Academic Consortium 21

FINAL REPORT

AC21 Project:

Intelligent Transport Systems (ITS): Development of collaborative research areas as bridge between developed and developing countries to ensure sustainable and innovative deployment

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1 INTRODUCTION

AC21 (Academic Consortium for the 21st Century) is a grouping of universities that collaborate to tackle the rapidly changing needs of society. This AC21 project addresses a project particularly relevant within this context i.e. *Intelligent Transport Systems (ITS): Development of collaborative research areas as bridge between developed and developing countries to ensure sustainable and innovative deployment.*

The use of technology in support of transport solutions (often referred to as Intelligent Transportation Systems) with resultant extensive data generation and its widespread deployment is common place in the developed world. Many developing nations are following suit in an attempt to address the ever growing transportation needs and increased congestion in major cities. However, the appropriateness of these solutions is under scrutiny. Furthermore, affordability of extensive infrastructure provision and the corresponding sustainability from an operations and maintenance perspective is seriously being questioned in many developing countries, especially against the background of extreme poverty and associated social needs.

The aim of this project is to bring together leading researchers in this field, both from a developed and developing country environment, and consider appropriate areas of collaborative research to ensure sustainable implementation for ITS in the developing country environment. Innovation and cost effectiveness are crucial ingredients.

2 THE AC21 PARTNER UNIVERSITIES

The AC21 partner universities, and main representatives of the various universities, are listed below:

<u>Project lead:</u>

Dr Johann Andersen, Industry Associate Professor, Department of Civil Engineering, Stellenbosch University. Assisted by Me Megan Bruwer, Lecturer in Transportation Engineering at the Department of Civil Engineering, Coordinator of the Stellenbosch Smart Mobility Laboratory (SSML), Stellenbosch University.

<u>Partner Universities:</u>

Dr Nagui M Rouphail, Director, ITRE, Professor of Civil Engineering, Department of Civil, Construction & Environmental Engineering, North Carolina State University

Dr John Hourdos, Research Associate Professor, Director Minnesota Traffic Observatory, Department of Civil, Environmental & Geo-Engineering, University of Minnesota

3 PROJECT ACTIVITIES

The main project activities are highlighted below.

Most of the activities centred around two project workshops. Workshop 1 was hosted by the ITRE at NC State University. It was held on Wednesday 25 May 2016 and attended by the three partner universities. Participants in the workshop included the various academic staff working in this field of interest, research staff from NC State, a post-graduate student from Zimbabwe (studying at Stellenbosch University), various post-graduate students from NC State University (with nationalities representing developing countries such as India and Bangladesh), representatives from the various international offices, and a group of staff and post-graduate students linked via video-conference in Stellenbosch.

Fig. 1: Delegates at the firsts project workshop at North Carolina State University

The aim of the first workshop was to:

(i) Understand and explore the areas of expertise from the partner universities as it relates to the project objectives
(ii) Provide an overview of relevant research areas, activities and initiatives
(iii) Present trends in ITS development internationally
(iv) Get to a better understanding of the application environment in developing countries
(v) Develop an initial framework for identifying major research and collaboration opportunities, with specific focus on innovation

The first workshop was highly successful and all set objectives reached. An initial working document was prepared as outcome of this activity.

Prior to the second workshop, it was envisaged to engage with all AC21 partner universities and involve them in a project webinar. This activity did not materialise as anticipated. Little response was received from AC21 universities, most likely due to the fact that (i) they might not have a dedicated

ITS programme and related field of research, (ii) the multi-disciplinary nature of the topic at hand meant that it was not always clear which department of faculty to approach, (iii) possible language barriers in correspondence, (iv) lack of direct personal academic relationships with partner universities in the field of ITS.

Workshop 2 was hosted by the Stellenbosch Smart Mobility Laboratory at Stellenbosch University. It was held on Tuesday 22 November 2016 and attended by the three partner universities. Participants in the workshop included the various academic staff working in this field of interest as well as post-graduate students from Stellenbosch University. The aim of this second workshop was to discuss particular research needs for ITS advancement in developing countries. Further sections elaborate on this aspect.

Following the workshop, and as part of the collaborative activities between the partner universities, both Dr Rouphail and Dr Hourdos lectured to local post-graduate students and industry representatives on their areas of expertise in a two-day workshop.

The project activities are concluded with this Project Report.

Fig. 2: Delegates of the workshop lecture in the SSML at Stellenbosch University

Fig. 3: Dr Nagui Rouphail lecturing students at Stellenbosch University

4 DEVELOPING COUNTRIES: CONTEXTUAL BACKGROUND

This section reflects on the application environment, with specific emphasis on the African continent.

