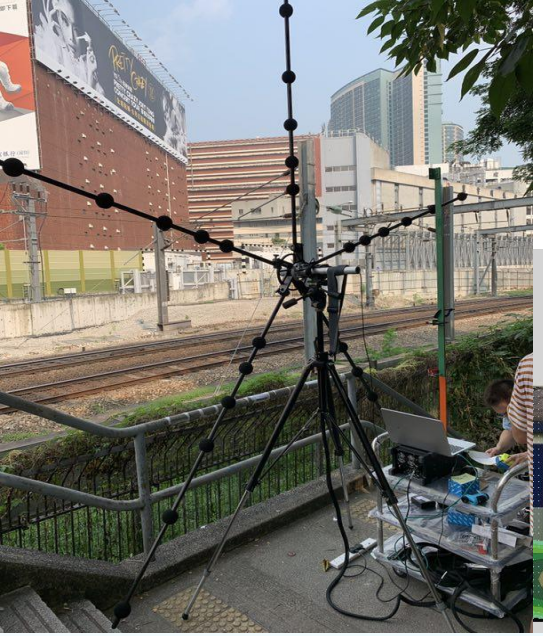

Noise & Safety Laboratory

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THE HONG KONG POLYTECHNIC UNIVERSITY
香港理工大學

DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING
土木及環境工程學系

Opening Minds • Shaping the Future
啟迪思維 • 成就未來

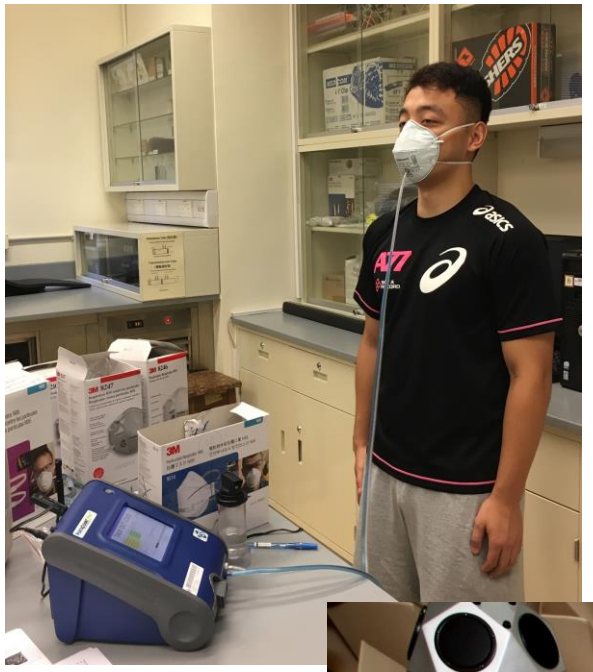
Introduction

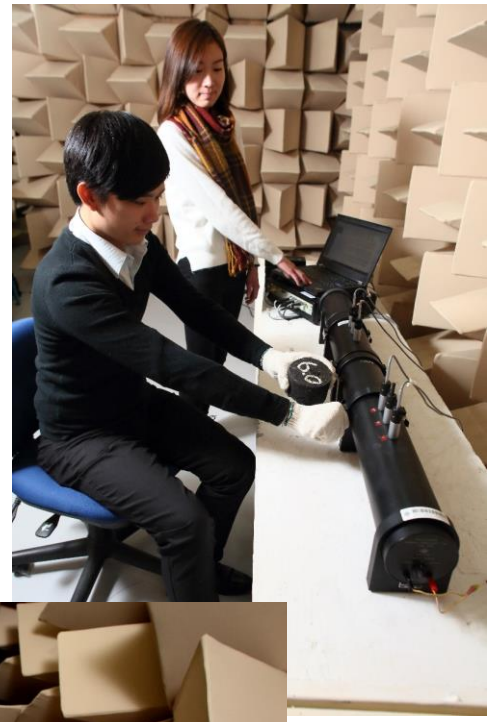
Noise & Safety Laboratory has a set of facilities of different disciplines for teaching and research purposes.

Students and researchers can carry out studies on the impacts of noise and vibration to the wellbeing of the community as well as assessments on the sound quality and performance of construction materials.

The laboratory is also well equipped for studying the habits and the attitudes of pedestrians and drivers for safer road design.

In addition, the laboratory has a collection of equipment to investigate occupational safety & health for the construction industry.





