5G and MIMO Radar Virtual Driving and Simulation for Mass Transit

Challenge Launch Date	October 7, 2019
Challenge Deadline	November 4, 2019
Challenge Statement	5G technology has the potential to solve key challenges faced by transit operators in helping them to run their systems safely and efficiently. While many recognize this as an opportunity there is limited data on the capabilities and performance of 5G for this application. Thales Canada is interested in working with an Ontario based academic institution to develop a series of models and simulations to better understand the operation of 5G for mass transit systems.
Project Partner	Thales Canada Inc.
Timeline	1 Year
Available funding	$75,000
Applicant Type	Ontario based Academic Institution
Location	Work can be completed remotely at the academic institution in Ontario with scheduled online meetings and face-to-face workshops. Demonstration and testing will be scheduled and performed in different phase of project according to plan that will be established between the applicant and Thales
Project Details	The efficiency of public transportation systems has a direct impact on the economies of cities. Public transportation also serves a larger public interest, delivering numerous benefits to society, one being lower carbon emissions which improves and promotes a healthier urban space. One of the cornerstones of success for the development of smart cities will be solutions for mass transit systems. Thales is connected to mass transit operators who face the following challenges: • continuous demand in traffic growth , both in terms of passenger flow and the number of and frequency of mass transit vehicles • the critical need to ensure passenger safety and security

	• demand for better and more intelligent remote management and monitoring that would result in further operational efficiency improvements through preventive maintenance solutions • strong demand for travel comfort improvement specifically providing passenger access to the internet **It is clear that one of the critical tools to meet the need of transit operators and build transportation systems for the smart cities of the future will be the selection and optimization of communication networks.** There are two main drivers behind the growing importance of communication services in mass transit: 1) Train Automation (ATO) 2) Passenger information and internet access LTE 4G/5G has already been identified as a major candidate for new generation Train to Ground (T2G) communication RAN (radio access network). The advanced features of 5G communication are extremely well positioned to serve future needs of ATO operation, however, there is little or not sufficient research and understanding in the railway community related to the following: 1) Channel propagation of 5G in typical railway underground environment 2) Effect of massive MIMO on the quality and range of communication. 3) Interaction of different bands of operation for 5G (mmWave, sub-6GHz and sub 1GHz) with other potential wireless communication devices, radar and sensor installations in a context of ATO operation. 4) Optimization of antenna types, antenna installations, polarization choices and spacing between antenna arrays. Thales URS wants to develop specific understanding of wireless propagation in the underground tunnel environment for all major bands of operation of future 5G in conjunction with the automotive radar application on the train for future ATO operation. Thales is interested in using an Altair Feko simulator and potentially enhance the results of this initial simulation with further processing that could be done in Matlab or other customized post processing tools to be developed in a language of choice. Major project tasks will be focused on :

	- The Development of a model for antenna arrays that could be used on the train for 5G mmWave, sub 6GHz and sub 1GHz operation. - The Development of a model of the antenna arrays that could be used for automotive radar operation on the train - The Development of an electromagnetic model of the train vehicle - The Development of an electromagnetic model of the 3 different tunnel profiles typically encountered in urban railway operations - Develop and perform electromagnetic wave simulation of the environment surrounding a 5G transmitters and receivers and MIMO radar operating at 77 GHz using Altair Feko - Modeling of the geometry of the surrounding environment that shall be defined through its material parameters. The geometry definition can include: ground properties, tracks, foliage, well-defined or statistically defined features including roughness of the ground surface and the embedded obstacles. - Simulation scenarios of choice would be potentially subjected to measurement and validation in realistic railway environments. - Analysis and potential shortcomings of commercial tools shall be evaluated. Possibility for enhancement of achieved results shall be identified by applying custom post-processing of Altair Feko results The simulations and post-processing tools should be capable to handling scenarios including, but not limited to, the following: 1. A radar mounted on a train over straight track with plane ground and/ or a single rough surface, in order to find reflections from rail tracks and the ground for tunable train speed. 2. The same as scenario (1), with parallel rail tracks on the left and right hand side with the possibility of adding moving trains to each side, with tunable speed. 3. The same scenario as (2) with applying curvature to rail tracks. There are two fundamental challenges in this project: 1. Limitations of conventional software packages: The wavelength for automotive radar at 77 GHz is 3.89 mm. 5G mmWave communication bands are 24-28Ghz, 37 to 40Ghz and 64-71GHz resulting in similar wavelength of 11mm, 6mm and 4mm. A typical constraint for the space discretization employed by electromagnetic solvers in that 10 grid points per wavelength need to be employed. With cubic cells of side length equal to .389 mm, even moderate size scenes produce very large computational domains of billions of cells. For example, a 5x5x2 domain results in 849.4 billion cells! As a result, the direct employment of existing

	commercial software packages or any single method by itself is not a viable solution. 2. Uncertainty of material parameters: Material characterization at mmWave frequencies is still an ongoing process. A recent survey of measurement data on the measured dielectric permittivity of typical construction materials in the millimeter-wave band has revealed large deviations between the reported values. As a result, a credible model has to account for the statistical uncertainty in the material parameters.
Project Goals/ Outcomes	Project goals will be to demonstrate through measurements, emulation and simulation following key performance objectives: 1. Optimum choice for antenna placements to maximize coverage and channel capacity 2. Optimum choice of antenna types 3. Possible interactions between 5G mmWave and radar sensors 4. Full interaction between the MIMO radar antennas and the environment, taking into account their radiation pattern. 5. Effects of the mounting surface and the radome on the operation of the antennas. 6. Capability to evaluate and optimize installation parameters such as tilt angle, height over ground, as well as beam-forming schemes and different wave polarizations. 7. Identify possible shortcomings of commercial tools and identify possible enhancements through custom post-processing tool developments to better match applications of 5G and radar technology in urban rail environment.
Applicant Capabilities	• 2 researchers (M.Sc. or Ph.D. level) • Strong background in wireless communications and 5G standards (Physical and MAC layer) • Strong background in antenna theory and simulation • Experienced in wireless channel modeling, statistical modelling, wireless channel emulation using COTS channel emulators
Additional Information	NA

Launched in 2018, the ENCQOR 5G Academic Technology Development Program partners Ontario based Researchers with ENCQOR 5G Anchor Firms on 5G technology development projects. Areas of research interest are defined by Challenge Statements submitted to OCE by the ENCQOR 5G Anchor Firms and posted to the OCE website on a rolling basis.

If you are interested in developing an expression of interest, please visit the program guidelines for information on next steps.

For any questions about new Challenge Statements or the ENCQOR 5G Academic Technology Development Program please contact Jennifer Moles at Jennifer.Moles@oce-ontario.org.