SMART MOBILITY PROGRAMME @ SCHOOL OF ELECTRICAL AND ELECTRONIC ENGINEERING
Overview

The Smart Mobility Programme @ School of Electrical & Electronic Engineering (EEE) is the latest addition to Singapore’s Intelligent Transportation System (ITS) eco-system committed to excellence in Vehicle to Everything (V2X) Research, Innovation, & Education.

01
RESEARCH
with the clear intention towards commercialisation.

02
INNOVATION
thru’ collective partnerships leverage our state-of-art campus-wide V2X facilities.

03
EDUCATION
dedicated to the training of future ITS leaders, innovators and entrepreneurs
**Education**

Youth Development for the ITS industry. Dedicated to the training of future ITS leaders, innovators and entrepreneurs.

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**Technical Activity**

- Seminars
- Workshops
- Research Projects
- Knowledge Sharing
- Industry Visit
- Career Talk

**Social Activity**

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**Benefits to Members**

- Mentoring
- Career
- Networking
- Volunteerism
- Merchandise
- Conferences Activities

**Benefits to Industries**

- Candidates
- Collaboration
- Internship
- Training
- Reputation
- Research & Development

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**Stay Connected to Intelligent Transportation Society**

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Innovation

Enabling Innovations in collaborations with partners thru’ our state-of-the-art V2X infrastructure.

Wireless & Data Transport Networks
- 40+802.11p RSUs
- 60+802.11n MESH Aps
- 10Gb/s campus backbone
- Dedicated RSU/OBU test sets

Video Surveillance System
- 100+ IP video cameras (fixed + mobile)
- Video management system
- Video analytics

Data Center
- Private V2X Cloud - Virtualized Infrastructure
- State-of-the-art Data Centre

Environment
- Large video wall
- Demo facility
- Project rooms
- Discussion rooms

Command & Control Center
- Buses
- Cars
- Motorcycles

Vehicles

Software Apps & Services
- Safety Applications
- Data Collection
- Data Analytics
- Service APIs

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- dedicated to the training of future ITS leaders, innovators and entrepreneurs

Youth Development for the ITS industry.
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Technical Activity

Research
- projects
- Knowledge Sharing

Industry
- Visit
career
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- Seminars
- Workshops
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- Candidates
- Career Collaboration
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- Reputation

Benefits to Members
- Research & Development

Benefits to Industries
- NTU-NXP Smart Mobility Test bed
Research

Our research programmes focus on key challenges in the future Smart Mobility Solutions, where we strive to bridge Intelligent Transportation System (ITS) related research to commercialisation.

**VEHICULAR**
- Optimal Route Selection in City Traffic Networks
- Light-field imaging for distance measure
- Image processing for rain, haze, fog removal
- Driver inattention detection
- Traffic signal control algorithms for urban road networks
- Autonomous systems and robotics
- Distributed traffic light scheduling
- Security enhanced technologies for IEEE 802.11p
- GPS-free TDOA and FDOA geolocation and tracking
- Coexistence of multiple ITS antennas
- Conformal antennas for V2X
- MIMO/SMART antennas for V2X
- Real-time scalable traffic prediction, Multi-modal optimization of public transportation systems
- Autonomous systems and robotics
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- Real-time scalable traffic prediction, Multi-modal optimization of public transportation systems

**INFRASTRUCTURE**
- Software Defined Networks for VANET
- Real time trajectory generation for multi-vehicle formation keeping and reconfiguration
- Network coding for VANETs
- Emergency broadcasting techniques
- MIMO for 802.11p network
- Cooperative and distributed localization in NLOS environments
- Urban outdoor localization of robotic platforms under GPS challenged environments
- GPS-free TDOA and FDOA geolocation and tracking
- Coexistence of multiple ITS antennas
- Conformal antennas for V2X
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**PEOPLE**
- VEHICULAR
- PEOPLE
- INFRASTRUCTURE

**OUR VALUE PROPOSITION**
- Comprehensive research capabilities within the School of EEE.
- Close collaboration with industry to define key areas of research.
- Establish standards and protocols related to ITS deployment and implementation.
- Clear intention to apply research for commercialization.
Centre for Infocomm Technology (INFINITUS)

Spearhead research and collaboration in strategic areas of information and communication technologies and applications.