Major Equipment

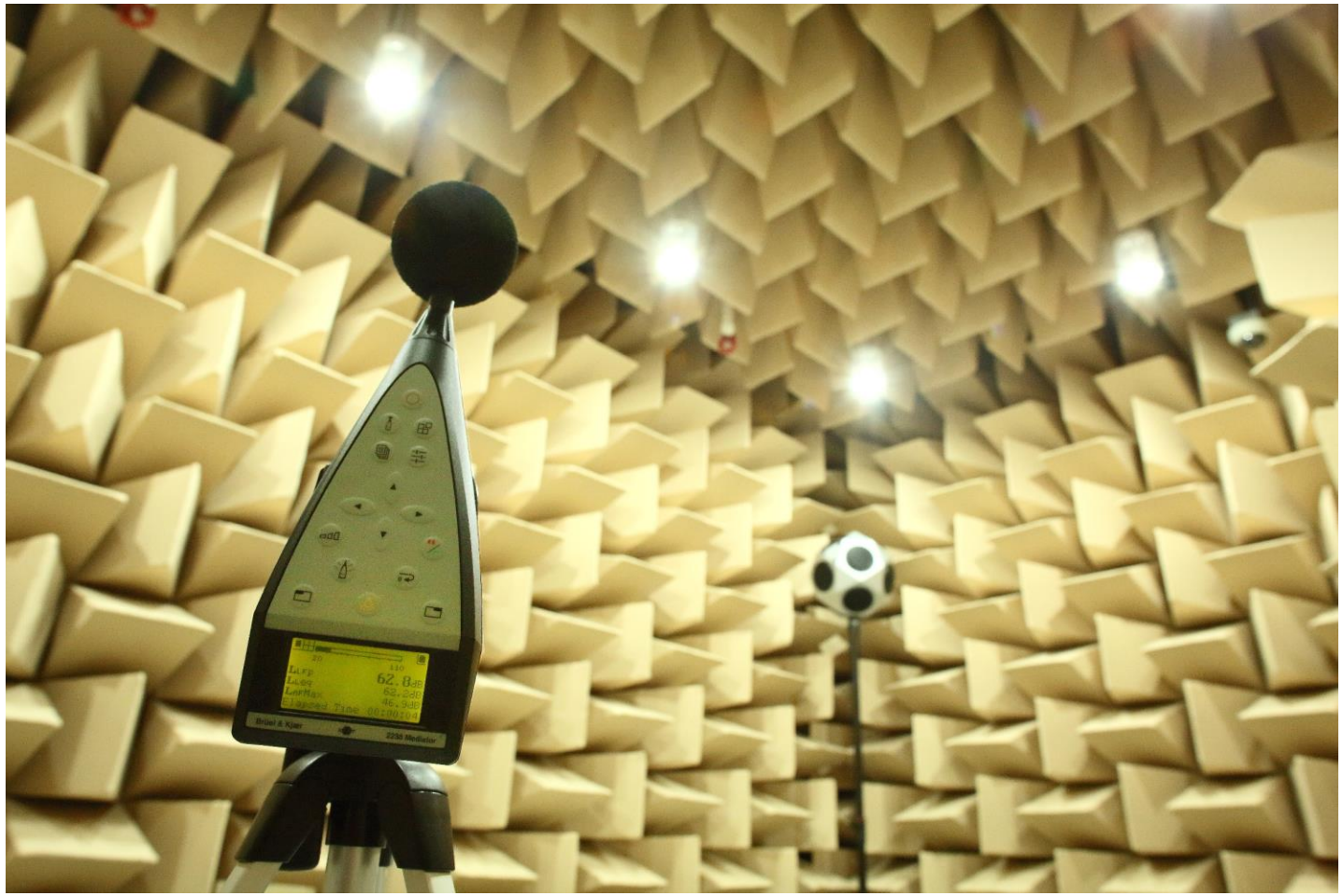
Semi-anechoic Chamber

The semi-anechoic chamber was constructed with a solid floating floor which can withstand heavy construction specimens and equipment.

The chamber has a working area of 3.3m W x 4.35m L x 3.0m H. The background noise level of the Chamber complies with NC16 (with air conditioning equipment in operation).

As there are no reflections from the walls and the ceiling, it is ideal for virtual acoustic experiments with mimics of noise sources from highways, city streets, countryside and other microenvironments.

Since the chamber is extremely quiet, it can also be used to test the noise reduction performance of construction materials and certify the sound power of products.



Major Equipment

Transmission Loss & Impedance Tube Kits

The system is for comparing and verify the performance of noise-control construction materials, e.g. pavement material, concrete, partition wall materials, etc. before they are manufactured into components.

The system is composed of a series of impedance tubes fulfilling international standards, ISO 10534 - 2, ASTM E1050 – 12, and transmission loss ASTM E2611 – 09, for measuring the sound transmission loss and the absorption coefficient of materials.

These kits consist of precision testing tubes that are equipped with microphones and sound sources. Material samples are inserted into the tube. A loudspeaker in the tube then emits precisely quantified sound, and the microphones measure the sound pressure level at specific locations along the length of the tube.

