Land Transport Authority

**Grant Call for Modelling and Simulation of Electric Vehicle and Power Assisted Bicycle Battery Fire**

## 1. OVERVIEW

1.1. In line with the Singapore Green Plan, the Land Transport Authority has publicly announced our target for a 100% cleaner vehicle population by 2040, with all new registration of cars and taxi from 2030 to be cleaner vehicles. EVs are expected to make up a significant proportion of the vehicle population moving forward. Beyond EVs, active mobility devices (e.g. Power Assisted Bicycles (PABs)) have also grown in number over the years as greener commute also gains momentum.

1.2. Ensuring the safety of electric vehicles (EV)s and battery-operated active mobility devices, such as power-assisted bicycles (PABs), is important with their growing adoption. One such challenge is the risk of lithium-ion battery fires[1]. The use of lithium-ion battery (LIB) can potentially lead to fire risks. Overseas case studies have shown that LIB fires can be extremely difficult to extinguish and may pose challenges such as the producing toxic gases during thermal runaway, potential reigniting after the primary fire has been put out, and accelerating combustion of adjacent properties due to the release of horizontal jet flames from vehicle battery packs. Coupled with Singapore's highly dense and built environment, there is a need for agencies to better understand the impact of EV/PAB battery fire across different types/models and local settings. This understanding will support the development and subsequently the implementation of the appropriate incident response measures to effectively manage EV and PAB battery fires.

## 2. SCOPE

2.1. LTA is launching a grant call to seek proposals to develop a model suited for simulating EV and PAB battery fire under local conditions. The proposal should cover the approach to building the model, derivation of burn tests parameters, simulation of EV and PAB battery fire across various vehicle modes and settings, and the development of an interface for capability transfer to agencies to simulate EV and PAB fires independently.

1.1.

[1] "Lithium-ion Battery Safety Issues for Electric and Plug-in Hybrid Vehicles", US Department of Transportation National Highway Traffic Safety Administration, Oct 2017

**Focus Area: Development of modelling tools to simulate EV and PAB battery fire across various land transport segments and under different local settings**

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| **Challenge** | Today, EV battery fires behave differently compared to internal combustion engine (ICE) vehicle fires due to the use of lithium-ion batteries. PAB fires mainly occur from electrical origin, and of the batteries that have been developed for PABs, lithium-ion and lead-acid batteries are the most popular. To optimise the approach for EV and PAB incident response and infrastructure design, it is pertinent for Authorities and first responders to better understand the implications of battery fires. However, conducting physical burn tests across different vehicle types and settings to ascertain the impact of battery fires can be both costly and operationally challenging. Hence, there is a need to develop a model to assist in simulating the impact of different EV and PAB battery fires. |
| **Current Situation** | While there have been multiple studies conducted internationally on the impact of EV and PAB battery fire, there lacks localised studies on how fires could behave in our highly dense local environment. Further, results on burn tests of heavy-duty vehicles, e.g. buses and heavy-goods vehicles and PABs are scarce today. |
| **Possible Solutions (but not limited to)** | This call seeks to invite proposals for the development of a model based on (but not limited to) computational fluid dynamics (CFD) methodology that can simulate the impact of EV and PAB battery fire and toxic gas propagation characteristics of fire in various vehicular segments under different local settings. These include simulation of (but not limited to) temperature, heat flux, toxic gases, and soot concentration for both spatial and temporal evolution. |
| **Requirements** | The model should be capable of incorporating the following inputs:<br>• Battery parameters at cell level, including but not limited to – chemistry of materials, energy density of battery cell, design of battery cell, thermal properties of battery cell, fire retardant additives within battery electrolyte.<br>• Battery parameters at pack and vehicle level, including but not limited to - chemistry of battery materials within pack, energy density of battery pack, design of battery pack, thermal management design (including fire retardation design), location of battery pack within vehicle, State of Health and State of Charge of battery pack.<br>• Results of existing full-scale EV and PAB burn tests (where applicable)<br><br>The simulation output of the model should be capable of demonstrating the following: |

