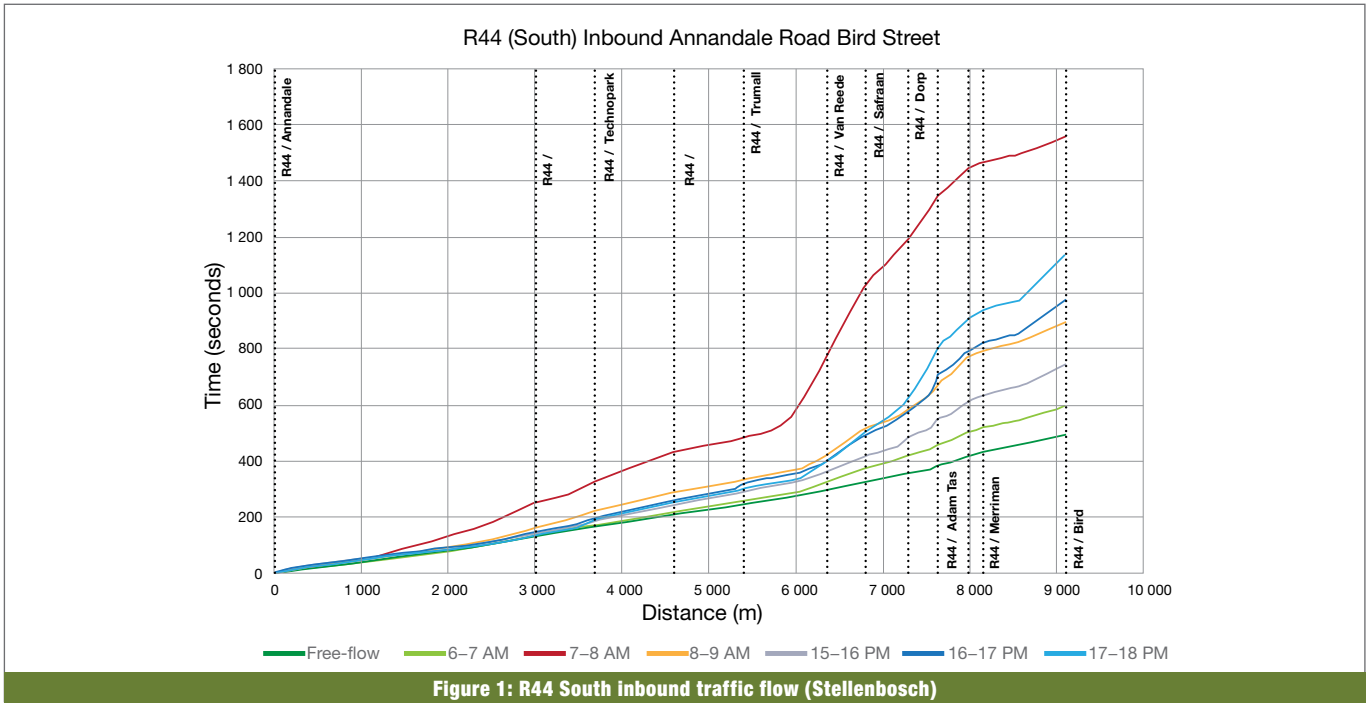

Figure 1: R44 South inbound traffic flow (Stellenbosch)

Student development

The formation of the SSML has allowed Stellenbosch University to incorporate state-of-the-art ITS applications into the undergraduate Transport Science curriculum, and allows specialisation in ITS at a postgraduate level through specific research projects.

In the undergraduate civil engineering curriculum, students are introduced to ITS in the introductory Transport Science course. The lab allows the physical demonstration of new technology developments in the transport field. Students are introduced to traditional data collection methods, as well as to new ITS methods, such as the use of probe data in travel time and speed analysis. The traffic signal installation of the SSML will be used this year for the first time to introduce students to an actual traffic controller when dealing with theory on traffic signal timing. The SSML provides a physical location to expose students to the ITS environment specifically, but also to transportation in general to foster their understanding and interest in this field of engineering.

At a postgraduate level, the SSML is positioned to expose students to actual ITS projects and research needs through its partnerships with industry. The SSML considers it vital for students to gain experience of industry during the postgraduate programme, thereby improving the work-readiness of graduates.

STELLENBOSCH: THE IDEAL TEST-BED ENVIRONMENT

With the support of the university, Stellenbosch is the perfect location to study ITS applications, providing an ideal real-world test-bed environment. Conditions that make this area favourable for mobility research include:

- good but limited connectivity
- quantifiable traffic flow
- existing congestion
- parking limitations, and
- rail connectivity.

