ENHANCING TRAFFIC & ROAD OPERATIONS USING ON-BOARD BUS CAMERAS

1 INTRODUCTION

The Land Transport Authority (LTA) spearheads land transport developments in Singapore. We plan, design, build and maintain Singapore's land transport infrastructure and systems. We aspire to strengthen Singapore's land transport connectivity and integrate a greener and more inclusive public transport system complemented by walk and cycle options. We harness technology to strengthen our rail and bus infrastructure and develop exciting options for future land transport. These are encapsulated under our Land Transport Masterplan 2040 (LTMP2040).

As we work towards achieving our goals under LTMP2040, we are often confronted with operational challenges driven by a dynamic operating environment. At the same time, we continue to strive towards better cost effectiveness, manpower optimisation, environmental sustainability, reliability and safer operations. These then present us with opportunities to work closely and co-create solutions to address the challenges and requirements with our ecosystem partners/innovators. LTA has launched this Call for Solutions for "Enhancing Traffic & Road Operations Using On-board Bus Cameras", and we invite interested partners/ innovators to collaborate with us.

2 PROBLEM STATEMENT

Current Bus Camera Systems

LTA has an estimated 6,000 buses operated by the Public Transport Operators (PTOs). The buses are installed with cameras that record video footage from multiple perspectives during bus service hours. The recorded videos are used to support investigation upon an incident occurrence and for the safety of passengers. They can be retrieved manually from the on-board recorder.

LTA aims to better utilise the existing bus camera platform to support new applications that can expand our detection capabilities and improve safety and operational response time. Through leveraging on existing systems, LTA could reap resource efficiencies while achieving a higher level of operational efficiency with enhanced safety. The new applications being considered are:

a. Detection of Traffic Violations and Illegal Parking Activities

Currently, LTA's enforcement efforts include the deployment of enforcement officers and mobile cameras at bus stops to detect traffic violations such as travelling in bus lanes during restricted hours. In addition, static and mobile cameras are also deployed at illegal parking hotspots to detect illegal parking activities. These detections methods are limited due to mobile camera resource and are labour-intensive, which limits enforcement presence and detection ability.

When an enforcement event is detected, the vehicle's colour, make/model, classification (e.g. heavy vehicle, bus, car, etc.) and the vehicle registration number will be recorded. A summary of the enforcement use cases are:

i. Bus lane enforcement – detection of vehicles travelling within the bus lane enforcement zone during restricted hours and record the distance or duration in which the vehicle has travelled; and
ii. Illegal parking – detection and determining the duration of a stationary vehicle within an illegal parking zone.
iii. Infringement of yellow boxes and bus priority boxes – detection of vehicles stopping in yellow boxes or failing to give way to buses at bus priority boxes.

b. Detection of Road Infrastructure Defects

LTA deploys vehicles at regular intervals to perform road inspections to scan for road defects. To achieve better cost effectiveness, LTA is keen to leverage on existing bus camera infrastructure to complement the regular road inspection schedules. A comprehensive list of these defects, including specific types and descriptions, is provided in the annex.

c. Detection of Bridge and Tunnel Defects

Manual structural inspection works are conducted at regular intervals for defects located on bridges and tunnels which can be labour-intensive. The defects of interest include:

i. Damaged movement joints of bridge structures
ii. Damaged / stained / scratches on parapets of bridge structures / vehicular underpasses
iii. Wild / rogue plant growth on bridge structures / vehicular underpasses
iv. Damaged / stained / scratches on cladding panels of road tunnels / vehicular underpasses

d. Detection of Road Work Non-Compliances (NCs)

Road work inspection is currently a manual and laborious process and provides limited coverage. These NCs include:

i. Unauthorised works resulting in obstruction of roads, i.e., work without permit and lane occupation during non-allowable work hours (traffic peak hours)
ii. Work area not properly cordoned off, i.e. insufficient cones, presence of gaps/ discontinuities between barricades

iii. Insufficient taper distance, i.e. insufficient traffic cones at transition area, insufficient transition zone distance depending on road speed limit
iv. Insufficient longitudinal safety buffer of at least 10m (for 40km/h speed limit roads) or more depending on road speed limit. Safety buffer is the distance between transition zone and activity zone and is the space that separates traffic from workspace.
v. Poor quality of interim road reinstatement that does not comply to LTA's requirements in terms of aesthetics:
   (1) Non-straight edges; and
   (2) Uneven surfaces.

