CITIES OF TOMORROW (CoT) R&D PROGRAMME
FIRST GRANT CALL
FOR VERTICAL 2

1. Definitions

1.1 In this Call for Proposal, unless the contrary intention appears: -

(a) "Collaborator" means any company, institution, incorporated body or other industry or academic collaborator, which is not an Institution or an Investigator but is to be engaged in the Research in collaboration with the Institutions or any of them;

(b) "Host Institution" means the body or institution or administering organisation named in the Letter of Award as the "Host Institution" as the body responsible for undertaking and managing the Research;

(c) "Institutions" means collectively the Host Institution and the Partner Institutions and "Institution" shall mean any one of them;

(d) "Investigators" means collectively, the Lead Principal Investigator, Team Principal Investigators and Co-Investigators; and

(e) "Partner Institutions" means the bodies or institutions named in the Letter of Award as the "Partner Institutions" as the bodies responsible for working together with the Host Institution to undertake the Research

2. Introduction

2.1 The Cities of Tomorrow (CoT) R&D programme is a multi-agency effort, led by MND, that recognises the challenges that cities face and aims to leverage R&D to address these challenges.

2.2 The vision of CoT is to establish Singapore as a highly liveable, sustainable and resilient city of the future, and as a vibrant urban solutions hub – a living model which features cutting-edge urban solutions. This will be achieved through the integrated development of R&D in 4 key verticals and 2 horizontals:

- Vertical 1: Advanced Construction
- Vertical 2: Resilient Infrastructure
- Vertical 3: New Spaces
- Vertical 4: Greater Sustainability
- Horizontal 1: Urban Environment Analytics
- Horizontal 2: Complexity Science for Urban Solutions

[Please see Annex A for the vision and research focus areas for each of the verticals and horizontals]

2.3 A total of S$150 million has been approved to fund CoT. The funding will be set aside from the S$900 million allocated to the Urban Solutions and Sustainability (USS) domain under the Research, Innovation and Enterprise 2020 (RIE2020). More details on USS can be found at: https://www.nrf.gov.sg/rie2020/urban-solutions-and-sustainability.

3.   Call Topics

3.1   For this grant call, there are a total of 3 Call Topics under Vertical 2. Please refer to Annex B for the details of these Call Topics.

4.   Eligibility

4.1   Principal Investigators (PIs) from all Singapore-based institutions of higher learning (IHLs), public sector agencies and not-for-profit research laboratories as well as companies and company-affiliated research laboratories/institutions, are eligible to apply.

4.2   The Lead PI who leads the Research must be based in Singapore[1] and collaboration with foreign organisations and experts in the capacity of Co-Principal Investigator (Co-PI), or as Collaborator is allowed. Research work should be done in Singapore, and should not be carried out overseas unless expressly approved by the grantor.

4.3   PIs are allowed to submit proposals for one or more of the Call topics above. Please clearly indicate the Call topic that the proposal will address in the Proposal Template.

4.4   R&D proposals already funded by other government agencies will not be considered under CoT. PIs and supporting agencies will need to declare their other funding sources as well as participation in other funding initiatives during application. Proposals with similar scope, which are currently under evaluation by other funding initiatives, will not be considered until the results from the other funding initiatives are finalised.

4.5   Grant applicants are strongly encouraged to collaborate with industry and development agencies to develop innovative solutions that can address the call objectives and demonstrate strong potential for real-world application within Singapore.

4.6   Where applicable, we encourage the integration of relevant social and behavioural research to complement the R&D work under these grant calls, to ensure user-centricity and acceptability of the solutions proposed.

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[1] Lead PIs must have a minimum of 9 months employment with a Singapore-based organisation (Singapore-based institutions of higher learning (IHLs), public sector agencies, not-for-profit research laboratories as well as companies and company-affiliated research laboratories/institutions), and must fulfil at least 6 months of residency in Singapore over a period of 1 calendar year.

5. Funding Support

5.1 The Call for Proposals offers funding support up to S$3 million (including indirect costs). Proposals more than S$3 million will require strong justifications.

5.2 When budgeting for funding under CoT, the total cost of the project should include all approved direct costs and indirect costs. All expenditure should be budgeted inclusive of any applicable Goods and Services Taxes (GST) at the prevailing rates.

