Problem Statement/Title: Data-driven Environmental Services operations

Desired Outcomes:
Development of digital platform for a seamless interpretation and analysis of Environmental Services (ES) data across formats to assist users to monitor conditions of their properties, improve service responses and optimise resource allocation in near real-time condition. The solution should translate to cost savings, improvement in productivity, service quality and performance for users.

Background of Problem:
Based on manpower landscape studies conducted by NEA, the ES industry comprising cleaning, waste, and pest management relies heavily on low-skilled and manual labour, and an aging workforce. The current ES industry is therefore one that is labour-intensive and unproductive. With a greater push and emphasis on the use of smart solutions to increase productivity in ES operations, the industry has seen an increase in adoption of smart solutions to aid workers in their daily operations. This has resulted in more and wider offering of smart solutions in the areas of Internet of things (IoT), robotics (e.g. vacuuming and scrubbing robot cleaners) and software solutions (e.g. Human Resource Management, Enterprise Resource Planning) to meet the demand.

However, most off-the-shelf robotics and software solutions are single-function, purpose-built tools that yield productivity gains only for specific tasks. These, according to industry feedback, do not offer substantial optimisation in resources or increase service offerings from the Service Providers (SPs) to the Service Buyers (SBs). As a result, SBs also do not undertake a broader whole-of-operations level reforms. SBs and SPs typically maintain status quo at the worksites without visible value-added offerings even with such smart solution implementations.

To yield visible improvements to service offerings and value proposition to their stakeholders, SBs agree that there is a need to scale up the implementation of multiple types of smart solutions in their premises, targeting changes to multiple work processes concurrently. SBs and SPs also see the need to draw on data extracted from these smart solutions to better understand the conditions of their properties and the resources utilised throughout the contract period so as to improve budget management.

However, SBs and SPs feedback that they have limited access to the data provided by the smart solutions. Hence, they were unable to perform analytics and correlate data from different sources to derive new insights and operation approaches. Monitoring and tracking the condition of their properties, and service performance of their vendors digitally is therefore impossible too.

Furthermore, from NEA's observations of the equipment available in market, existing solution offerings are typically built using proprietary protocols which might prevent data integration for seamless analytics presented using an intuitive graphical user interface. In addition, users of a certain brand of smart solutions will be restricted to view collated data based on what it was built for (e.g. historical trend charts). This creates problems to SBs and SPs such as:

1. Need to subscribe to multiple proprietary software solutions
2. Have to toggle between multiple dashboard user interfaces belonging to different smart solution providers in order to monitor property conditions through toggling between multiple dashboard user interfaces that each smart solution provides
3. Usage of data restricted to what the software was designed and built for
4. Inability to cross reference data inputs from multiple types of IoT devices to yield new insights and effect workflow improvements for building management

Technical Requirements:

To provide a Command and Control (C2) platform to interface with existing smart solutions used for ES management and operations. The C2 platform shall be the only platform required by SBs or SPs to manage the suite of smart solutions deployed in ES operations in future.

Suggested technical requirements are specified below. Applicants are encouraged to propose beyond the suggested requirements in order to achieve the specified desired outcomes.

1. The platform should have a **scalable** and **extensible** architecture that would allow management of devices, connectivity, data and security. It should also offer microservices or web services that could be used by applications to securely access data, devices, etc according to the rights given. Application(s) that is/are to be delivered as part of the platform, should offer the following to the end-users:
    a. Performance tracking and delivery of service(s) from service providers and compute a performance index automatically
    b. Automated generation of performance and service cost analysis reports to aid in activities such as tender budgeting and contract administration
    c. Real-time monitoring of sites' status via a unified dashboard
    d. Assign and alert service providers of ad-hoc, daily and periodic ES-related tasks *(e.g. cleaning of toilet or spillages, clearing of filled bins, rodent detection and elimination, etc)* based on audits, sensors data *(e.g. cameras, toilet sensors, rodent sensors, etc),* predictive analytics, etc. This should enable the automated deployment of robots or manpower.
    e. Automating repetitive backend administrative tasks *(e.g. manpower scheduling, monthly service provider performance documentation, calculation of disbursement of contract sums, data collation, etc)*
    f. Offer predictive analytics to aid in manpower and resource optimisation *(e.g. predicting maintenance needs, optimisation of workflow, easing administrative needs of contract administration and planning)*

2. All applications developed should be designed and developed with end-users in mind and take their cognitive load into consideration to ensure that they will be able to operate or use the platform with ease, thus reducing the resistance to adoption. As an example, older cleaning staff might face difficulty in learning digital platform or interpreting messages sent by the platform and this should be addressed.