e. Detection of Bus Stop Infrastructure Defects

Given the large number of bus stops island wide, regular inspection of these assets for defects is conducted manually and laborious, requiring a significant amount of time and resources. These defects include:

i. Damaged structure of bus stop
ii. Damaged seats
iii. Damaged bollards
iv. Damaged / stained / faded reflective sheetings on bollards
v. Damaged / stained / faded bus information panels
vi. Damaged / stained / faded bus stop signage
vii. Damaged / stained / faded yellow band on bus stop
viii. Functionality of lights

f. On-site Analysis of Bus Operations

On-site monitoring of bus operations is currently conducted manually (manual on-ground surveys at selected bus stops to gather additional data, which informs our assessment of service improvements) to pre-empt or detect Unable-To-Board (UTB) instances. It is labour-intensive, costly and may not be an efficient use of resources.

3 WHAT ARE WE LOOKING FOR?

LTA is seeking proposals that can cover **one or more** of the above use cases.

a. General requirements:

i. Explore the feasibility to use existing bus cameras for potential areas of road applications listed in Section 2;
ii. Encompass video analytics (VA)/artificial intelligence (AI) capability to be able to scan and automatically detect the use cases under Section 2;
iii. Propose new deployable camera and AI on buses with equivalent or wider FOVs if existing bus cameras are not adequate to perform the roles;
iv. Log the type of detection, capture an image for reference, geotag the location whenever detected, monitor the rectification status if it is a defect, and escalate alerts to LTA officers where necessary.

b. Use case specific requirements:

   i. Traffic Violations & Illegal Parking Activities:
      (1) Detect, classify, and identify vehicle licence plate that is violating bus lane, infringing yellow boxes or bus priority boxes, or parking illegally; and
      (2) Proposal should include plans on how the solution can differentiate between dotted bus lanes and solid bus lanes.

   ii. Detection of Road Infrastructure Defects:
      (1) Compute defect dimensions and evaluate the severity of each defect, where possible.

   iii. On-site analysis of Bus Operations
      (1) Detect and count pedestrians that are trying to cross at undesignated crossings; and
      (2) Detect areas with high pedestrian counts.

c. Alternative Solutions:
   LTA is also open to other alternative solutions such as:

   i. the use of the participant's existing infrastructure and fleet that can fulfil the required capabilities; or
   ii. the use of non-camera based systems.

Participants are required to specify in the Technical Proposal the type(s) of detection capabilities (from Section 2) and performance that can be achieved, whether the solutions can be integrated and to what extent. The proposal should also specify the end-to-end workflow of the proposed solution from frontend video retrieval to notifying LTA on the detection results within 24-48 hours, and the emulation of the bus (if need be) for the purpose of the POC. The proposed solution should have minimal impact to bus operations and maintenance, and with minimum involvement by bus captains during bus operations.

4 EVALUATION GUIDELINES

Submission of the Technical Proposal that covers one or more of the use cases mentioned in Section 2 and comprises the following content:

a. Technical solution that covers system design and architecture and addresses how the videos are optimally processed and analysed according to Section 3;
b. The use case(s) mentioned in Section 2 that can be addressed; and
c. Estimated cost of trial for implementation on two (2) buses.

The Technical Proposal will then be evaluated in the following ways:

a. Ability to fulfil baseline requirements and KPIs stated in the table below;
b. Feasibility and scalability of the proposed solution;

c. Innovative/efficient use of bus cameras and ability to integrate multiple VA/AI models from the use cases in Section 2;
d. Track record of deploying such solutions; and
e. Cost of trial implementation.