5.3 Budget items are categorized as direct or indirect cost items. Direct costs are defined as the incremental cost required to execute the programme. This excludes contributions in-kind[2], existing equipment and the cost of existing manpower as well as building cost. Indirect costs are costs that are incurred for common or joint objectives and therefore cannot be identified readily and specifically with a particular sponsored research project, but contribute to the ability of the Institutions to support such research projects (e.g. providing research space, research administration and utilities, and not through the actual performance of activities under the sponsored projects).

5.4 Supportable direct costs can be classified into the following cost categories:-
   (a) Expenditure on manpower (EOM);
   (b) Equipment;
   (c) Other Operating Expenses (OOE);
   (d) Overseas Travel; and
   (e) Research Scholarship

5.5 For all direct cost items proposed for the project, please note that:
   (a) Host Institutions must strictly comply with their own procurement practices;
   (b) Host Institutions must ensure that all cost items are reasonable and are incurred under formally established, consistently applied policies and prevailing practices of the Host Institution; and
   (c) All items/ services/ manpower purchased/ engaged must be necessary for the R&D work.

5.6 The Lead PI should exercise due diligence and ensure that the proposed budget is correct and free from error.

5.7 For proposed Equipment to be purchased, please ensure that they are currently unavailable in the Host Institution. In the event where the Lead PI is aware that a similar Equipment is available in the Host Institution, but has still proposed to purchase such Equipment, the Lead PI has to provide the necessary justifications for CoT Directorate's approval. Please also note that there is a requirement to share Equipment purchased using NRF funds with other researchers in Singapore.

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[2] Contributions from public agencies account as direct costs.

5.8 At the end of the Research, CoT Directorate shall have the option to require the Host Institution to transfer ownership of any of the Assets to CoT Directorate or any other person or body at no cost.

5.9 The CoT will support 100 percent of the approved qualifying direct costs of a project for Singapore-based IHLs, public sector agencies and not-for-profit hospitals and research laboratories. Companies and company-affiliated research laboratories or institutions will qualify for up to 70 percent of the approved qualifying direct costs of a project.

5.10 Support for indirect costs, in the form of overheads, will only be provided for Singapore-based IHLs, and not-for-profit entities[3]. Funding support of 20 percent of the total qualifying approved direct costs (i.e., Total direct costs less exceptional items) will be allowed. Host Institutions will be responsible for administering and managing the support provided by CoT for the indirect costs of research. Indirect costs must be specifically provided for in the grant, and approved by the Grantor based on the nature of the research.

5.11 Please refer to the document "Guidelines for the Management of Competitive R&D Grants" for information on Disbursement of funds, Variation requests, Audit and Progress reports and List of Non-Fundable Direct Costs for Research Projects.

5.12 CoT Directorate's decision on the funding support to be awarded for each project is final.

6. **Intellectual Property Rights**

6.1 Government agencies who are Institutions or Collaborators shall co-own any Intellectual Property (IP) arising from the Research. If Government agencies choose not to co-own IP, they shall make this position known prior to award.

6.2 The Institutions shall keep and maintain a full, comprehensive and updated list of all Research IP, which shall be made available to CoT Directorate for inspection at any time.

6.3 The parties shall use best efforts to ensure that Research IP is properly managed and wherever feasible, fully exploited and commercialized. When required to do so by CoT Directorate, the Institutions shall attend such meetings as CoT Directorate may direct to discuss the potential for exploitation and commercialization of Research IP.

6.4 The Government and public sector agencies shall reserve a non-exclusive, non-transferable, perpetual, irrevocable, worldwide, royalty-free right and license to use, modify, reproduce and distribute the Research IP for non-commercial, R&D and/or educational purposes.

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[3] A*STAR RIs do not qualify for indirect cost funding.

7. Letter of Award & Acceptance

7.1 Successful applicants will be informed by the CoT Directorate. Notification in the form of a Letter of Award will be sent to the Director of Research for the respective Lead PI's Host Institution, and copied to the Lead PI.

7.2 The Letter of Award will include the following:
(a) Statement of Acceptance;
(b) Terms and Conditions of the Grant;
(c) Guidelines on Grant Management;
(d) Performance Indicators and Milestones; and
(e) Schedule and Budget Details.