Rapid urbanisation, coupled with increasing economic development results in higher congestion in cities. In previous years, a lower economic base resulted in limited mobility needs, however the economic base in Africa and other developing countries is now much higher, and so even a small increase in development and GDP growth has a profound effect on the transport needs of developing countries.

Trends that are observed in developing countries that influence the transport environment include:

- Large labour force (a high number of lower earning individuals), often in the informal sector
- Growth in consumption (increasing freight movements)
- Massive investment in connectivity, however focus is device intensive, resulting in a need to improve internet connectivity
- High data costs

An opportunity exists in developing countries to leapfrog the legacy technologies that are installed and used in ITS projects in developed countries. This allows developing countries to use the latest technologies and provides practitioners an opportunity to implement minimal infrastructure, low cost, efficient ITS projects that will be particularly suited to rural environments, smaller cities and the developing world context. Developing ITS technologies can then be scaled and adapted to suit developed country needs, resulting in smarter and more efficient ITS applications globally.

Further contextual thoughts and issues were identified during the course of the project and listed below:

1. Policy makers and research personnel need to be guided by an overarching vision and supporting mechanism for sustainable adoption of ITS in the developing country environment;
2. A coordinated funding approach, involving different public and private organisations, is a necessary step to ensure proliferation of ITS in this environment;
3. The use of mobile phones (smartphones) can be seen as a portal to ITS;
4. Consider the rate of compliance within the application environment;
5. The cost and availability of data is critical;
6. There is a need to develop an index for evaluating ITS projects. Performance evaluation should be considered both from an authority and user point of view;
7. The high demand for transit in the developing country environment should be recognised in working towards ITS solutions;
8. Mere replication of ITS technologies are not feasible and sustainable;
9. There is need to assist and/or invest in local technologies;
10. Traveller information systems are less expensive than traffic management/control systems; investments should explore and follow this hierarchy;
11. Ensure multi-modal integration at network level, including data storage and data collection;
12. Ensure that the costs of operations and maintenance are minimised in the design of ITS systems and equipment. This could seriously impact on the long-term sustainability of the deployment;
13. Communication costs are high
14. Heterogeneous nature of traffic and optimal (often implying non-conformance to road rules) needs to be understood and accounted for;
15. Transportation not adequately viewed as a service;
16. Vandalism and infrastructure damage to be accounted for in deployment approach.

5 RESEARCH PROJECTS IDENTIFIED

A number of specific research areas were identified for further consideration. These are particularly relevant to the Stellenbosch environment, with a focus on replication in the developing country environment.

5.1 Urban transport demand modelling

A transport demand model and network simulation is required in an urban environment before effective planning and management of the transport network can be carried out (for example through traffic signal management, Advanced Traveller Information Systems – ATIS and public transport management systems). The data demands for traditional modelling are restrictive, particularly in the developing country context. Research is needed to investigate using less resource intensive data sources to initiate transport models. One such data source is Floating Car Data (FCD). Research into the use of FCD to calibrate transport models (through comparison of travel times and speeds) and initiate aspects of models, such as the origin-destination matrix, is required. The perfect testbed for this research is the developing country environment, where the outcome of the research will fill a specific need for improved and more efficient transport modelling methods.

It is proposed to initiate an experimental traffic demand model for the town of Stellenbosch in collaboration with Stellenbosch Municipality, international software providers, FCD providers, modelling specialists and academics. As far as possible, FCD will be used to initiate and calibrate the model. This will be augmented by traditional traffic counts that are obtained from existing traffic sensors on the road network of Stellenbosch. Stellenbosch is particularly suited to a trial modelling process because the town is relatively isolated from neighbouring urban areas, with clearly defined arterial routes into the Stellenbosch area. Additionally, the relatively small town (population of 156 000 according to the 2011 Census) is a high activity zone, attracting a number of trips from surrounding areas resulting in high traffic flows and severe congestion.

5.2 Rural / remote / private road monitoring and management

The majority of roads in Africa are rural and remote. Also, a number of private roads (not under the jurisdiction of government roads agencies) are in use. Very little to no management of traffic operations, and to some extent regular maintenance inspections is carried out on these remote roads. Research into methods for speed control strategies, incident response management, information dissemination to road users, and management of level road over rail crossings (which are often in fact inactive), is required.

Due to the vast distances over which this management needs to occur, both in terms of distance to the nearest suitable location for a traffic management centre, as well as the length of the roads to be managed themselves, traditional traffic sensor technology such as inductive loops, radar and CCTV, is prohibitive. Communications to sensors and the number of sensors required to effectively be able to observe operations on a sensible percentage of these road networks would simply cost too much to install and maintain. Floating Car Data provides an alternative source of readily available traffic information. Research into the extent that replacement of limited traditional sensor technology with FCD can take place must be investigated. While this research is conducted in the developing country environment, the application to rural and remote areas globally is easily inferred.

