

Project Title

NUHS Group Facility Management Strategic Transformation - From Preventive to Predictive Maintenance

Project Lead and Members

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- Mr. Leong Kim Teck, Assistant Director, Group Facilities Management, National University Polyclinics (NUP)
- Ms Low Jie Ling, Manager, Group Facilities Management, Ng Teng Fong General Hospital & Jurong Community Hospital (NTFGH & JCH)

Organisation(s) Involved

National University Health System – Group Facilities Management

Healthcare Family Group(s) Involved in this Project

Healthcare Administration

Applicable Specialty or Discipline

Facilities Management, Engineering

Project Period

Start date: 2019

Completed date: On-going

Aims

To leverage on technology to improve workplace safety, efficiency, productivity and to develop a future ready engineering workforce

Background

See poster appended/ below

Methods

See poster appended/ below

Results

See poster appended/ below

Lessons Learnt

The implementation of Building inspection by Drone and IoT sensor systems are unconventional for FM in hospitals. Stepping up from the conventional preventive and legacy approach to predictive mode with the help from technology have improve the workplace safety, efficiency, productivity and also produce tangible outcomes.

There are endless possibilities with drone deployment and IoT Sensor Systems. For example, the drone can also be deployed to augment security and to conduct constant surveillance at vital facilities (water tanks, power plants) in NTFGH / JCH, NUH and AH.

And, IoT Sensor System can also be implemented at user departments where the sensors deployed can help to better monitor and manage the room indoor air quality and temperature. This not only allow hospital to monitor and analyse the energy usage at localised area or department it can help to educate user to understand and improve energy management aligned with NUHS and National Green Plan direction. NUHS-GFM have progressively rolled-out the installation of IoT sensors as there were tangible results achieved.

Conclusion

See poster appended/ below

Additional Information

2022 National HIP Best Practice Medal – Automation, IT & Robotics Innovation

Project Category

Technology

Digital Health, Sensors, Data Analytics

Care & Process Redesign

Value Based Care, Operational Management

Keywords

Digital Transformation, Preventive Maintenance, Predictive Maintenance,
Sustainability Innovation

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NUHS GROUP FACILITY MANAGEMENT STRATEGIC TRANSFORMATION – FROM PREVENTIVE TO PREDICTIVE MAINTENANCE

MEMBERS:

NG KIAN SWAN (LEAD),

KELVIN QUEK, KOH YONG LEE, JONSON SOFIAN TEO, KUAN KWOK YEW, LEONG KIM TECK, LOW JIE LING

- SAFETY
- PRODUCTIVITY
- QUALITY
- COST
- PATIENT EXPERIENCE
- EFFECTIVENESS

Background

Opportunity for Improvement

NUHS Group Facility Management (NUHS GFM) is an important key in keeping the NUHS hospitals operate smoothly whilst maintaining a safe and healthy environment conducive to meeting the needs of patients, staff and the public.

Hospital Facilities Management (FM) is manpower-intensive and has inherent inefficiencies as the process rely heavily on hard copies and manual workflows. For the longest time, FM heavily dependent on labour and manual workflows where these are prone to errors and lapses, if not safety risks. In 2018, NUHS GFM embarked on a “Go Digital Journey” and moved from Preventive to Predictive Maintenance. Preventive maintenance is typically scheduled based on our operating experience with an asset class, and it’s usually time-based. With Predictive Maintenance, GFM, NUHS is able to leverage on technology to improve workplace safety, efficiency, productivity and to develop a future ready engineering workforce.

With FM operations growing fast and an aging workforce, continuing with the traditional manual operations, including using the conventional preventive maintenance approach is no longer sustainable and effective

Establish Baseline Measures

Definition

- Building inspection by drone** helps to reduce the operational risk and improve safety of the workers at much lower cost. It eliminates the needs for the worker to work at heights or having to walk at ledges or narrow platforms.

	Traditional Building Inspection	Drone Inspection conduct by Specialist	Training our engineers to use Drone for building inspection.
Resources	Total: 5 manpower · 3 Certified Gondola Specialists · 2 FM Engineers · 1 Workplace Safety Officer	Total: 2 manpower · 1 Licensed Drone Specialist · 1 FM Engineer	Total: 2 FM Engineers with licensed Drone certifications
Time	Average 2 to 3 months of setup and inspection depending on size & height of buildings.	Average 2 to 4 hours per inspection	Average 4 hours per inspection
Cost	Average \$28,000 per tower NTFGH x 3 buildings: \$84,000 NUH x 7 buildings: \$196,000	Average \$9,000 per tower NTFGH x 3 towers : \$27,000 NUH x 7 towers : \$63,000	\$10,000 per set up NTFGH x 3 Buildings: \$1,600 for licenses and training NUH x 7 buildings: \$1,600 for licenses & training
Frequency	Once every 5 years	Once Per Year (5 inspections over 5 Years)	Twice Per Year (10 inspections over 5 Years)

- Internet of Things (IoT) Sensor Systems:** The most obvious benefit of IoT-enabled temperature and water level monitoring in our hospitals is to provide continuous monitoring, reduces the need for intense manual labor to carry out on-site physical inspection and triggers critical alerts that enable swift response and rectifications to mitigate the risks of hospital flooding and fire.