Absorption Impedance Tube

Transmission Loss Tube

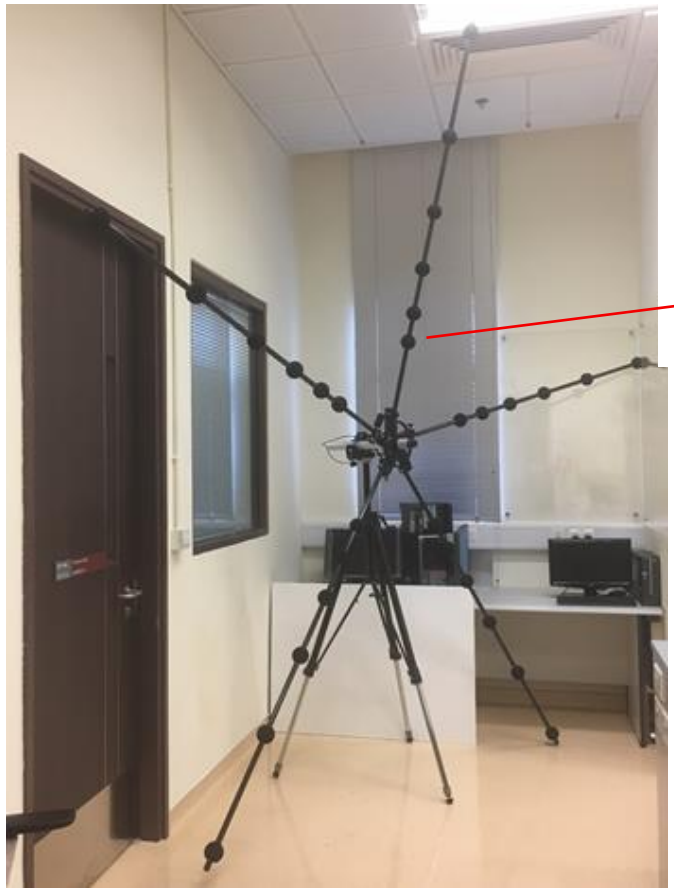
Major Equipment

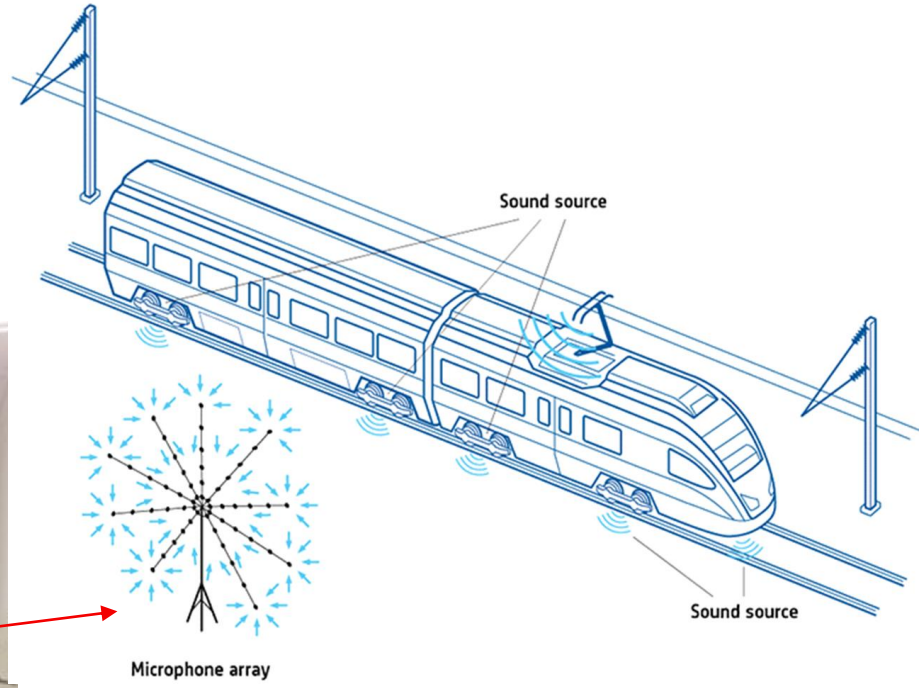
Beamforming System with Acoustical Array and its Accessories for the Noise Source Mapping of Moving Source

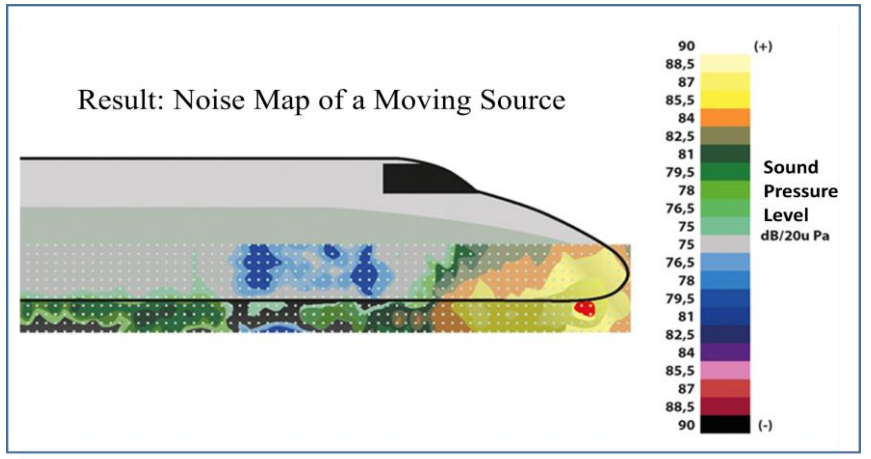
Beamforming system is a signal processing technique used in sensor arrays for directional signal transmission or reception.

The system is applicable for localization of noise sources on moving transportation vehicles, e.g., High-speed trains, MTR trains.

Noise source identification by differentiating sound levels is based on positions, vehicle speeds, frequency contents and sound power radiation using array-based microphones.







Major Equipment

Driving Safety Simulator - OKTAL CDS-650

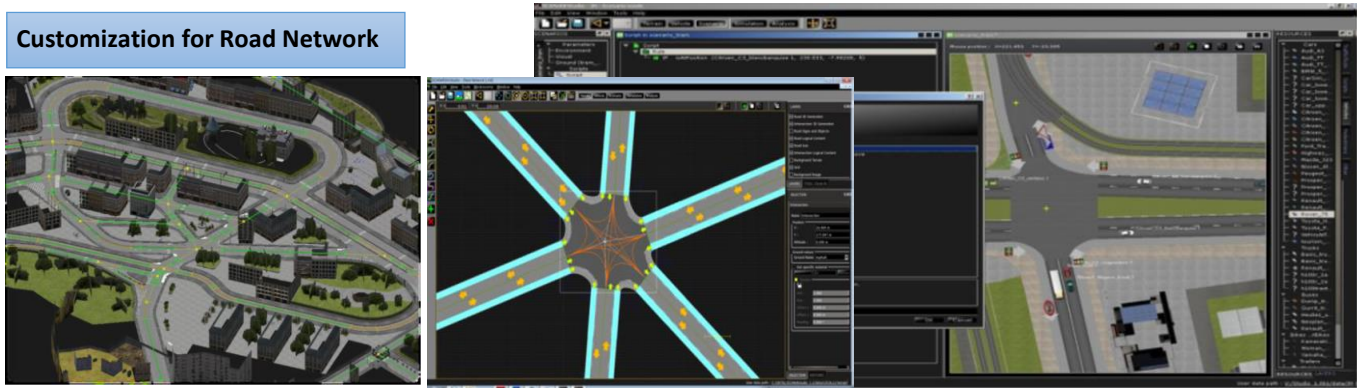
The compact driving simulator and driving simulation package is installed for safety research. Drivers' safety as well as comfort are related to the human factor and the driving environment. The simulator can model different driving scenarios for studying the responses of various high risk groups of drivers.