5.3 Traveller information

Personal navigation devices (PNDs) and navigation apps on smartphones provide routing information to users. The routes that are recommended do not however take local conditions and preferred routing into account. An example of this is routing along the fastest path, which could be through a potentially dangerous area where the majority of drivers would not like to travel at night. It is important to integrate routing information with local conditions. This is not only applicable in the developing country context, this is a global issue.

Research should be done into the methods to determine areas where people are uncomfortable to travel at particular times of the day. Possible methods include observation of deviation from recommended routes during particular times of the day, and redistribution of observed trips away from certain areas. Floating Car Data can again be used for such applications.

5.4 Environmental impacts

The exposure of people to the adverse environmental impact of mobility in the developing country context should be investigated. This includes exposure to vehicle emissions and high noise levels. This is particularly necessary for developing countries because of the aging vehicle fleet and perhaps less stringent environmental control of vehicles.

6 FUNDING OPPORTUNITIES

Future research and development opportunities are dependent on availability of funding. Several funding avenues i.e. international funding opportunities were discussed.

Suggested sources are summarised below for further exploration:

- National Science Foundation (based in USA): can request funding with an international supplement for research in foreign countries
- World Bank funding
- EU Funding (specifically for projects conducted with EU partners)
- Private companies abroad with interests in developing countries

7 GOING FORWARD: White Paper on Technology for Transport in Developing Countries

The project is concluded with this Project Report. However, the project team will further elaborate on future opportunities through development of a White Paper for deployment of ITS in the developing country environment. The emphasis will be on sustainable deployment of transport technologies, unlike what is believed, is currently the case. It is envisaged that this White Paper will be a major contribution in ensuring a more responsible, cost-effective but also practical approach toward technology applications in transport within the developing country environment. Input will be received in preparing this paper from the three core universities in this project, Stellenbosch University, North Carolina State University and the University of Minnesota.

This white paper will be presented at the South African Transport Conference (SATC) in July 2017 (hosted annually in Pretoria, South Africa) to stimulate discussion and get input from a wide audience of ITS specialists that are working in the developing country environment for input towards a final product. It is also envisaged that this paper will form the basis of discussion with stakeholders in the foreseeable future to debate policy and funding directives for ITS in the developing county environment.

ANNEXURE: CURRENT RESEARCH ACTIVITIES

Research activities associated with technology applications in transportation at the partner universities were identified early. A high level summary is provided below.

STELLENBOSCH UNIVERSITY

1. City transport - bicycle sharing, parking app, traffic planning platform (TomTom City), congestion mapping and public transport (minibus and mobility patterns)
2. Traffic demand models - using historic FCD data to estimate traffic flow and Stellenbosch demand model (PTV)
3. Real time operations - live data input for dynamic traffic modelling, ground truthing of live FCD with road side sensors, and traffic control platform for TMC
4. Traffic engineering - traffic signal optimisation, dynamic traffic signal optimisation, FCD costing model
5. Connected vehicle/Traveller in the developing country
6. Road agency focus
7. Freeway management – infrastructure optimisation, speed management and incident management systems

NORTH CAROLINA STATE UNIVERSITY

1. Assessment of data collection technologies: local RTMS fixed sensors, field Bluetooth devices, video, video image processing, in-vehicle OBU-OBD interface (i2d), third party data (INRIX, HERE, RITIS, NMPRDS etc.) and mobile devices
2. Modelling and simulation of ITS
    a. Active traffic management in HCM 6th edition for freeway facilities (FREEVAL-DSS)
    b. Signal Optimization using Dynamic Green Times from ATMS
    c. ITS-impacted Energy and Emissions Modeling using mesoscopic modeling (DTA-Lite)
    d. Incident Management Impacts on Facility Travel Time Reliability (FREEVAL-2015E)
    e. Visualization of Connected Vehicle Data

UNIVERSITY OF MINNESOTA

I-94 WB Field Lab – 1.74 mile long, 4.81 crashes per million vehicle miles

- Data collected – traffic video, traffic incident record, autoscope video data extraction, SMS radar vehicle trajectories and loop detector data

ATM tools in Minnesota

- Traffic adaptive ramp metering
- Changeable message signs
- Freeway Incident Response Safety Team
- Dynamic priced HOT lane

- Priced dynamic shoulder lane
- Advisory speed limits, I-35W and I-94
- Intelligent lane control signs, I-35W and I-94