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| | • Impact of EV battery fire across various vehicle categories. This should include but not be limited to, cars, motorcycles, light goods vehicle, heavy goods vehicle, very heavy goods vehicle, and buses.<br>• Impact of PAB battery fire across different battery profiles (i.e. lead-acid, lithium-ion).<br>• Temperature/ heat flux profiles, length of jet flame and fire spread to adjacent vehicles.<br>• Fire and toxic gas profile under various environment. This includes, but not limited to:<br>  ○ For PABs: on cycling paths and roads, within homes, enclosed environments such as lifts and ICE/EV buses;<br>  ○ For EVs: multi-storey carpark, basement carpark, tunnels, heavy vehicle parks, on-roads etc.<br><br>Other requirements:<br>• The model should be developed in a modular and reusable manner (e.g., allowing for further expansion). The model should also be transferrable and have a simplified User Interface (UI) for LTA and Government agencies to access. The requirements for the transfer of the model (with an UI) and details of hosting the model, shall be specified in the proposal.<br>• Post project completion, successful applicants shall provide extended support for maintenance of the model (of up to 3 years from point of completion), which includes, but not limited to including new battery chemistry parameters, battery energy density difference. Maintenance of the model will not be covered under the current budget.<br>• Applicants should demonstrate good track record in the development of modelling tools for EV and PAB fire simulation to deliver the desired scope.<br>• Applicants who can provide full scale burn tests readings from separate projects for validation of model will be viewed favourably. If such burns tests have been conducted and the applicant intend to be use it for validation of the model, kindly include a summary of the tests results in the submission.<br>• For publications arising from work performed under this project, LTA and the appropriate officers shall be listed as authors/co-authors depending on the level of contribution. |

## 3. ELIGIBILITY CRITERIA

3.1. This call is open to all R&D organisations in Singapore including publicly funded institutes of higher learning (IHLs), not-for-profit research institutions, public sector agencies, private companies, and company-affiliated research entities.

3.2. The Lead Principal Investigator (PI) and Co-Lead Principal Investigator (Co-PI), who are responsible for delivering the outcomes of the project, will be required to have minimum 9 months of residency per year in Singapore. International parties can participate in the project as Collaborators. All work must be done in Singapore, unless expressly approved by LTA.

## 4. APPLICATION PROCESS AND EVALUATION CRITERIA

4.1. Proposals will be selected and evaluated based on the criteria below,

i) Clear elaboration of model design,
- Applicants should clearly articulate the methodology that will be used to build the model. This should include the data points which will be used to validate the model, the specific information required from Authority (e.g. building blueprint, house layout) and the limitations of the model.
- Applicants should also elaborate comprehensively on the environments that can be simulated using the model across the various vehicle types.

ii) Strength of project execution, and
- Applicants with access to burn test data/ resources will be preferred. If project is successful, output of the model will be shared with the relevant public agencies and used to support design of incident response measures, buildings fire safety provision, active mobility or other road infrastructures.
- Applicants should also clearly outline how the project will be phased and the overall timeline of the project.

iii) Technical competency of the team.
- Applicants are expected to be equipped with both knowledge and technical capabilities and expertise that are required to deliver the desired scope.

4.2. The grant call will be launched on 9 Apr 2024 (Tuesday), 1200hrs. Interested applicants should submit proposals to LTA_innovate@lta.gov.sg by 31 May 2024 (Friday), 1700hrs. Only documents in **Word**, **Excel** and **PDF** formats should be submitted.

4.3. Proposals should cover the objectives, proposed approach and project execution plan. This would include detailing the development plan for the modelling tools to simulate

EV and PAB battery fire across under different local settings, plans for transfer of the model to LTA and Government agencies for access after project completion and requirements for inclusion of new environments post-project. The guideline for drafting the proposal can be found in the documents for information section under Urban Mobility Innovation (UMI) Initiative, UMI Grant Call – Modelling and Simulation of Electric Vehicle and Power-Assisted Bicycle Battery Fire on Land Transport Innovation Portal (LTIP) page.

4.4. The general level of funding support for approved qualifying direct and indirect[2] for different research performers is elaborated in the below. A list of non-fundable direct cost items can be found in the documents for information section under Urban Mobility Innovation (UMI) Initiative, UMI Grant Call – Modelling and Simulation of Electric Vehicle and Power-Assisted Bicycle Battery Fire on Land Transport Innovation Portal (LTIP) page.

| Category of Research Performers | Support for Qualifying Direct Costs | Support for Indirect Costs |
|---|---|---|
| Institute of Higher Learning (IHLs), not-for-profit research institutions | 100% | 30% |
| Singapore-based Small and Medium-sized Enterprises (SMEs[3]), start-ups and not-for-profits | 70% | - |
| Singapore-based Large Local Enterprises (LLEs) | 50% | - |
| All non-Singapore entities based in Singapore (including non-Singapore not-for-profit) | 30% | - |

4.5. Funding support will be up to three years. Deliverables are expected to be commensurate with the level of funding requested. Funding support will be based on achievement of milestones in a payment schedule.

4.6. Proposals that provide cash or in-kind contributions will be viewed favourably. Multi-disciplinary/organisation teams or teams with industry collaborators are also encouraged to perform holistic analysis and facilitate downstream commercialisation and deployment of R&D technologies developed. Proposals which involve a trial or pilot and include plans for scale-up are preferred. Where applicable, technology

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[2] Indirect costs are costs that are incurred for common or joint objectives and therefore cannot be identified readily and specifically with a particular project, but contribute to the ability of the research performers to support projects (e.g. providing space, financial administration, utilities).