Driving Scenarios

Environmental Conditions

Road Types

Customization for Road Network

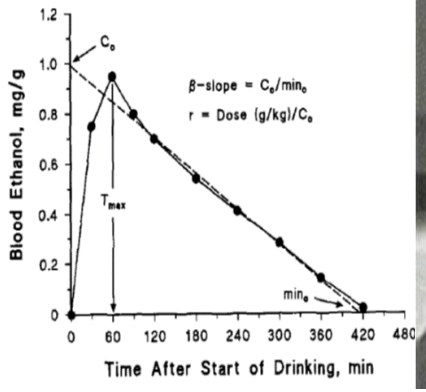


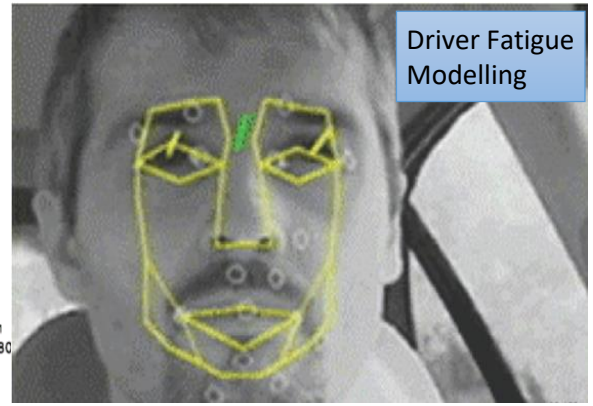
Application

Influence of Alcohol

Temporal Profile of Blood Alcohol Concentration by Widmark's equation

Ref: Andreasson, R., Jones, A.W., 1995. Erik M.P. Widmark (1889–1945): Swedish pioneer in forensic alcohol toxicology. Forensic Sci Int. 72, 1–14.





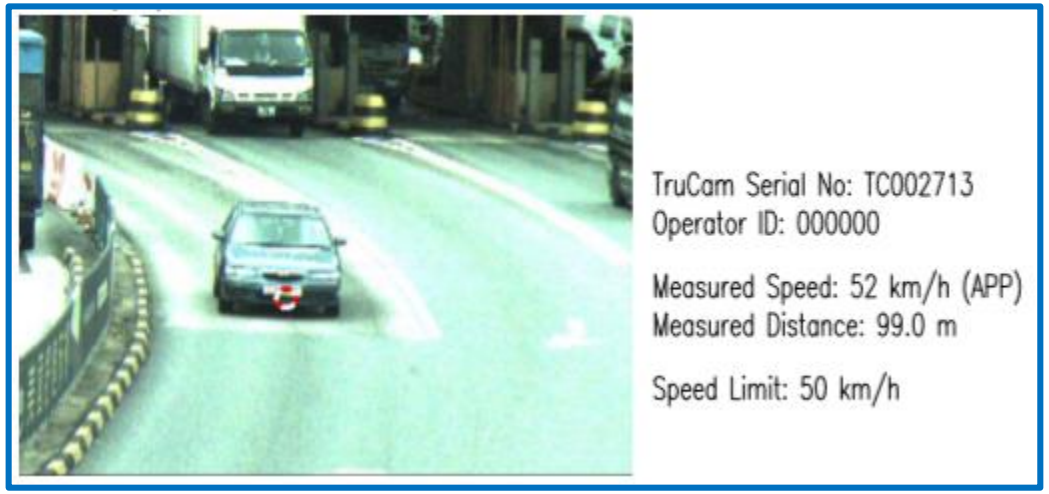
Major Equipment

Laser Speed Gun - LTI 20/20 TruSpeed

The laser speed measurement device has pinpoint targeting for distinguishing the speed and direction of a single vehicle in multi-lane traffic which is a major advantage over radar technology.

Laser Speed Gun with Video - LTI 20/20 TruCAM

The equipment collects and stores a complete chain of video evidence for both speeding and tailgating violations, along with a high-resolution image. The data it produces can be fed into any Geographic Information System (GIS) framework for providing historical data to determine why, where, when and how to deploy valuable human and capital assets in the future.



Major Equipment

Static and Dynamic Coefficient of Friction Measuring Meters

An analysis of over 225,000 food and beverage industry worker insurance compensation claims, revealed that slip/fall accidents accounted for over 40% of dollar claims paid out.

The set of friction meters provides data about safety levels and ongoing maintenance through simple tests of static coefficient of friction (SCOF) and dynamic coefficient of friction (DCOF) of floors and walkways. Keeping records of COF monitoring and enhancments can be useful in defense of negligence litigation.

Major Equipment

Portable Ambient Air Analyzer- GASMET DX4040

The analyzer is a compact unit made up of Fourier transform infrared (FTIR) spectrometer, rhodiumgold coated sample cell, built-in sample gas pump and signal processing electronics. And it is designed for on-site simultaneously measurements of 25 different gases (organic & inorganic) at low concentrations in ambient air. Typical usage areas include industrial hygiene and emergency response situations.