7.3 The Acceptance Form must be acknowledged by all of the following:
(a) The Director of Research (or equivalent);
(b) The PI; and
(c) The Co-Principal Investigators (Co-PIs).

7.4 Upon acceptance of the CoT grant, the PI, Co-PIs and Host Institution are bound by these clauses and all other terms as specified in the Letter of Award.

7.5 The PI or Co-PIs cannot also be the authorised officer representing the Institution. In such cases, another officer duly authorised by the management of the Institution shall approve on its behalf.

7.6 The Acceptance Form and Annexes (if applicable) should be returned to CoT Directorate within a pre-determined time frame from the date of the Letter of Award. The date on which the Statement of Acceptance is signed shall be taken as the date of acceptance of the Award.

7.7 After the acceptance of the Award, the Host Institution, Partner Institutions and the Collaborators shall enter into a written agreement that is consistent with the obligations assumed under this Research and that includes conditions about: -
(a) the role of each party in the Research;
(b) the provision of cash or in-kind contributions to the Research by each party;
(c) the work to be undertaken by each party and its technical/scientific contributions;
(d) terms relating to Intellectual Property ownership and commercialization; and
(e) any other obligations to be fulfilled as laid out in this set of guidelines.

7.8 The Investigators are responsible for putting in place research collaboration agreements where and when applicable.

8. Research Integrity Policy

8.1 The Host Institution shall ensure that all necessary approvals for the research, including all ethics approvals, have been granted prior to the commencement of any research activities.

8.2 The Host Institution is responsible for establishing a research ethics and integrity policy and enforcing its compliance. In carrying out any Research, the Host Institution shall agree to:-

(a) Comply with the provisions of any relevant laws of the Republic of Singapore, statutes, regulations, by-laws, rules, guidelines and requirements applicable to it, as well as all applicable policies and procedures adopted by CoT as the same may be amended or varied from time to time;

(b) Have in place a research integrity policy which sets out the principles for the responsible conduct of research and procedures for investigating and responding to accusations of misconduct;

(c) Provide training in responsible conduct of researchers, for all researchers;

(d) Be held responsible for the conduct of research and researchers; and

(e) Ensure compliance with best practice, as well as the ethical, legal and professional standards relevant to the research.

8.3 All PIs, research personnel and all other persons involved in the Research must comply with the research ethics and integrity policy, and other approval requirements needed to carry out the research programme. The PIs should undertake the following declaration:

(a) In carrying out Research, agree to comply with the provisions of any relevant laws of the Republic of Singapore, statutes, regulations, by-laws, rules, guidelines and requirements applicable to it, as well as all applicable policies and procedures adopted by CoT R&D programme as the same may be amended or varied from time to time;

(b) Agree to hold primary responsibility for the responsible conduct of research, and shall abide and comply with the ethical, legal and professional standards relevant to research, in accordance to the research integrity policy of the Host Institution; and

(c) Declare any potential conflict of interest that may arise from the purchase of equipment/ physical items or engagement of manpower/ services in the course of carrying out Research.

9. Evaluation Criteria

9.1 Proposals will be evaluated based on the following criteria:

(a) Potential Contribution to CoT Objectives
- Relevance of proposed research in contributing to objectives stated for the CoT Call Topic.

(b) Potential for Breakthrough and Innovation
- Quality and significance of proposed research, including value for money, and the potential for breakthrough/innovation to advance knowledge and understanding within its own field or across different fields.

(c) Potential for Application and Deployment in Singapore and Commercialisation/Export

- Potential for application of research outcomes in Singapore by a public agency and potential for solutions to be replicated in Singapore beyond a single site/project.
- Feasibility for commercialisation/ export in areas where Singapore has a competitive advantage.

(d) Execution Strength and Technical Competency of Research Team

- Quality of plans for execution and delivery of the research programme and goals, including the appropriateness of the proposed milestones and deliverables (specific to evaluation of full proposal applications)
- Quality, significance, and relevance of the recent research record of the PI and co-PIs and the strength of the applicant group, including likely synergy in delivering research and potential for international leadership.

10. Submission Instructions

10.1 Please download all files and read all instructions and guidelines for the Grant Call from www.mnd.gov.sg/citiesoftomorrow/ongoing-grant-calls/v2-resilient-infrastructure.