Advanced Sensing  
Navigation & Positioning  
Cyber Security  
Comms & Network Systems  
Data & Video Analytics

Contact Us:  
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Lead Project Investigator  
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ITSS Student Branch:  
Zhao Ming  
PhD Student  
ITSS Student Branch President  
Email: MZHAO003@e.ntu.edu.sg
The NTU-NXP Smart Mobility Test Bed was inaugurated in April 2015 at the Nanyang Technological University (NTU) in Singapore to serve as a common facility for ITS community to collaborate in developing and testing of next generation transportation innovations that enhance commuter safety and transportation services.

**SMART MOBILITY TEST BED RESOURCES**

The Smart Mobility Test Bed includes an end-to-end ITS system with 5 major components:

1. ITS Wireless Infrastructure & Data Transport Network
2. ITS Applications and Services
3. ITS Data Centre
4. ITS Control Centre
5. ITS vehicles
By 2016, the test bed will fully cover NTU’s 200-hector campus, providing an environment with mixed clutters, various terrain types and a large population, to simulate a small city with state-of-the-art V2X infrastructure.

• ITS Wireless Infrastructure & Data Transport Network:

The ITS wireless infrastructure which comprises IEEE1609 WAVE/DSRC-compliant Road-side Units (RSU), together with the data transport network consisting of wired and wireless backhauls, provides the data paths between applications running on various devices (e.g. OBU, smartphones, tablets, laptops and etc.) and ITS services hosted in the data centre. The data transport network also provides the control paths from the Control Centre to different network elements that need to be monitored and managed in the Smart Mobility Test Bed.

• ITS Applications and Services:

ITS-related safety and non-safety applications are deployed to offer road safety, cooperative traffic management, and infotainment services. New applications may be developed to extend features and functions supported by the WAVE DSRC protocol stack such as WBSSD, IPv6 over IPv4, locationing, charging/tolling, platooning and etc. In addition, the services include various 3rd party software applications to be used to support various test bed functions, such as network management system (NMS), video management system (VMS), network planning.
• **ITS Data Centre:**

The Data Centre is a dedicated facility where backend servers, networking equipment and data storage required for the Smart Mobility Test Bed are hosted. For this project, the Data Centre will be established at the High Performance Computing Centre (HPCC), and made accessible through the NTU campus network.

• **ITS Control Centre:**

The Control Centre is a dedicated operation facility where operators monitor the performance and availability of various elements in the Smart Mobility Test Bed, e.g. cameras, OBUs, RSUs, Servers, switches, routers, applications etc. The Control Centre also provides an environment for NTU and partners to jointly develop and integrate multiple functions into system for Proof-of-Concept (PoC) demonstrations.

• **ITS Vehicles:**

ITS vehicles generally refer to motorized vehicles, such as buses, cars, motorcycles, equipped with IEEE1609 WAVE/DSRC-compliant On-board Units (OBU) to support communications with other vehicles and backend to exchange information. The vehicles will also be fitted with other devices, e.g. cameras, displays and WIFI APs, to create in-vehicle systems that connect externally through OBUs.

• **Smart Mobility Test Bed Engineering Services**

The Smart Mobility Test Bed Team, made up of talents from academia and industry, offers professional systems engineering and software engineering services ranging from consultation, solution design, implementation as well as demonstration. These services aim to support consortium members in setting up the proper environment and resources needed for their R&D and showcasing activities.
- **Site planning** - real estate, power and connectivity.
- **Installation** - cabling, mounting and installation.
- **Network planning** - MESH wireless planning, RSU connectivity planning.
- **Demo/showcase planning & support** - plan and support customer demonstrations in an end-to-end ITS environment.
- **System maintenance** - on going system maintenance (e.g. health monitoring, power supply costs and real estate costs).
- **Data collection** - drive testing, troubleshooting and etc.

Contact the Smart Mobility Test Bed team to arrange for a site visit and meeting. Submit the Membership Application Form.

Jointly prepare an Agreement outlining project scopes, required resources and schedules.

Project kickoff, execution & demonstration.
Assoc Prof Guan Yong Liang, PhD (Imperial College, London)
Email: eylguan@ntu.edu.sg

Research Interest
Coding and signal processing for communication systems and storage systems. V2X communication. 4G and 5G cellular communication. Massive MIMO.