Assessment of expected accuracy for bus cameras trial will be based on the envisaged performance shown in the table below:

S/No	Potential Use Case	Envisaged Accuracy Requirement
i.	Illegal parking	• ≥ 85% true positive • ≤ 5% false negative
ii.	Bus lane enforcement	• ≥ 85% true positive • ≤ 5% false negative
iii.	Road infrastructure defect detection	• ≥ 85% true positive • ≤ 5% false negative
iv.	Bridge structure, road tunnels & underpass defects detection	• ≥ 85% true positive • ≤ 5% false negative
v.	Roadwork and road regulation non-compliances	• ≥ 80% true positive • ≤ 5% false negative
vi.	Bus stop infrastructure defects detection	• ≥ 85% true positive • ≤ 5% false negative
vii.	On-site Analysis of Bus Operations	• ≥ 85% true positive • ≤ 5% false negative

Vendors are highly encouraged to submit the results of their solution (using the sample data provided by LTA) to support the evaluation of the submitted proposals. Shortlisted proposals will be invited for a live demonstration of the proposed solution using the same set of sample data. This will be done in physical sessions and will be arranged by LTA separately after the close of the Call for Solutions.

LTA will assess the merits of these proposals and selected participant(s) will be invited to conduct a further Proof-Of-Concept (POC) to evaluate the possibility of implementation based on the proposed solutions.

If a POC is to be conducted, it is estimated to last for 4 months, with the proposed solution to be on actual trial for a period of 2 months. It could either be conducted live using operational buses or using recorded bus camera footages that cover designated travel routes twice a week. The schedule for each day will be as follows:

- Day time – Peak & Non-Peak (1 hour each)

- Night time – Peak & Non-Peak (1 hour each)

The selected participant(s) shall submit their plan(s) with cost to conduct the POC (including any equipment/installations proposed on the bus, subjected to the LTA's approval). All installations proposed must be able to be removed after the trial with no damage or modifications to the original bus infrastructure, aesthetics and/or systems. If the POC is successful, LTA may consider expanding the implementation of the developed solution on more buses and/or bus routes.

5 TECHNICAL BRIEFING

LTA will hold a briefing to provide more information on the problem statement on **24 Oct 2024** at the **Land Transport Authority (LTA) – Bedok Campus Office (71 Chai Chee Street, Singapore 468981), Auditorium.** Each organisation/team may send a maximum of 2 representatives to the briefing. If you are interested to attend the briefing, please register here by **21 Oct 2024, 4pm.**

Participants can collect a total of six (6) video recordings of approximately 5 minutes each (total file size of 1GB) after the briefing. The recordings consist of a typical bus camera view facing the road, for participants to understand the expected camera view and try out their solution on these sample feeds to address the requirements under Section 3.

As a prerequisite to receive the footage, participants must submit a **signed softcopy** of the Non-Disclosure Agreement (NDA) provided on the Land Transport Innovation Portal, via the briefing registration form. Each participating organisation/team is to submit one NDA. Please note that to ensure consistency across all participating organisations, LTA will not be accepting any edits to the NDA clauses.

Participants must bring a laptop (note: USB storage devices will not be accepted) with sufficient storage space to the briefing to receive the sample video footages.

6 SUBMISSION DEADLINE

All proposals must be submitted by **21 Nov 2024, 1600 hours** (SGT/GMT+8) via this submission form.

We encourage interested parties to visit the Land Transport Innovation Portal for the latest updates.

7 GUIDELINES FOR PARTICIPATION

The purpose of this brief is to provide preliminary information on the problem statement on enhancing traffic & road operations using on-board bus cameras. Please note that the information provided does not form part of any subsequent contract.

To register for this Call for Solutions, you must be from one of the following:

a. Private company, with local business registration;
b. Tertiary institution based in and operating from Singapore;
c. Research institution based in and operating from Singapore; or
d. A consortium of any of the above.

If you will be registering as a consortium, do appoint a lead member as the main applicant and make all submissions through this lead member. The actions by the lead member of the team will be treated as representative of the consortium. All correspondence will be directed to the lead member.

Please provide relevant information on your (or consortium members') past experiences that are relevant for this submission.