10.2 All proposals must be submitted to **both** cot_submission@mailbox.hdb.gov.sg and BCA_COT@bca.gov.sg by 02 Aug 2018, 2359 hrs. **Late submissions or submissions from individual applicants without endorsement from the Host Institution will not be entertained.** It is advised to restrict submissions to 10 MB.

10.3 Full proposals and supporting documents are only considered to be submitted to the grantor if all relevant forms with the relevant attachments are submitted. The documents required are:
(a) Form A – Full Proposal;
(b) Form B – Budget;
(c) Form C – Capability Indicators; and
(d) Form D – Undertaking Form

10.4 Please follow the naming convention and format for labelling of softcopy attachments:

Attachment	Naming Convention	Format of attachment
Full Proposal Template	*[Topic Code]* FP_ *Project title*	MS Word
CVs	*[Topic Code]* CV_ *Project title*	MS Word
References	*[Topic Code]* References_ *Project title*	MS Word
Letters of Support	*[Topic Code]* LOS_ *Project title*	MS Word
Budget Template	*[Topic Code]* Budget_ *Project title*	MS Excel
Capability Indicators	*[Topic Code]* Indicators_ *Project title*	MS Excel
Undertaking Form	*[Topic Code]* Undertaking_ *Project title*	PDF

Important: Where relevant privileged or confidential information is needed to help convey a better understanding of the project, such information should be disclosed and must be <u>clearly marked</u> in the proposal.

<u>Annex A: Vision and Research Focus Areas for CoT Verticals and Horizontals</u>

The CoT programme was developed by MND Family in conjunction with our partner agencies, with the aim of delivering outcomes in collaboration with the research community and industry partners. 4 verticals were identified to address key issues of national concern and R&D roadmaps were drawn up to direct funding through the setting of challenge statements. 2 horizontals, which represent specialisation in fields that are cross-cutting, were also identified as key enablers for the 4 verticals.
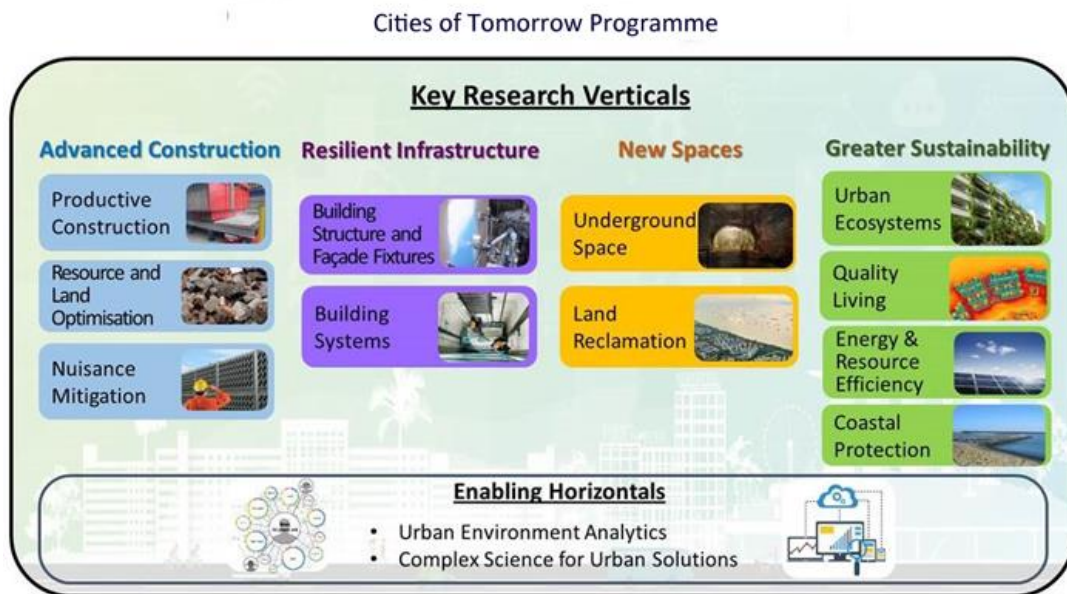
The vision and research focus areas for each of the verticals and horizontals are as follows:

<u>Vertical 1 - Advanced Construction</u>

Vision: To build a highly productive, integrated and technologically advanced construction sector

Key Research Focus Areas:
- *Productive Construction* – Develop an integrated, intelligent, digitally-enabled construction environment that is highly productive and cost effective.
- *Resource and Land Optimisation* – Reduce and reuse resources required in construction, and intensify land use for off-site production.
- *Nuisance Mitigation* – Reduce the environmental impact of construction activities.