Respiratory Fit Tester - TSI 8038

The tester quantitatively measures the fit of a respirator while the user simultaneously performs a series of moving, breathing and talking exercises, which is designed to simulate the same movements made in the working field. With the real-time test results, the user's technique of donning and wearing a facepiece can also be enhanced.

Major Equipment

Screening Audiometer - GSI 39

Screening audiometer is for assessing the type and degree of hearing loss. During the test, subjects put on the headset. The operator controls the selection of frequencies and intensities of noise signal. Each ear's hearing threshold values per frequency tested will be identified. Test results are displayed as an audiogram.

Thermal Environmental Monitor - Questemp 34

The equipment utilizes traditional wet bulb sensing technology for heat stress assessment. The meter measures environmental factors (e.g. humidity, wind, temperature and radiant heat), and helps to determine whether there is a heat hazard present in an indoor or outdoor workplace.

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Research Spotlight

Build a Connection between Rail Corrugation & Railway Noise
for
"Enhancing Safety, Punctuality & Ride Comfort of Railway Transportation"

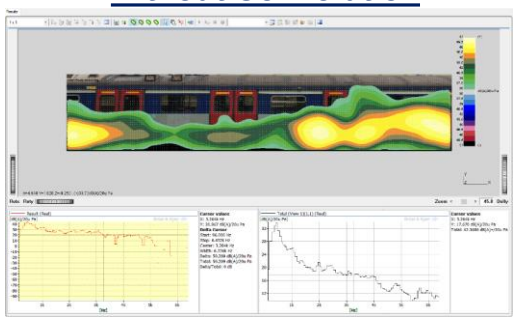
Introduction

Rail surface conditions play a major role in **railway noise**. It is essential to evaluate the relation between corrugation (a type of track wear that develops from track and train wheel set contact over time) and noise level.

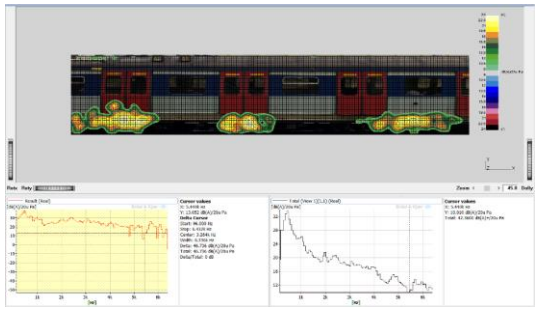
Different from any other measurement techniques based on single microphone, the **beamforming system** with 30 microphones as a pentangular array is used for separating noise sources, and then provides a straightforward virtual distribution of sound pressure level and sound power in both spatial field and frequency domain. It thus can easily be applied to **differentiate the wheel-rail noise** from any other noise sources, so that the reversely assessment on rail corrugation by noise can be achieved.

The assessment can also be applied to **determine a proper time instant** for necessary **rail grinding.** Based on the test and analysis, the connection between corrugation and wheel-rail noise, including rolling noise and squeal noise, can be further investigated for improving the design of railway and train to enhance the **safety &** the **ride comfort** of railway transportation.

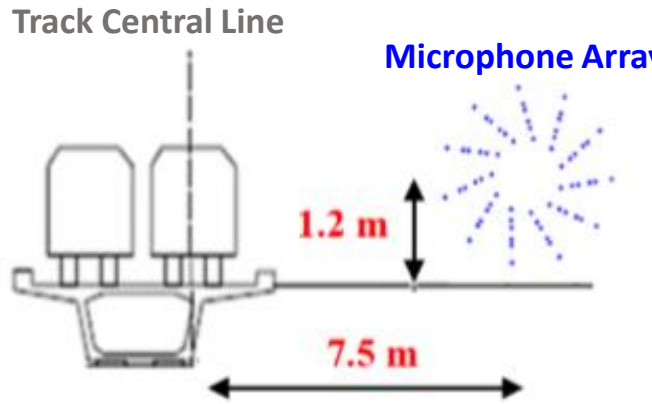
Result without Convolution



Result with Convolution



- Railway noise
- Beamforming measurement
- Differentiating wheel-rail noise from other sources
- Determination of rail grinding
- Investigation on corrugation & wheel-rail noise
- Improvement on the design of railway & train
- Enhancement of SAFETY & RIDE COMFORT



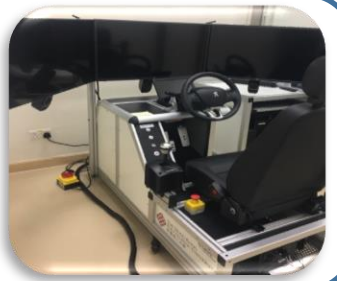
Department of Civil and Environmental Engineering
土木及環境工程學系

Research Spotlight

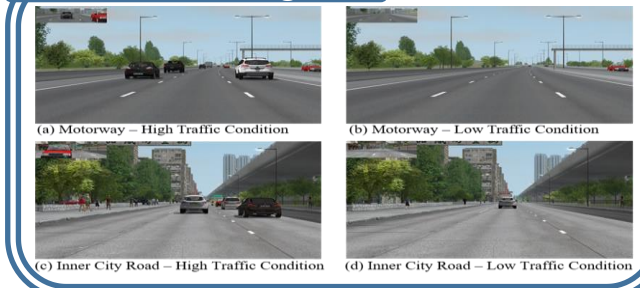
Factors Affecting The Driving Performance Of Professional Drivers: A Driving Simulator Study

Introduction

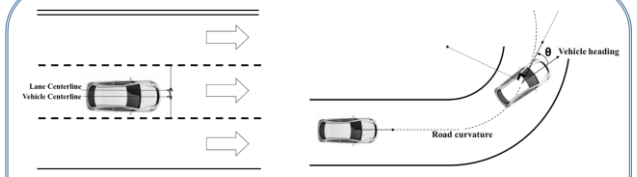
In Hong Kong, commercial vehicles constitute to about 20% of the total vehicle fleets while over 70% of crashes involve at least one commercial vehicle. It is essential to identify the factors contributing to the crashes involving professional drivers. Also, the proportion of elderly drivers who stay in transport sectors has been increasing because of the shortage of labour and aging population in Hong Kong. This study aims to evaluate the degradation of driving performance of professional drivers, after driving for prolonged period, using the driving simulator approach.