	Impact of Incident With Manual Inspection	With IoT
Maintenance Mode	Reactive mode when fault happened	Proactive approach to resolve before fault escalated
Manpower	2 to 6 technicians 2 to 6 housekeepers Depends on severity of the breakdown/ Incident.	1 technician
Time	2 to 8 hours to rectify breakdown	~30 minutes for site assessment and deploy countermeasures
Cost	Average \$1,000 to \$10,000 Depending on severity of the breakdown and damage recovery required. Compromised patient care, safety of patients, staff and members of the public are affected, huge financial impact on hospital operations, hospital reputation and damaged equipment.	\$50 to \$100 (cost of technician to initiate the assessment and deploy countermeasures)
Frequency	Daily manual inspection by areas	Real time monitoring 24/7, 365 days

- Touchless technology in lifts** allow the lift user to call lift car and select the lift floor without physically touching the lift button. This has greatly reduced the contact point as compared to the conventional touch operation where there is physical contact between lift user and the lift button.

Analyse Problem

With aging infrastructure and growing populations, hospitals will strain under the pressure and may place patient and employee health and safety at risk. Alexandra Hospital, National University Hospital, Ng Teng Fong General Hospital and Jurong Community Hospital are member institutions under NUHS. The buildings’ age ranging from 7 years to 87 years and keeping these facilities safe and operational requires a dedicated approach that goes beyond just “fixing what’s broken” and hoping that the rest of the hospital operation stays up and running. As buildings age, it requires even greater effort to maintain and sustain a safe and healthy environment conducive for patients, staff and the public.

Facilities Management is manpower-intensive and has inherent inefficiencies, as information and process flow rely heavily on hard copies and sequential workflows. There is also a lack of precision with respect to the requirements of a specific asset and when it should be serviced. Failure of critical hospital infrastructures, due to aging, human errors and lapses can cause disruptions to hospital operations and impact on patient care and create safety related issues for patients, employees and members of the public.

Select Changes

- The first is the new approach to shift from a labour-intensive preventive maintenance to predictive maintenance and using technology and data-enabled operations.
- For greater efficiency and better governance, inefficient layers and duplicated efforts in FM processes are to be eliminated. This is supported by using lean management tools and a common and collaborative platform with real-time information. Processes are streamlined and standardised to ensure an effective oversight of FM operations and the performance of contractors.
- Digital transformation was achieved by integrating technology in NUHS facility management services, automating processes and embracing the potential of Internet of Things (IoT) to improve turnaround time for response and recovery and user experience.
- By leveraging on technology and IoT (Internet of things) and AI (artificial intelligence) it helps us to transform the way hospital FM is undertaken, improve operational efficiency and workplace safety whilst maintaining a safe and healthy environment conducive to meeting the needs of patients, staff and the public.
- NUHS GFM embarked on the three (3) major projects to improve the Safety, Efficiency and Productivity, namely:
 - Building Inspection by Drone**
 - IoT Sensor systems**
 - Touchless technology to improve infection control**

Test & Implement Changes

Building Inspection by Drone

NUHS is the **FIRST** cluster to use drones to perform building façade inspection. Building inspection by drone helps to reduce the operational risk and improve safety of the workers at much lower cost. It eliminates the needs for the worker to work at heights or having to walk at ledges or narrow platforms.

Using IoT Sensors to improve operational efficiency and workplace safety

IoT sensor systems to monitor sewer inspection chamber waste water levels

- NUHS GFM uses IoT sensor to predict when maintenance is needed before the infrastructure / equipment fails and causes a risk to patient safety. This type of predictive maintenance keeps the hospitals running smoothly, ensure patient received the best possible care, mitigate risk of damaged expensive equipment due to fire or flooding
- The effects of flooding can be disastrous to hospitals. In a very little time, flood water has the ability to cause irreparable damage to equipment and major disruption to hospital operations.
- NUHS is the first healthcare cluster to introduce IoT sensor system at sewer line to monitor the waste discharge water levels. By installing wireless IoT sensor system in the inspection chamber, the water level monitoring can help to improve the visibility on potential overflow/flood situations or wastewater backflow caused by sewer line blockage.