Vertical 2 - Resilient Infrastructure

Vision: To create a robust, flexible and well-maintained city that has reliable and cost-efficient infrastructure

Key Research Themes:
- *Building Structure and Façade Fixtures* – Minimise building defects and enhance building inspection processes, as well as to reduce the cost and manpower needs for maintenance.
- *Building Systems* – Enhance the performance and reliability of key Mechanical and Electrical services.

Vertical 3 - New Spaces

Vision: To ensure sufficient space capacity to support Singapore's growth, yet maintain a liveable environment

Key Research Themes:
- *Underground Space* – Enhance underground mapping accuracy and reduce cost of underground development.
- *Land Reclamation* – Reduce material usage, cost, and environmental impact of land reclamation.

Vertical 4 - Greater Sustainability

Vision: To create a high quality living environment that is inclusive, resource efficient and adaptive to climate change

Key Research Themes:
- *Urban Ecosystems* – Create sustainable, resilient and green cities through applying an ecosystem approach to urban planning, development and management.
- *Quality Living* – Create a comfortable and pleasant living environment for residents.
- *Energy and Resource-Efficiency* - Enhance the energy and resource efficiency of towns, estates and buildings to reduce the environmental impact of operations.
- *Coastal Protection* - Future-ready coastal protection for sea level rise.

Horizontal 1 - Urban Environment Analytics

Vision: To achieve responsive and targeted service delivery as well as resource efficiency in municipal services and urban planning

Key Research Themes:
- *Data Analytics, Sensing and Predictive Diagnosis* – Provide targeted services, anticipate emerging trends for better response, and prioritise resources to optimise output.
- *Mapping, Modelling & Simulation* – Assess the impact of climate change on the natural and built environment, and to incorporate mitigating measures in planning processes.
- *Intelligent Systems* - Improve industry productivity through automation, as well as to improve reliability and consistency of compliance checks.

Horizontal 2 – Complexity Science for Urban Solutions

Vision: Applying complexity science to solve dynamic urban problems, by finding hidden regularities and parameters that affect urban planning

Key Research Themes:
- *Improving Liveability in Singapore* – Use complexity science to create decision support tools for urban planning, so as to better plan for a dense and liveable Singapore.

Annex B: Grant Call Topics

Project Code: CoT_V2_GC2018-1_P1
Call Topic: Technologies to Geo-reference and Detect Underground Services and Assets for New Estates

1   <u>Background</u>

1.1   Embedded and underground services such as electrical trunkings and water pipes are commonly found in the building and residential estates. Existing services plans or as-built drawings may be available or obtained from authorities for references, but may not be accurately updated and documented. Thus, services detection and trial pits are still required to be done at site to verify the actual location of those services before carrying out any excavation works. Very often, services disruptions were encountered due to the damage caused by excavations and construction works due to failure in detecting these underground services.

1.2   This project will help to reduce the amount of time and uncertainty involved in locating the buried services and assets and thus improve accuracy and productivity. It will also help to reduce the risk of services disruption due to accidental damage of these services.

2   <u>Objectives and Scope of Call for Proposals</u>

2.1   The desired outcomes of the research are to:

(a)   Develop spatial solutions through technologies that include, but are not limited to Drones, Global Navigation Satellite System (GNSS), and point cloud etc., to geo-reference and detect all types of underground services and assets (e.g. service shafts and culverts). The solutions will enable capture, documentation, and updating of as-built newly laid services, towards development of a services information database that can help to pinpoint the actual location, path and depth of such services before carrying out any excavation works in future;

(b)   Develop scanning and geo-referencing technology for detecting underground services as well as assets for new estates, and automatically capture the digital information into drawings of as-built buildings, such as in BIM drawings format;

(c)   Develop solution to provide 3D rendered models for closer examination of the underground services and assets; and

(d)   Develop augmented reality device to provide the user with a composite view and details of potential underground services at site.