Scenario Design



Performance Indicators



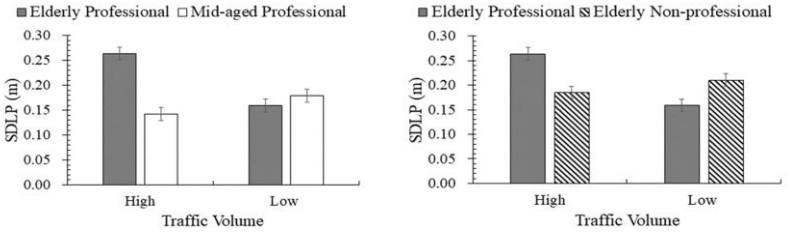
Lateral position: the perpendicular distance between the centerlines of the traffic lane and vehicle

Heading error (HE): the angular deviation in the tangents between the road curve and vehicle trajectory

Results: Between-Subjects Effects

Variable	d.f.	F-Statistics	p-level
Main Effect			
Road Type	1	2394.63**	<0.001
Traffic Flow Condition	1	7.65**	<0.01
Driver Type	1	76.64**	<0.001
Age	1	18.92**	<0.001
Interaction Effect			
Traffic Flow Condition x Age	1	27.10**	<0.001
Road Type x Driver Type x Age	1	16.21**	<0.001
Road Type x Traffic Flow Condition x Driver Type x Age	1	7.71**	<0.01

** *Statistically significant at the 1% level*



(a) Elderly Versus Mid-aged Professional Drivers

(b) Professional Versus Non-professional Elderly Drivers

Results: Within-Subjects Effects

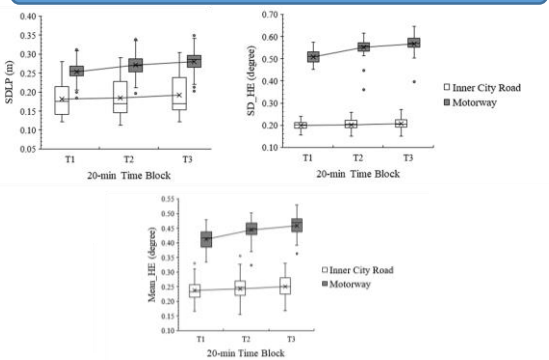


Fig 1.Variations in SDLP , Mean_HE and SD_HE Between Time Blocks

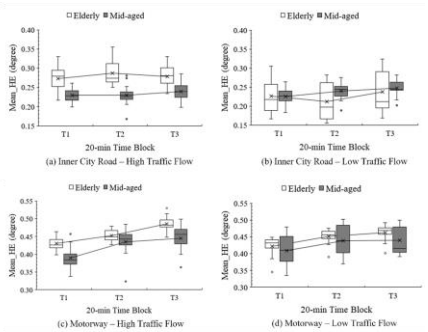
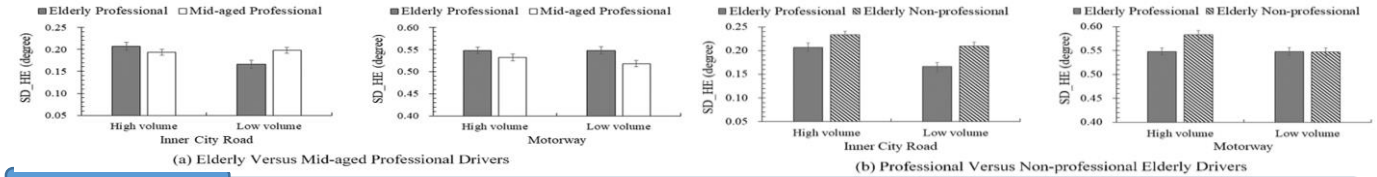


Fig 2. Variations in MeanHE over Time of Mid-aged and Elderly Drivers under Different Road Environments



(a) Elderly Versus Mid-aged Professional Drivers

(b) Professional Versus Non-professional Elderly Drivers

Highlights

1. Driving performance of professional driver was assessed using driving simulator approach
2. Effects of driving time, driver type, age, road type and traffic condition on the lateral position and steering control were examined
3. Degradation of driving performance over time of driving was prevalence on the motorway
4. Driving performance of elderly professional driver was superior to the counterpart on the inner city road under low traffic condition