3. As it is anticipated that different kinds and large number of devices would be connected to the platform, it should provide proper device provisioning and management features. For example, it should enable a systematic and secured approach for users to connect new devices to the platform, enable Over-the-Air (OTA) firmware update to existing connected devices (where applicable), monitoring of devices' health, determining or updating devices' location at various sites, etc.

4. New IoT sensors useful for monitoring environment conditions could also be included in your proposal. Some examples include IoT sensors that are able to detect water spillage, defective devices such as automatic faucet, automatic toilet flush, rodent detection, fill-sensors bins, etc. Such devices should be integrated as part of the platform to facilitate testing and evaluation. Aesthetic and practicality of device design should also be duly considered so that deploying the devices would not affect the aesthetic of the building due to protrusion and exposed trunking. It should be easy to deploy, e.g. without need for

wirings or tapping into power sources. The IoT sensors should also come with appropriate Ingress Protection rating with respect to the type of environment factors they would be subjected to.

5. An open platform is preferred that could support heterogeneous wireless network supporting different wireless standards such as WiFi, BLE, Thread, Mesh, etc commonly used by IoT devices and messaging protocols such as MQTT, DDS, XMPP, etc. Support for heterogeneous wireless network could be implemented via edge gateways or any other feasible means. It is well known that the different wireless protocols evolve and get upgraded over time and therefore the platform should preferably allow hardware, firmware and software upgrade. The wireless standards and messaging protocols are specified for reference and participants should clearly indicate the wireless standards and messaging protocol supported or why they are not supported.

6. With the recent advancement in implementing Artificial Intelligence (AI) at the edge to reduce bandwidth requirements amongst others, proposals can also look into the adoption of edge AI in the proposed platform where relevant to process information such as camera images to detect cleanliness, etc.

7. Data management capability to store and manage the collected data so that they could be retrieved later for processing by applications. Sources of data could be coming from deployed IoT devices, smart equipment or from data stored in databases on the cloud. Therefore, it would be necessary to support different data collectors to ingest data from a myriad of data sources. It should be possible to add new data collector plugins to support new data sources when the need arises. Furthermore, it would be desired that the data are processed so that they are structured into common formats such as XML, JSON, etc. for consumption by applications.

8. Connectivity management for management of device connections to the platform. This would be required for platform that plan support connections via wireless networks such as NB-IoT, LoRaWAN to manage activation, provide usage reports, billing, etc.

9. The platform should offer user management functions that enable user role and access permission to be configured. This is necessary to accommodate different level of users such as cleaners, cleaning supervisor, facilities management (FM) staff and managers. This would ensure that they would be given access only to data and information relevant for their job functions only.

10. The platform should offer availability of not less than 99% to ensure minimal downtime in the delivery of the ES in using the platform, and recommend a suitable backup scheme to ensure that the platform and its data could be recovered should the need arise, for example due to an attack or hardware failure.

11. The platform should be capable of scaling up for usage at the FM level.

12. Ensure ease of use whereby the platform could be set up and configured rapidly according to SB or SP requirements.

13. Solvers are to provide an onboarding strategy in their proposal elaborating the strategies and means to bring stakeholders into this project (e.g. smart solution vendors and service providers).

14. The platform shall ensure implementation of end-to-end security measures as recommended in the Singapore Technical Reference, **TR 64** (Guidelines for IoT security for smart nation) or otherwise to demonstrate cyber-physical security capabilities in the protection of platform and data from attacks.

15. The platform design could also reference **TR 50** (Technical Reference for IoT information and services interoperability for Smart Nation), which was developed to facilitate the sharing of IoT data and information across multiple industry applications.

Timeframe for development of proposed solution/product

Pilot (with Data analytics and AI capabilities) development within 12 – 15 months from notification of award.

Requirements of prototype

Meeting all the project scope as required by project owner(s).

Market Potential for proposed solution/product

1. Transformation of ES operations process from headcount to outcome-based, driven by data leading to manpower productivity improvement and cost optimisation

2. Scalable solution to tap into an increasing inclusion of IoT in the FM industry to support the growing trend of smart buildings and districts