Current ITS related projects
MIMO and relaying for DSRC/802.11p network
Network Coding for Network Load Reduction for V2X Communication Networks

Asst Prof Tay Wee Peng, PhD (MIT, USA)
Email: wptay@ntu.edu.sg

Research Interest
Distributed detection, estimation and signal processing, localization, sensor networks, social networks, information theory, statistics and applied probability

Current ITS related projects
Cooperative and distributed localization in NLOS environments
Urban outdoor localization of robotic platforms under GPS challenged environments
GPS-free TDOA and FDOA geolocation and tracking

Prof LU Yilong, PhD (UCL, UK)
Email: eylu@ntu.edu.sg

Research Interest
Antennas, array antennas, array signal processing, new radar concepts, computational electromagnetics, and evolutionary computation for optimization of complex problems.

Current ITS related projects
Coexistence of multiple ITS antennas
Conformal antennas for V2X Communications
MIMO/SMART antennas for V2X communications

Asst Prof Justin Dauwels, PhD (ETH, Zurich)
Email: jdauwels@ntu.edu.sg

Research Interest
Data-driven intelligent transportation systems, data analytics, graphical models, signal processing, machine learning, computational neuroscience

Current ITS related projects
Real-time scalable traffic prediction, leveraging on traffic incident and weather information
Mobile apps for intelligent transportation systems
Multi-modal optimization of public transportation systems

Asst Prof Su Rong, PhD (Univ of Toronto, Canada)
Email: rsu@ntu.edu.sg

Research Interest
Supervisory control theory, model-based fault diagnosis, planning and scheduling in complex systems, green building, intelligent transportation systems, multi-agent systems

Current ITS related projects
Distributed traffic light scheduling
Intelligent air traffic flow management
Professor Wang Dan Wei  
**Email**: edwwang@ntu.edu.sg

**Research Interest**
Autonomous systems and robotics  
Traffic signal control algorithms for urban road networks

**Current ITS related projects**
Real time trajectory generation for multi-vehicle formation keeping and reconfiguration

Assoc Prof Chau Lap Pui, PhD (HKPolyU, Hong Kong)  
**Email**: elpchau@ntu.edu.sg

**Research Interest**
Image and video processing algorithms, robust video transmission, and human motion analysis.

**Current ITS related projects**
Driver inattention detection  
Image processing for rain, haze, fog removal  
Light-field imaging for distance measure

Assoc Prof Maode Ma  
**Email**: emdma@ntu.edu.sg

**Research Interest**
Wireless Networking and Network Security

**Current ITS related projects**
Hanover and Authentication for Mobility Management  
Security Enhanced Technologies for IEEE 802.11p

Assoc Prof Xiao Gaoxi  
**Email**: egxxiao@ntu.edu.sg

**Research Interest**
Complex systems and networks, wireless and optical networks, resilient systems and risk assessment, software-defined networks, distributed and self-organized systems

**Current ITS related projects**
Optimal Route Selection in City Traffic Networks with Unknown and Stochastic Link States  
Software Defined Networks for VANET

