THE EDUCATION UNIVERSITY OF HONG KONG

FACULTY OF LIBERAL ARTS AND SOCIAL SCIENCES

Impact Case Study Prize
for the Dean's Research Fund 2020-21

Brief Introduction of Awardee's
Impact Case Study and Future Research/KT Development

Awardee (Dept):	Dr Ling Man Ho, Associate Professor (MIT)
Impact Case Study:	Advanced statistical models in data analysis for reliability and safety assessment

A. Briefly introduce your impact case study for which you have received the prize.

Many products are designed to function for a long period of time, presenting a challenge for experiments that can accurately demonstrate their life characteristics. Inaccurate lifetime predictions present significant risks to safety, as well as economic losses from inaccurate maintenance and replacement scheduling. Engineers have sought to overcome this challenge by using accelerated life-tests that shorten products' lives or hasten the degradation of product performance by incorporating stress factors. The research team applied reliability models and statistical methods to the improvement of such predictions, by extrapolating data from accelerated life-tests already conducted; making statistical inference on the life characteristics of products; and developing time- and cost-effective accelerated life-tests for data collection. In addition, this research has had impact on research practice. A book in relation to methods and analysis of one-shot device test data from accelerated life-tests has been released in 2021.

In 2014, accelerated degradation models that incorporate various levels of electrical current were considered to model light intensity of LEDs. Subsequently, a two-phase degradation model was developed to model system performance that incorporated physical and chemical changes and provided a more accurate prediction of the failure time of the LED based on its current light intensity. This information based on current system performance could be invaluable for maintenance policies to reduce maintenance cost, while maintaining a high level of product usage availability.

This research has had significant impact in reliability engineering, with associated economic and safety benefits. It has had practical use for subsequent applied engineering research and practice. The unique contributions resulted in joining a collaborative Theme-Based Research project, *Safety, Reliability, and Disruption Management of High Speed Rail and Metro Systems*, in 2016. This project, which aims to support Hong Kong's development by establishing it as a centre of expertise in the safety, reliability, and efficient management of complex networking systems, is using the models in on-going applied research to more accurately predict the failure of ball bearings of Mass Transit Railway Corporation (MTR) trains, working with MTR engineers.

B. How you used/will use your prize and perhaps its usefulness to your research / KT development?

Inferential methods for one-shot devices with multiple components, when the components function independently, have been developed. However, components are often coupled together in the manufacturing process, assembly, and function, resulting in correlated failure modes. Applying a statistical model with an independence assumption to data with dependence structures can severely bias the reliability estimate, and yield unreliable results and imprecise failure prediction, which can cause poor safety and even deaths. In this regard, several models that efficiently capture the dependence among components will be investigated. As the collected data contain more information and the models are generally complicated, it will bring a new opportunity and a big challenge in statistical computational methods.

C. Expected research/KT outcomes/outputs/impacts arising from this prize.

Some novel methods that provide more accurate reliability estimation will be developed. Also, new accelerated life-test experimental designs that efficiently collect data for reliability estimation will be investigated. The new methods and designs will be presented to MTR for considerations and advice from practical points of view.