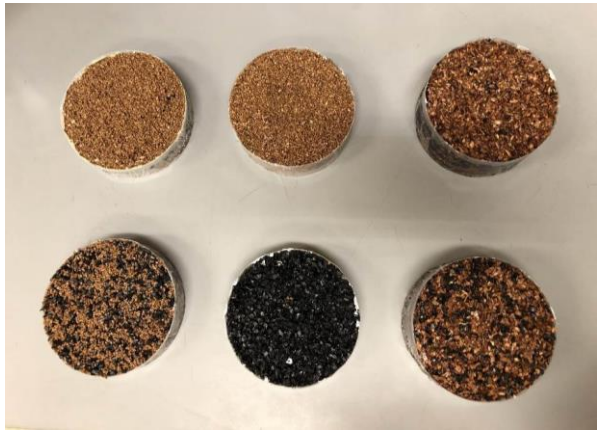
Research Spotlight

Smart Noise Barriers/ Enclosures for Dual Active & Passive Control of Construction Noise

Objective

Investigate a new hybrid noise barrier to control construction noise (dual passive & active control)

1) **Passive part:**
Recycled composite materials for sustainable consideration & sound insulation (wood wastes and rubbers)

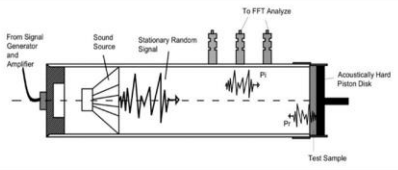


Sample testing apparatus

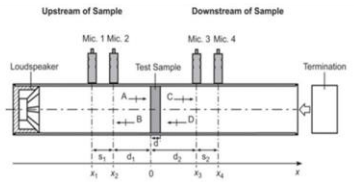
Passive investigation procedures

Sample fabrication using wood and rubber materials → ***Acoustic properties test Apparatus: Impedance tube (transmission loss and absorption coefficient)*** → ***Data analysis for various parameters*** → ***Design guideline for obtaining the efficient sound insulation performance***

Absorption coefficient testing:



Transmission loss testing:



Consideration factors:

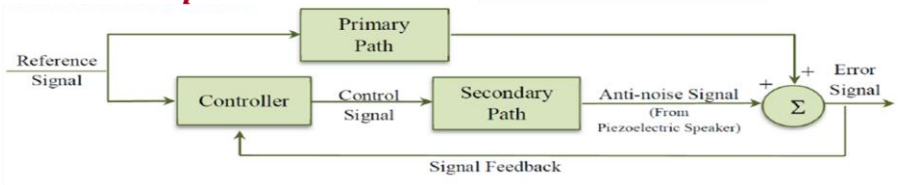
1. ***Weight ratio of wood and rubber***
2. ***Thickness of samples***
3. ***Wood particles size***
4. ***Epoxy resin usage***

Testing parameters:

1. ***Transmission loss***
2. ***Absorption coefficient***

2) **Passive part:**
Implementation of control algorithms and smart material

Constituent part



Adaptive feed-forward control mechanism

Basic control algorithm:

- ***The kernel of the signal process is utilized a control algorithm for "anti-noise" generation.***
- ***Relying on the adaptive process, the secondary signal will be kept updating with the correlation of error signals.***

Estimation of transfer function coefficients

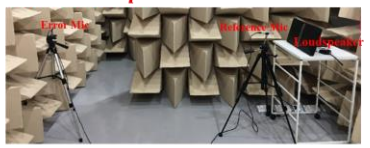
Primary path:

- ***The path between a reference microphone to an error microphone***
- ***The noise propagation medium is chiefly in air***
- ***Linear time invariant system (LTI) to simulate and demonstrate the path***
- ***Estimation transfer function to describe the real state of transfer path using adaptive FIR filter.***

Secondary path:

- ***Adaptive algorithms: (i) finite impulse response (FIR) filter, (ii) infinite impulse response (IIR) filter, and (iii) online estimation system to approximate the real transfer function.***

Experimental setup:



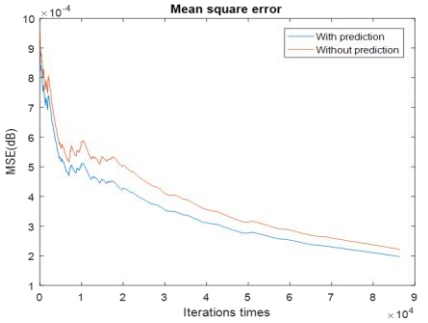
Primary path impulse response estimation

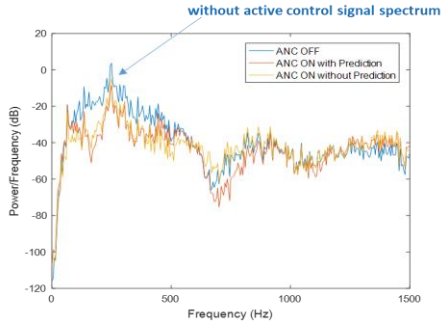
Experimental setup:

Secondary path impulse response estimation

Case study: convergence performance

- ***Mean square error & frequency spectrum performance***





Acknowledgement
The work described was supported by the Environment and Conservation Fund of HKSAR
(Project Title: Smart Noise Barriers/Enclosures for Dual Active and Passive Control of Construction Noise (Project No.: ECF Project 83/2017)).