Dr Wesley Tan Chee Wah  
**Email**: wesleytan@ntu.edu.sg

**Research Interest**

**Recently Concluded ITS related projects**
VELOR: Velocity-based Routing Protocol  
A Study on Research Issues in Vehicular Ad Hoc Networks
<table>
<thead>
<tr>
<th>No</th>
<th>Project Title</th>
<th>Student Name</th>
<th>Undergraduate/Postgraduate</th>
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<tbody>
<tr>
<td>1</td>
<td>Real-Time Control and Learning for Urban Transportation Systems</td>
<td>Wang Yu and Luo Yiwen <em>(Supervisor: Prof Wang Danwei)</em></td>
<td>PG, UG</td>
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<td>2</td>
<td>Data Processing for Traffic Control System Tuning</td>
<td>Yang Chule <em>(Supervisor: Prof Wang Danwei)</em></td>
<td>PG</td>
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<td>3</td>
<td>Vehicular WiFi Transmission Quality Measurement</td>
<td>Dayana Bte Jamaludin and Kee Jing Yi <em>(Supervisor: Prof Guan Yongliang)</em></td>
<td>UG, UG</td>
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<td>4</td>
<td>Data-Driven Traffic Modeling</td>
<td>Muhammad Tayyab Asif <em>(Supervisor: Prof Justin Dauwels)</em></td>
<td>PG</td>
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<tr>
<td>5</td>
<td>Compressed Traffic Prediction in Large Urban Networks</td>
<td>Nikola Mitrovic <em>(Supervisor: Prof Justin Dauwels)</em></td>
<td>PG</td>
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<td>6</td>
<td>Simulation of Logistics Operation in Distribution Centers</td>
<td>Chung Keng Yang and Sim Hong Xun <em>(Supervisor: Prof Justin Dauwels)</em></td>
<td>UG, UG</td>
</tr>
<tr>
<td>7</td>
<td>Analysis of Smart Card data</td>
<td>Brenda Yeam Peiting and Wang Liqiong <em>(Supervisor: Prof Justin Dauwels)</em></td>
<td>UG, PG</td>
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<tr>
<td>8</td>
<td>Fusion of Flow and Speed Data</td>
<td>Foo Her Yiow <em>(Supervisor: Prof Justin Dauwels)</em></td>
<td>UG</td>
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<tr>
<td>9</td>
<td>Dynamic Routing</td>
<td>Bowen Mao, Foo Her Yiow and Christian Gunjan Rajeshkumar <em>(Supervisor: Prof Justin Dauwels)</em></td>
<td>UG, UG, PG</td>
</tr>
<tr>
<td>10</td>
<td>Traffic App Development</td>
<td>Muhammad Taha <em>(Supervisor: Prof Justin Dauwels)</em></td>
<td>PG</td>
</tr>
<tr>
<td>11</td>
<td>Traffic App Development for Dynamic Routing</td>
<td>Aditya Narayanan <em>(Supervisor: Prof Justin Dauwels)</em></td>
<td>PG</td>
</tr>
<tr>
<td>12</td>
<td>Effect of Accidents on Traffic</td>
<td>Lee Kelvin, Saha Liza, Khurana Dhriti and Xu Hengjie <em>(Supervisor: Prof Justin Dauwels)</em></td>
<td>UG, PG, PG, UG</td>
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<tr>
<td>No.</td>
<td>Project Title</td>
<td>Authors</td>
<td>Students Level</td>
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<td>13</td>
<td>Use Rainfall Data to Improve Traffic Prediction</td>
<td>Ho Yao Tong Victor and Kumar Swapnil (Supervisor: Prof Justin Dauwels)</td>
<td>UG, UG</td>
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<td>14</td>
<td>Effect of Rainfall on Traffic Conditions</td>
<td>Xiao Li, Zhao Zinian and Leong Wai Leong (Supervisor: Prof Justin Dauwels)</td>
<td>PG, UG, UG</td>
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<tr>
<td>15</td>
<td>Integrated Simulator for V2X Operations</td>
<td>Ong Min Lwin and Selwyn Chan Yao Feng (Supervisor: Prof Justin Dauwels)</td>
<td>UG, UG</td>
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<td>16</td>
<td>Car-to-Car Communications Test-bed and Experiment</td>
<td>Li Yude (Supervisor: Prof Chong Han Joo Peter)</td>
<td>UG</td>
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<td>17</td>
<td>Broadcasting Data for C2C Communications</td>
<td>Lim Yong Hao (Supervisor: Prof Chong Han Joo Peter)</td>
<td>UG</td>
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<td>18</td>
<td>Internet Access for Vehicles using V2I Platform</td>
<td>Lee Chek Kee (Supervisor: Prof Tay Wee Peng)</td>
<td>UG</td>
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<td>19</td>
<td>Development of Distributed Localization Algorithm for Mobile Vehicles</td>
<td>Aaron Mong Feng Cheng (Supervisor: Prof. Tay Wee Peng)</td>
<td>UG</td>
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<tr>
<td>20</td>
<td>Development of Vehicle Map and Safety Application</td>
<td>Kee Jing Yi (Supervisor: Prof Guan Yong Liang)</td>
<td>UG</td>
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<td>21</td>
<td>Applying MIMO Coding to V2X Communications, Performance Analysis</td>
<td>Dayana Bte Jamaludin (Supervisor: Prof Guan Yong Liang)</td>
<td>UG</td>
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<td>22</td>
<td>Design and Development of a Low Profile Antenna for Dedicated Short-Range Communications</td>
<td>Wang Shenya (Supervisor: Prof Lu Yilong)</td>
<td>UG</td>
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<td>23</td>
<td>Multi-Band Antennas for ITS Applications</td>
<td>Fan Yunfei (Supervisor: Prof Lu Yilong)</td>
<td>UG</td>
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<tr>
<td>24</td>
<td>Study and Design of MIMO Antennas for ITS Applications</td>
<td>Yang Fengyuan (Supervisor: Prof Lu Yilong)</td>
<td>UG</td>
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