2.2   The research development shall be ready and practical for deployment in actual site environment and building projects.

2.3   Solutions developed shall provide quicker and more efficient scanning capabilities on site, and be able to minimally achieve a data accuracy of +/-100 mm, beyond current SLA survey standards for underground services and assets.

2.4 Solutions /technologies deployed shall allow the detection, scanning, and creation and updating of 3D models/data of both exposed and buried/covered underground services that are not in time for survey during construction. The solutions /technologies shall also be able to capture and update the as-built location of services as and when services have been shifted during backfilling and after installation.

2.5 Data/information captured shall provide details including, but not limited to, geo-reference coordinates, exact location with reference to site environment, depth, dimensions and type of services (e.g water pipe, high-tension cable, box culvert) etc.

2.6 The study shall include the review and understanding of current site practices of underground services installation and if required, propose new construction practices and/or new site protocols to support the new methodology of underground services detection and documentation.

3 <u>Funding Support</u>

3.1 This Call for Proposals offers funding support for a period up to 2.5 years. Proposals spanning more than 2.5 years will require strong justifications.

Project Code: CoT_V2_GC2018-1_P2
Call Topic: Automated Solutions and Artificial Intelligence System for Inspection, Diagnosis and Maintenance of External Building Facades

1   Background

1.1   Due to aging building stock and the increasing complexity of façade design, it is necessary that building façades are regularly inspected and maintained to ensure safety. Current inspection processes are normally done within the confines of the building and can be manual and labour dependent. To have an effective inspection, the building professionals (e.g. Professional Engineers, Registered Architects, Resident Engineers, Resident Technical Officers etc.) are required to work at heights to carry out close range inspection. Such method of inspection is often laborious and prone to fatigue and human errors. There may also be areas that are difficult for humans to access.

1.2   To improve the inspection professional's safety (i.e. prevention of fall from height), there is an urgent need to explore automating the inspection process and transforming it to become less labour dependent by incorporating building diagnostics technology, such as seamlessly recording all defects and inspection data gathered from the autonomous inspection. This would thus improve various aspects of building inspection such as safety, productivity and inspection accuracy. The external façade inspection system should help to improve building inspection personnel safety, increase the reach of building façade inspection, and reduce the dependency on professional manpower willing to undertake such building façade inspections.

1.3   Further research on a portable non-destructive testing tool is also needed as defects on the façade systems are often concealed by the façade barrier. As facades get more complex, less visible and less accessible, these defects remain undetected until failure occurs. There is a need for a portable non-invasive and non-destructive equipment that can detect defects concealed behind façade barriers, so that they can be repaired before failures occur. The objective of this phase of research is to develop portable scanning equipment that can function as a quick diagnostic tool to assist façade inspectors in detecting defects and any tell-tale signs on the building facade safely and accurately, without the need to remove the façade layer.

2   Objectives and Scope of Call for Proposals

2.1   The desired outcomes of the research are to:

(a)   Develop customised, autonomous and cost-effective robotic system that is capable of manoeuvring around building envelopes, including those with irregular profile, easily and safely. Using a combination of different technologies, the inspection robotic system should be able to conduct checks on external facades to detect building defects; and

(b)   Develop an intelligent inspection software system to recognize building defects through data analytics based on data collected during the inspection.

2.2 The project shall consist of 4 work areas as follows:

(a) Work area 1: Develop two integrated robotic systems (system 1 & 2) that can check the façade of buildings' envelope efficiently and safely. System 2 shall consist of robotic solution that can scale and get in contact with the façade envelope, inclusive of façade with irregular shapes and profile, to carry out close-up inspection to detect potential defects area.

(b) Work area 2: Develop technology to incorporate various methods of building diagnostics and testing into the robotic inspection system.

(c) Work area 3: Develop artificial intelligence (AI) and machine learning capability and diagnostic tools for defects analysis.

(d) Work Area 4: Develop portable testing tool for inspection and detection of concealed defects behind claddings and/or curtain walls system without the need for dismantling. The device shall be able to be integrated into the robotic system as plug & play accessories.