Research Spotlight

Disaggregated and Aggregated Levels Factors Affecting the Red Light Running Behavior of Pedestrian

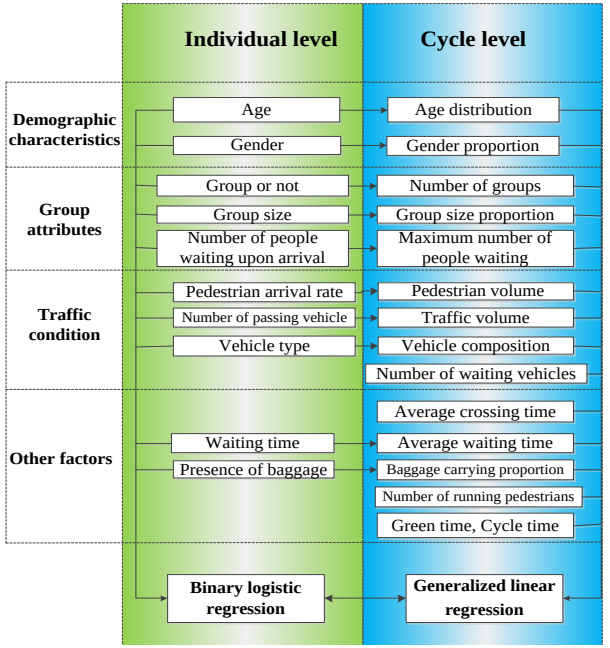
■Pedestrian safety

◆Pedestrian safety is of **great concern.** **Pedestrian fatality** rate in Hong Kong is much higher than that in the United States and most Western countries (**Loo et al., 2007; NHTSA, 2012**). On average, there are **3600 pedestrian injuries (**60 are fatal and 800 are severely injured) every year.

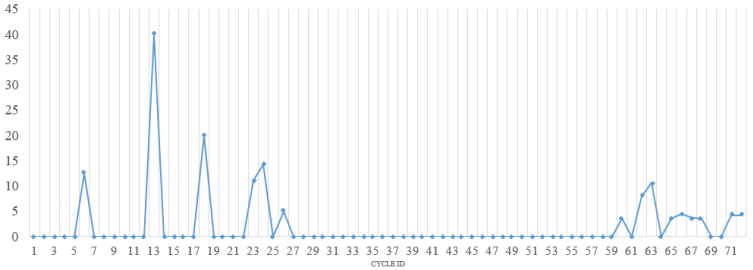
■Observation survey

No.	Location	Number of traffic lane	Crosswalk width (m)	Average traffic volume (/lane/hour)	Average pedestrian volume (/m/hour)
1	Prince Edward Road West j/w Nathan Road	4	5.5	275	410
2	Argyle Street j/w Nathan Road	4	6.5	310	362
3	Argyle Street j/w Sai Yee Street	2	4	219	217
4	Tonkin Street j/w Shun Ning Road	4	5.5	165	234
5	Hung Hom South Road j/w Po loi Street	2	4	105	154
6	To Kwa Wan Road j/w Chi Kiang Street	2	4	125	258

■Methodology



■ Results



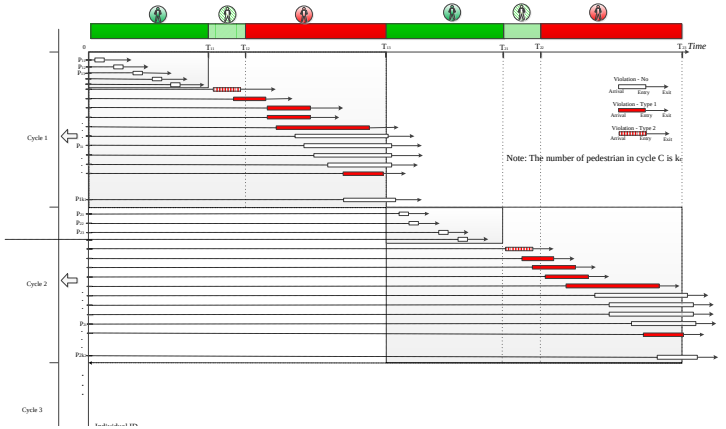
Violation rate of each cycle

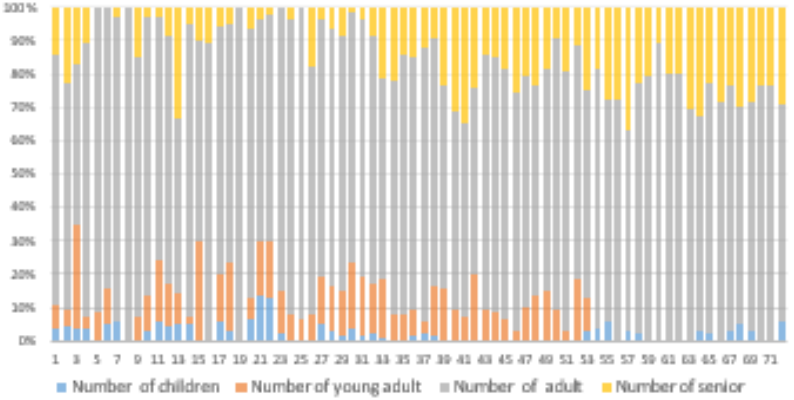
Framework:

◆ A two-level framework was proposed.

◆ **Level 1 - Binary logit regression** for the estimation of propensity of red light violation of individuals.

◆ **Level 2 - Generalized linear regression** for the estimation of red light violation rate of each cycle.





Age distribution of observed pedestrians

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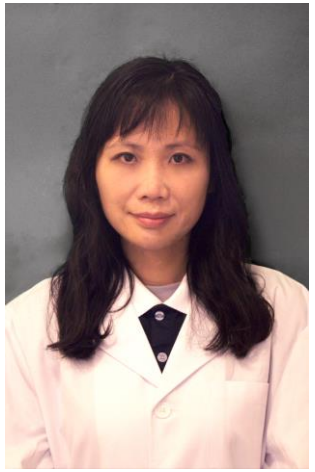

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YouTube Channel: Noise & Safety Lab

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Address: Room ZN1106, The Hong Kong Polytechnic University

Opening Hours: Monday to Friday 08:50 – 17:40
(excluding 1hr Lunchtime & Public Holidays)