[3] SMEs refer to entities having a Group Annual Sales Turnover of not more than $100M, or maximum employment of 200 employees.

readiness level (TRL) of the proposed technology should be at least TRL 5 (prototype demonstration in a relevant environment) and above at the end of the project. Appendix 1 shows the definitions of the TRLs.

4.7. The following may be rejected without review:

- Late or incomplete proposals (including proposals that do not follow the guidelines)
- Proposals that do not fall within the scope of the grant call
- Duplicates of proposals submitted to any other funding agencies for simultaneous consideration
- Ineligibility of the Investigators or R&D organisation

4.8. Submission of proposals to LTA shall be construed as consent by the applicants to participate in the evaluation process. Selection of reviewers is at the sole and exclusive discretion of LTA. LTA shall not be liable for the release of information concerning proposals to third parties by individuals involved in the evaluation process.

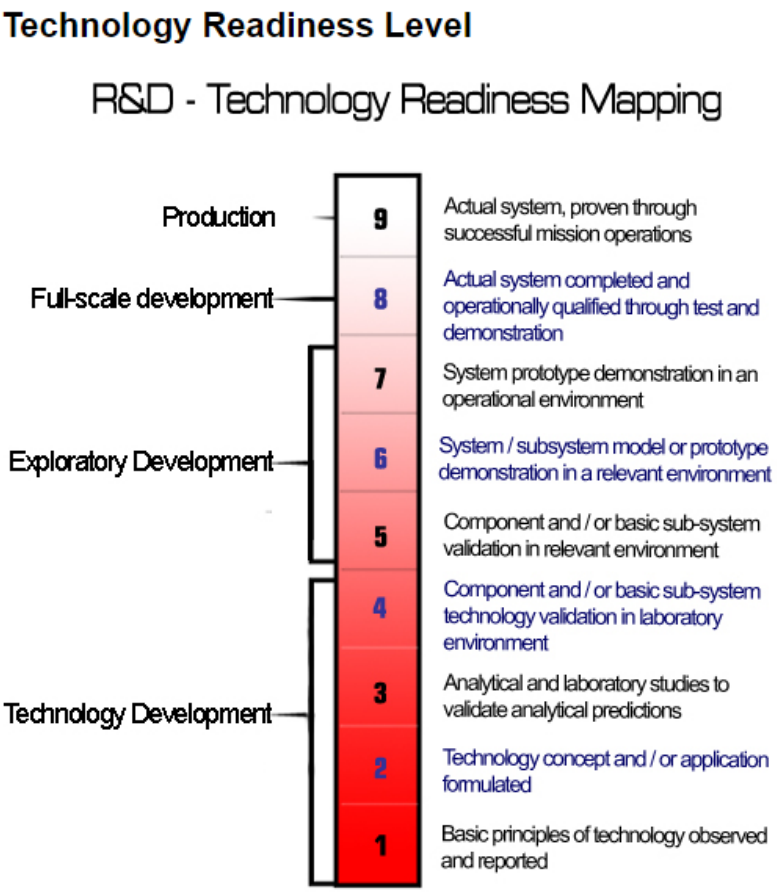
4.9. LTA may require proposals to be revised or combined as it sees fit to enhance outcomes, facilitate integration of approaches, and optimise funding resources. LTA's funding decision will be final.

## 5. CONTACT INFORMATION

5.1. For further enquiries on this Open Call, please email LTA at LTA_Innovate@lta.gov.sg.

**Appendix 1: Technology Readiness Level Chart**

A progressive approach, depending on the Technology Readiness Level (TRL) at the point of decision, is used to evaluate test-bedding of new mobility concepts.




<u>Prototype demonstration in a relevant environment (for TRL 5 & 6)</u>

A technology of interest has demonstrated potential to meet certain transport objectives. It will then be pursued for further development at the component level and subsequently tested for operational viability within confined test areas that mimic part of an envisaged operational environment.

<u>Proof-of-Concept (POC) demonstration in an operational environment (for TRL 7)</u>

If a technology of interest has been proven its potential at the component level, its development will be further pursued. In this case, the test-bedding environment will be escalated into the actual operational environment with actual interaction with other road users and commuters. At this stage, we will focus on evaluating the proposed mobility concept, which deploys the technology of interest, for its envisaged benefits and values in meeting the transport objectives.

Full Scale Deployment (FSD) (for TRL 8 & 9)

This level will be considered after a successful Proof-of-Concept (POC) demonstration. However, it may not be a straight-forward process as other considerations like commercial viability, operational sustainability, and other policy considerations (especially when the new mobility concept could be disruptive to existing modes of travel).