IoT sensor systems to monitor ambient and system temperature

- One of the main triggers for hospital fire is the continuous and overcharging of certain types of medical equipment, battery banks or overheated system.
- NUHS GFM uses IoT thermal sensors to monitor the ambient/ system temperature of specific rooms such as plant room, UPS rooms at real time. This arrangement helps to mitigate the risks of explosion / fire.
- Patient safety presents another top concern. In hospitals, uninterrupted access to power can mean the difference between life and death. Hospitals need constant, reliable power to feed medical instruments, life support machines, and diagnostic equipment. IoT sensor monitoring in the electrical plant room ensure reliable electrical power to critical areas, identify potential issues before a power failure occurs.

Touchless technology in the visitor lifts - Improving infection control and reduce the transmission of bacteria/ virus

- At the time of growing fear around the spread of COVID-19 virus, we had witnessed visitors using sharp/hard object to press on lift buttons. These actions had resulted in damaged lift buttons and affected the lift operation. GFM team had to engage the lift vendor to replace the damage lift buttons.
- Through the observation and verification of the frequent damaged lift buttons, GFM decided to try out the Touchless technology in lift to improve visitors experience and further improve infection control and reduce the transmission of bacteria/ virus.
- NTFGH is the **FIRST** hospital to roll out touchless technology in the visitor lifts to improve infection control and reduce the transmission of bacteria/ virus. Visitors just need to hover their finger near the button that they want to press. The lift buttons still work if pressed and have braille markings for the visually impaired.
- Using the Touchless technology in visitor lift also helps to reduce the dependence of housekeeping workforce. Housekeeping resources are redeployed to critical areas like emergency department, fever tents, etc during the COVID-19 circuit breaker period.

Key Outcome and Results

Building Inspection by Drone

By using drones to conduct hospital building inspections at **AH, NUH, NTFGH and JCH**, we achieved the following results:

- Enhanced Workplace Safety** - eliminate the need for workers to work at heights for building inspection thus greatly reduce workers or objects fall from height.
- Cost Savings** - Minimally 50% manpower savings.
- Accuracy** - Ability to inspect hard to reach locations – Drone is able to inspect the higher pitched roof structures or hard to reach locations.
- Increase productivity and efficiency** – Less FM resources being deployed to facilitate and conduct the inspections.
- Quick inspection and data sharing** – The image analytic/processing tool is able to analyze the image captured by drone to identify the faults. The entire process takes much lesser time compared to traditional approach.
- Regular inspections** – Traditional building inspections using gondolas typically take about 2 to 3 months to setup/dismantle and conduct the inspections. Whereas for drone inspection, there is flexibility in planning and inspection can be carry out according to hospital operations. With the quick setup for drone inspection, hospitals can carry out regular inspections leading to better governance and oversight and early detection of defects.
- Zero incident** of falls as no staff is required to physically access the high-risk areas. Gone are the days where building and roof inspections require workers to scale ladders, rent gondolas, use scaffolding equipment, walk on ledges or weak roofs which are risky and expensive.

Using IoT Sensors to improve operational efficiency and workplace safety

IoT sensors acts as a monitoring and warning tool. The data captured by IoT sensor system is capable of further analysis in term of trending, usage, frequency of threshold limit occurrence, timing etc for better monitoring and prediction to enable GFM to plan for improvement or system reconfiguration.

- Early detection of sewer blockages at NTFGH enable NUHS GFM staff to rapidly deploy countermeasures thus preventing the backflow/ overflow of waste water into patient areas.
- IoT-enabled temperature monitoring in the UPS room at JCH triggered critical alerts when the 3 battery banks in UPS room. Were bloated and the room temperature range exceeded threshold level. Corrective measures were quickly put in place to mitigate the risks of batteries explosion and hospital fire.

The use of IoT offers NUHS GFM staff a holistic view of the health status and performance of relevant systems at any given time, even when they are not physically present. This type of predictive maintenance provides early warning notification and diagnosis of FM issues days, weeks or months before failure. This helps to improve workplace safety, minimise disruption to hospital operations, reduce equipment downtime, increase reliability, and improve performance while reducing operations and maintenance expenditures.

Using the Touchless technology in visitor lifts

This initiative improves visitor experience, infection control and reduce the transmission of bacteria/ virus. It also helps to reduce the dependence on housekeeping staff to clean the lifts. There is also great teamwork and support among the GFM, Housekeeping and Hospital Infection Control Teams.



Spread Changes, Learning Points

The implementation of Building inspection by Drone, IoT sensor systems and Touchless technology in visitor lifts are unconventional for facilities management department in hospitals. Stepping up from the conventional preventive and legacy approach to predictive mode with the help from technology have improve the workplace safety, efficiency, productivity and also produce tangible outcomes. There are endless possibilities with drone deployment and IoT Sensor Systems to make our hospital safer, smarter and sustainable!