Do note that all proposals submitted through this call should be sufficiently brief, but with sufficient details for LTA's preliminary evaluation and shortlisting only. If your solution is shortlisted after the close of this call, we will contact you for further clarifications. You may be asked to make presentations and/or provide more information on your solution to LTA and/or requested to host LTA at any proposed venue and/or facilities for visits and better understanding of the proposed solution.

If your proposal is further shortlisted for detailed development, the approach for funding will be discussed and you may be asked to fill up further application forms to include finer details on your proposed solution. Do also note that you may be required to co-fund part of the solution development trial, subject to the respective funding guidelines.

Any documents submitted will be treated as confidential and not be returned. By submitting any documents, you hereby consent to any disclosure by LTA of your documents to the Government of Singapore, the relevant Government Agencies, and/ or government-related agencies, as LTA considers appropriate in our discretion for purpose of evaluation in this Call for Solutions.

Notwithstanding any other provision in this Call for Solutions, LTA may amend, suspend or withdraw all or any part of the Call for Solutions or the Call for Solution process, which will be informed via the Land Transport Innovation Portal.

8 CONTACT US

Please submit any queries regarding this Call for Solutions via this form no later than **7 Nov 2024, 4pm.** LTA's responses to the queries will be updated on Land Transport Innovation Portal before the close of the Call for Solutions.

Annex

These are the common defects in our roads and roads related facilities and the list is non-exhaustive. It serves as a guide for all participants. Any additional defects or hazards posing safety concerns to road users, if not listed here, would also be considered if determined to be valid by the Authority.

Inventory Type	**Items To Be Inspected / Defects to be identified**
Carriageway (Flexible Pavement)	• Bleeding / peeling / ravelling • Corrugation / rutting / bump / distortion • Crack • Potholes / depression / settlement • Joint • Manhole • Water ponding / inadequate drainage • Faded / missing road markings • Colour coatings (enhanced School Zone, Give Way to Bus zone & Silver Zone) • Slipperiness • Paint spillage / dropping of wet concrete • Overgrown grass at edges of carriageway • Missing or damaged raised markers • Missing or damaged traffic signs
Carriageway (Rigid & Semi rigid Pavement)	• Slipperiness • Inadequate drainage • Settlement • Slab rocking • Loss of water proofing, Loss of seal • Joint sealant extrusion • Longitudinal joint opening • Cracks (transverse / diagonal / longitudinal / corner)
Pedestrian Crossing	• Water ponding • Raised markers / buried LED studs • Faded / missing road markings • Ramp / Barrier Free Accessibility (BFA)
Service Roads	• Bollard - damaged / missing / reflective tape • Drain • Pavement • Footpath • Kerb • Road line • Traffic signs • Obstructions
Roadside Carparks Lots / Entrance Driveways	• Refer to '*Carriageway (Flexible Pavement)*'

Kerb	• Damage / dislodged • Missing • Too high / too low / less than minimum height • Mis-aligned • Unpainted / faded paint
Grating / Drop in chamber/ Catch basin	• Missing • Rusty • Choked
Railing	• Alignment • Cleanliness • Damage / missing • Painting • Rusty
Impact Guardrail / Swing Gates / Drop Gates	• Missing • Fallen • Not secured firmly • Replacement due to impact • Rusty / corrosion • Condition of support (timber support) • Damage
Gantry	• Damaged • Rusty • Tilted
Flyovers / Viaducts / Bridges	• Expansion joint – potholes, bleeding, loose missing joint plate (mechanical joint), noisy, poor rideability • Crash cushion • Missing, damaged, choked drainage inlets, water stagnation • Overgrown tree branches protruding into carriageway/leaning against structure • Overgrown creepers, dead creeper etc.
Tunnels / Underpasses	• Expansion joint – potholes, bleeding, loose missing joint plate (mechanical joint), noisy, poor rideability • Crash cushion • Missing, damaged, choked drainage inlets, water stagnation. • Water leakage • Cracks
All roads	• Unauthorised banners / signs / advertisement during inspection