

Problem Statement/Title: Interior glass cleaning robot for glass windows in buildings

Desired Outcomes:

To increase productivity (manpower and time) of the glass cleaning process, while ensuring safety of the public and cleaners

Background of Problem:

With the wide use of glass panels in building, there is a need to dedicate manpower resources to keep the glass surfaces clean. Currently, cleaners perform such tasks manually using cleaning agents, cloths and wipers. However, such tasks are labourious and dangerous especially when cleaning areas of certain heights.

The current window/glass cleaning regime at Changi Airport's Terminal 4 involves:

1. 6 monthly and Daily spot cleaning
2. Glass cleaning manpower rotated over 3 shifts per day (each shift lasts about 8 hours)
3. Areas for the cleaning includes high security areas and public areas (*e.g. Arrival/departure hall, gate holding rooms, lounges*)

As the airport has many high security areas, it is time consuming for the cleaners to clean certain areas. For example, for the cleaners to access the Gate Holding Room (GHR), a supervisor would need to unlock an unoccupied GHR for the cleaner to enter to clean the glass. Also, at the end of the cleaning of each GHR, the cleaner would need to wait for his supervisor to pick them up to the next GHR and so on.

In addition, the current cleaning process is time consuming as it involves the following process:

- For daily routine spot cleaning (reaching to clean glass panel less than 4m in height):
 - 1 cleaner deployed per shift, cleaning an average of 500sqm (*Each shift lasts about 8 hours*)
 - Cleaner to push a small-scale trolley consisting of 2 buckets (*clean water and dirty water*)
 - Cleaner to lay 2 long towel of approximately 1.5m each at the edge of the glass panel to absorb the dirty dripping water during cleaning process
 - Cleaner to use the duster, glass chemical bottle, water and a squeegee to clean the glass
- For 6-monthly cleaning (*cleaning entire glass panel of height above 4m*):
 - Daily routine to clean a set of high glass panels (an average of 500sqm of glass windows is cleaned for each glass cleaning activity)
 - Requires the use of scissor lift, boomlift, safety officer, deploy up to 10 stanchions to barricade cleaning sector, long runs of pipe (*up to 15m*), involving 4 cleaners wearing PPE for work at height
 - Given the limited manpower and extensive use of glass panel, each set of high glass panels are typically cleaned every 6 months.

There are robotic window and glass cleaners available in the consumer market which are designed for domestic applications. Apart from the need for a power cord, such machines

still require constant manual application of the cleaning detergent to the glass surface during the cleaning process. As such, there is a need to design a solution that is suitable for commercial applications.

Technical Requirements:

Proposers are open to propose either 1 complete solution or 2 separate solutions to fulfil the requirements for both the daily routine spot cleaning and the 6-monthly cleaning. Proposers are also open to propose a solution for either the daily routine spot cleaning or the 6-monthly cleaning.

This project(s) (*both the daily routine spot cleaning and the 6-monthly cleaning*) is to be divided into 2 phases (*i.e. to complete phase 1 before proceed to phase 2*):

- a. Phase 1: The device should be able to operate on its own with minimal intervention on both horizontal and vertical glass and metal cladding surfaces
- b. Phase 2: The device should have swarm intelligence capabilities to perform collaborative cleaning capabilities as a single unit or as a group to efficiently clean a wide surface area

Requirements to be fulfilled for phase 1, before proceeding to phase 2:

The device should meet the following requirements:

- a. Ensure safety for the cleaners and the public:
 - i. Safe for the cleaners to operate
 - ii. Should have a failsafe to prevent harm to public in case of malfunctions (*i.e. machine should not drop off vertical surfaces*)
 - iii. No higher than 60dba or within safe human range
 - iv. Strictly no emission of foul smell, or churning dust back to the environment or churning heat that will affect the ambience temperature
 - v. Tracker system to track location of the device
- b. To operate with minimal human intervention so that cleaners can be redeployment to other tasks:
 - i. Device should be portable - Weight should be less than 10kg with dimensions smaller than 600mm by 600mm
 - ii. A maximum of 1 cleaner to be allocated for transporting the device to the required cleaning area, and to operate the device in commencing its cleaning functions autonomously
 - iii. Once programed to commence its cleaning functions, it should be unmanned, cleaning on its own with an option for manual overwrite to take control
 - iv. Minimally be able to self-dose the cleaning agent to effect cleaning for a minimum of 2 hours per operation.
 - v. Autonomous process to ensure that the applied cleaning agent is removed/wiped away while ensuring that the water do not drip during the entire cleaning process.

- c. The following requirements should be met:
 - i. To be used in glass and metal cladding surfaces
 - ii. Should not leave behind any chemical residue, water streak, detergent or stain after cleaning
 - iii. Should be able to crossover at least 30mm(depth) by 30mm(width) obstacles for glass panels with frames
 - iv. Power source: Cordless
 - v. Charging time: Must minimally have a 1:1 charging ratio (*e.g. To charge 2 hours for 2 hours of use*)
 - vi. Monitoring and reporting system (*i.e. to have DVR or provide live video feed for remote inspection*)

Requirements for Phase 2

- a. To fulfil all the requirements in phase 1
- b. To include swarm intelligence capabilities to perform collaborative cleaning capabilities as a single unit or as a group to efficiently clean a wide surface area

Other information to be included in the proposal includes:

- a. Expected performance indicators
- b. Percentage increase in cleaning productivity (*e.g. reduction in the need for cleaning crew, eliminate the need for cleaners to clean at height*)
- c. Charging cycles
- d. User friendliness of the device

What solutions you are not interested in (if any)?

- Systems that are not cost effective
- Systems that requires significant human intervention during operation

Timeframe for development of proposed solution/product

After start of project (About 15 months' project cycle)

Phase 1 (9 months)

- Completion of site evaluation, concept design & detailed design 2 months after start of project
- Completion of working prototype ready for trial 5 months after start of project
- Trial, evaluation and refinement of working prototype at CAG T4 for 4 months

Phase 2 (4 months)

- Upon successfully trial of the working prototype for phase 1, 2 months to be allocated to include the phase 2 requirements in the existing working prototype
- Trial, evaluation and refinement of working prototype at CAG T4 for 2 months

Completion of fully functional end product ready for pilot deployment 2 months after successful trial for phase 2

Requirements of prototype

Prototype should minimally comply with the points listed under Technical Requirements.

Market Potential for proposed solution/product

Recognising the use of glass is prolific in Singapore's built environment, there is potential for this product to be used in commercial indoor glass cleaning operations.