2.3 The research development and solutions shall be ready for deployment in actual building inspection including prototyping and test-bedding. Specific design and requirements of the systems for each work area shall include but not limited to the following:

(a) Work Area 1

(i) System 1 - the Quick Scan Inspection System 1 to quickly scan 100% of the façade elevations to identify and detect defects. System 1 may consist of, but not limited to inspection solutions integrated with Unmanned Aerial System/drone technology. System 1 should be able to detect defects such as but not limited to: cracks, water seepages, hollowed or delaminated external finishes, tiles debonding, brickworks bulging, façade deformations, and corroded or deteriorated external fixtures, fittings or connections.

(ii) System 1: Quick Scan Inspection System shall include but not limited to:
- More than one (1) robot to be used in tandem during inspection;
- Software should include automated masking technology and identification of building windows openings to ensure privacy;
- Autonomous flight path software to be included;
- Software should include accurate stitching of images and 3D mapping reconstruction; and
- Automated solution to complement the system and enable inspection to be carried out despite loss of GPS signal.

(iii) System 2 - the robotic close-contact inspection system should be able to carry out identification or non-destructive tests to detect or confirm defects such as but not limited to: cracks, water seepages, hollowed or delaminated surface finishes, tiles debonding, and corroded or deteriorated external fixtures, fittings or connections.

(iv) System 2: The robotic system shall be able to carry out close contact inspection on the building, and should be:
- Lightweight, compact, efficient as well as aesthetically pleasing;
- Integrated with multi-sensors (Refer to Work Area 2); and
- The system developed shall have the capability to perform and inspect on the following areas and requirements but not limited to:

System	Requirements
Protrusions and Recessed Surfaces	Able to overcome recesses and protrusions of at least 1.0 metre from the edge of the building façade
Mobility of system	Ability to self-climb on various façade profiles and able to: (a) Adapt to existing building design (b) Work within narrow and confined external spaces (c) Move in x-, y-, and z-axis with rotational movement (d) Manoeuvre to inspect tight corners of façade surfaces and the top and bottom ledges / canopies (e) Auto-sense barriers or obstruction during movements (f) Inspect a building height of about 120 metres (g) Be easily transported and handled by a single man
Controllability	Ability to control: (a) via remote sensors or auto-sensing (b) with no interference to electronic products in the vicinity (c) despite the presence of a barrier in between or without line-of-sight
Public Inconvenience	(a) Minimize the need to cordon off large area around the building and restrict public access (b) Low noise generation
Safety	The operation of the system shall not affect or cause any damages to the adjacent and neighbouring premises or property, operator and pedestrians
Power supply	Ability to be powered by (a) preferably existing power sources from standard commercial and residential buildings (b) alternative power source / generator that is silent, portable and non-disruptive

(b) **Work Area 2:** Development of technology to incorporate various methods of building diagnostics and testing into the robotic inspection system.

    (i)   System 2 (Close contact inspection robotic system): Technology to be included but not limited to:
- Tapping device to check for hollowness behind plaster and tiles;
- Pulse/sound reader to accurately interpret the sound waves received;
- Infra-red scanner and/or other imaging technology that is able to detect various types of defects as mentioned above. More than 20 Mega-pixel camera;
- Laser depth scanner;
- Inclinometer

(c)   Work Area 3

    (i)   This work area shall include:
- Development of automated system that is able to tag defects spatially, transmit and store the field data collected for defects diagnosis and analysis purposes;
- Integration with the various building diagnostics technology hardware as well as conduct defects recognition analysis;
- Perform predictive data analytics using artificial intelligence (AI) and machine learning for more accurate defect identification, classification and defects probability rating;
- Mobile application software for automatic generation of defects report so that reports can be viewed on portable viewing devices; and
- Data management platform and software to be provided to link and transmit inspection results back to Agencies' Smart Hub.

(d)   Work Area 4

    (i)   This work area shall include:

- Development of a portable, quick scanning tool for detection of defects on cladding and curtain wall, and deterioration of fixings concealed behind the cladding system;
- The proposed equipment should be compact, safe-to-use, and portable (able to be held by a single person during the scanning process);
- The detection mechanism can either be contact or contactless and shall not affect or damage the façade material, or leave any imprint on it;
- Provide real-time on-board diagnostic ability and instant feedback to the user. The equipment should be able to capture and store field measurement data in a form that can be transferred to a PC;

- Perform predictive data analytics using artificial intelligence (AI) and machine learning for more accurate defect identification and classification. A PC-based software should be developed to provide further diagnostic and data analytics capabilities, to smartly identify anomalies indicating potential defects; and
- The equipment should be designed both as a standalone device and to be integrated with robotic inspection system (System 1 and System 2) as plug-and–play devices to provide multiple scanning methods and enhanced inspection capabilities.