The Stellenbosch Local Municipality, which includes the towns of Stellenbosch, Franschhoek and Pniel, has a population of 156 000 according to the 2011 Census. Approximately half of the municipality's residents live in Stellenbosch. Stellenbosch University, located in central Stellenbosch, has approximately 30 000 enrolled students and permanent employees. According to a study conducted by the Stellenbosch Municipality in 2009, one third of students live on campus in Stellenbosch central,

another third in the town and surrounding neighbourhoods, and one third in surrounding towns and Cape Town.

Stellenbosch is well connected with five arterial routes that provide access to the town from surrounding areas. The arterials form a basic radial configuration, extending from the town centre. In Stellenbosch, the five radial arterial routes come together to form a single north–south arterial road west of the town centre – Adam Tas Road. Collector roads extend predominantly in an east–west direction from the arterial into the town centre. As the accesses are well defined and limited to only five arterial routes, traffic flows into and out of Stellenbosch are easily monitored.

The general traffic direction is towards the Stellenbosch town centre during the morning peak traffic period, and out of Stellenbosch to surrounding areas in the afternoon peak, as would be expected of a net trip attractor.

Drivers in Stellenbosch experience very high congestion along the arterial routes during the morning and afternoon peak traffic times. Progression along the arterial roads is slow and very often hampered at traffic signals by upstream grid-lock conditions. Furthermore, parking demand within the town and on the university campus exceeds capacity, and mobility on campus and through Stellenbosch is severely constrained.

THE STELLENBOSCH MOBILITY SITUATION

An example of current research being conducted by the SSML is the quantification of congestion in Stellenbosch. This is required at the outset of SSML activity to provide comprehension of the study environment, as well as to set a benchmark for measuring the outcomes of research initiatives.

Operational performance of a transport network can be determined through comparison of travel time and speed. Slower speeds are indicative of increased congestion and reduced performance along a road. As traffic volume increases, density of vehicles increases and average traffic stream speed decreases to accommodate the reduced following distances. The SSML has used innovative techniques to quantify traffic congestion in Stellenbosch by studying speed and travel times obtained from probe data (data obtained from vehicle sensors) on the arterial routes.

Travel time probe data allows a comparison of travel time and speed averaged over a selected period which reduces the impact of a particular event on traffic flow. This information allows a comparison of the travel time along the route, plotted by a time-distance graph, as presented in Figure 1 for the morning peak hour along the R44 south of Stellenbosch. Slower speeds are indicated by an increase in gradient. By investigating areas of increased gradient, areas of congestion and queue formation can be identified.

Traffic on the outskirts of Stellenbosch during the morning peak hour, especially along Strand Road (R44 south) and the R304, is highly congested, with speed affected up to 6 km from town. During the afternoon peak hour, congestion on the arterial network on the outskirts of town is less intense than during the morning peak hour. However, roads within central Stellenbosch are more highly congested than in the morning, particularly along Adam Tas, with an average speed of less than 10 km/h. Typical additional delays experienced on this arterial during peak periods range between 17 and 20 minutes. These numbers are clear indicators of a worsening traffic situation and the ideal environment for the SSML to make a contribution in addressing these challenges.

THE SSML TEAM

Johann Andersen is the programme manager of the SSML and an Industry Associate Professor in ITS at Stellenbosch University. He teaches ITS principles in graduate and undergraduate civil engineering programmes and guides research in ITS.

Megan Bruwer is the SSML project coordinator managing SSML research and advisory projects, and industry interaction. Megan also lectures transportation engineering at Stellenbosch University to undergraduate students.

The SSML team is augmented by international interns and enrolled postgraduate students studying in the field of ITS at Stellenbosch University.

CONCLUSION

The SSML is anticipated to have a significant and beneficial impact on the teaching of transportation engineering at Stellenbosch University in both the undergraduate degree and in postgraduate research in the field of ITS. The support of industry in this endeavour is considered vital to the success of the SSML, both in providing hardware and software for research purposes, and in providing students with access to industry projects.

In preparing graduates for the ITS environment, the SSML will support the industry in meeting demands to develop, coordinate, operate and maintain ITS projects by providing education, training and research opportunities in this field. South Africa has been experiencing a period of intense development in the transport sector, and particularly ITS. This momentum must be maintained for South Africa to develop in line with international trends, and to ensure that our infrastructure is used optimally. ☐