(e) The proposal should include detailed descriptions of all safety features for System 1, System 2, and the portable quick scanning tool.

(f) All data sets derived from this research shall belong to HDB/BCA.

(g) Upon request by HDB, the prototypes created during this research shall be made available for long-term loan at the site(s) designated by HDB, such as the HDB Centre of Building Research, for training and demonstration purposes.

(h) The team should comprise personnel with expertise such as but not limited to automation, robotics, Artificial Intelligence (AI) and machine learning, external façade inspection, civil engineering, mechanical engineering, electrical engineering, etc.

3 <u>Funding Support</u>

3.1 This Call for Proposals offers funding support for a period up to 3 years. Proposals spanning more than 3 years will require strong justifications.

Project Code: CoT_V2_GC2018-1_P3
Call Topic: Lift Monitoring and Diagnostic System

1   <u>Background</u>

1.1   There is currently a lift monitoring system in place to monitor lift operations and manage emergency events, for example man-trap cases. However, the current lift monitoring system does not provide sufficient information that could translate to meaningful diagnostics of lift faults. Moreover, lift fault diagnosis and rectification has to be done manually by the maintenance crew on site. Manpower demands for lift technicians are increasing with the growth in the number of lifts; whilst manpower supply is dwindling as our workforce ages. With aging infrastructure and a shortage of lift maintenance professionals, there is an urgent need to improve the productivity of this industry through the efficient use of technology.

1.2   One way to improve productivity is through the implementation of a Remote Monitoring & Diagnostics System. Whilst some of the major Original Equipment Manufacturers (OEMs) have these technical capabilities, it is costly for lift owners to procure such services. Furthermore, for lift owners with multiple brands of lifts, it is not cost-effective and efficient to use multiple lift remote monitoring systems. Having a 3rd party Remote Monitoring & Diagnostics System in the market will provide lift owners with a one-stop solution for their lifts. However, it is not easy to differentiate and assess them because there are many variations in their solutioning available in the market. In addition, their solutioning capabilities are still relatively unknown when compared to that of the OEM counterparts. It is therefore important to conduct research to develop an integrated 3rd party remote monitoring and diagnostics system.

2   <u>Objectives and Scope of Call for Proposals</u>

2.1   The objectives of the project are to:

(a)   Develop a 3rd party Remote Monitoring and Diagnostics System that integrates requirements and functionalities of a variety of current lift technologies, as well as improves the accuracy of lift fault diagnosis, allowing predictive and proactive maintenance. This System should be comparable to or better than OEM systems in terms of monitoring methods and prediction analysis;

(b)   Leverage Smart Technology and AI to improve lift monitoring and performance; and

(c)   Identify and develop a common standard for Remote Monitoring & Diagnostics System to allow any 3rd party solution provider to develop such remote monitoring and diagnostics solutions for the market.

2.2   The project will be split into three areas: 1. Developing the system, 2. Enhancing the system through AI and, 3. Developing a common standard for lift remote monitoring and diagnostics.

Work Area 1

(a)   Develop a 3rd party Remote Monitoring and Diagnostics System with the following capabilities:
        (i)   Remotely monitor lift status and health;
        (ii)   Remotely conduct lift fault diagnoses; and
        (iii)   Integrate existing and new lift sensors
(b)   System should be robust, easy to attach and require minimal configurations across various OEMs
(c)   System should be comparable to or better than those of OEMs
(d)   System should address and mitigate cyber-security risks

Work Area 2

(a)   Enhance the System through Smart Technology and AI to continually increase the accuracy of predicting lift faults and lift part failures.

Work Area 3

(a)   Develop a common standard for lift remote monitoring and diagnostics.

2.3   The developed remote monitoring system will also be assessed based on costs and ease of technical implementation.

3   Funding Support

3.1   This Call for Proposals offers funding support for a period up to 2.5 years. Proposals spanning more than 2.5 years will require strong justifications.