PUB SINGAPORE'S NATIONAL WATER AGENCY

# R&D and Smart Initiatives of Water Supply (Plants) [WSP] Department

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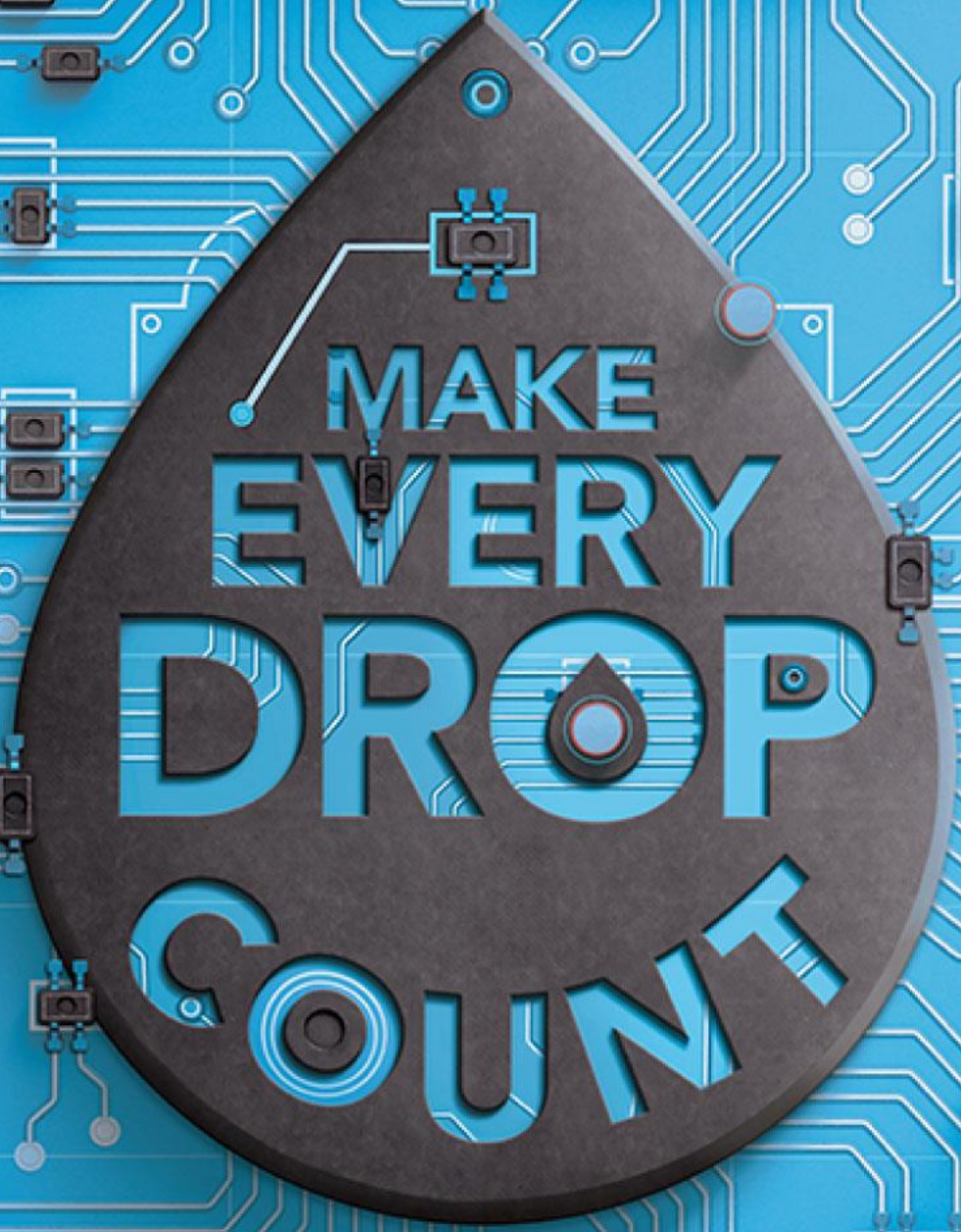
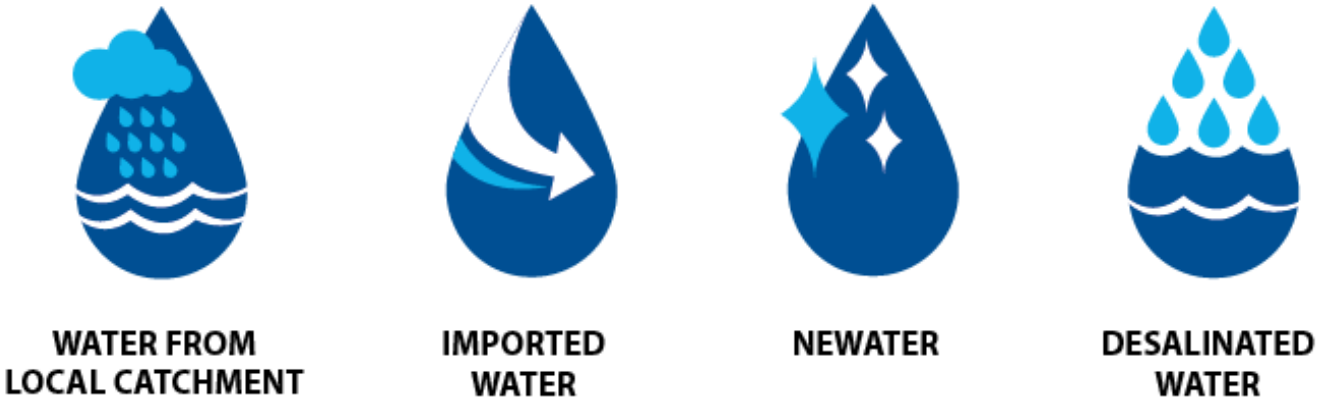


# WSP's Mission: Supply Good Water

To provide an adequate and affordable supply of safe drinking water.

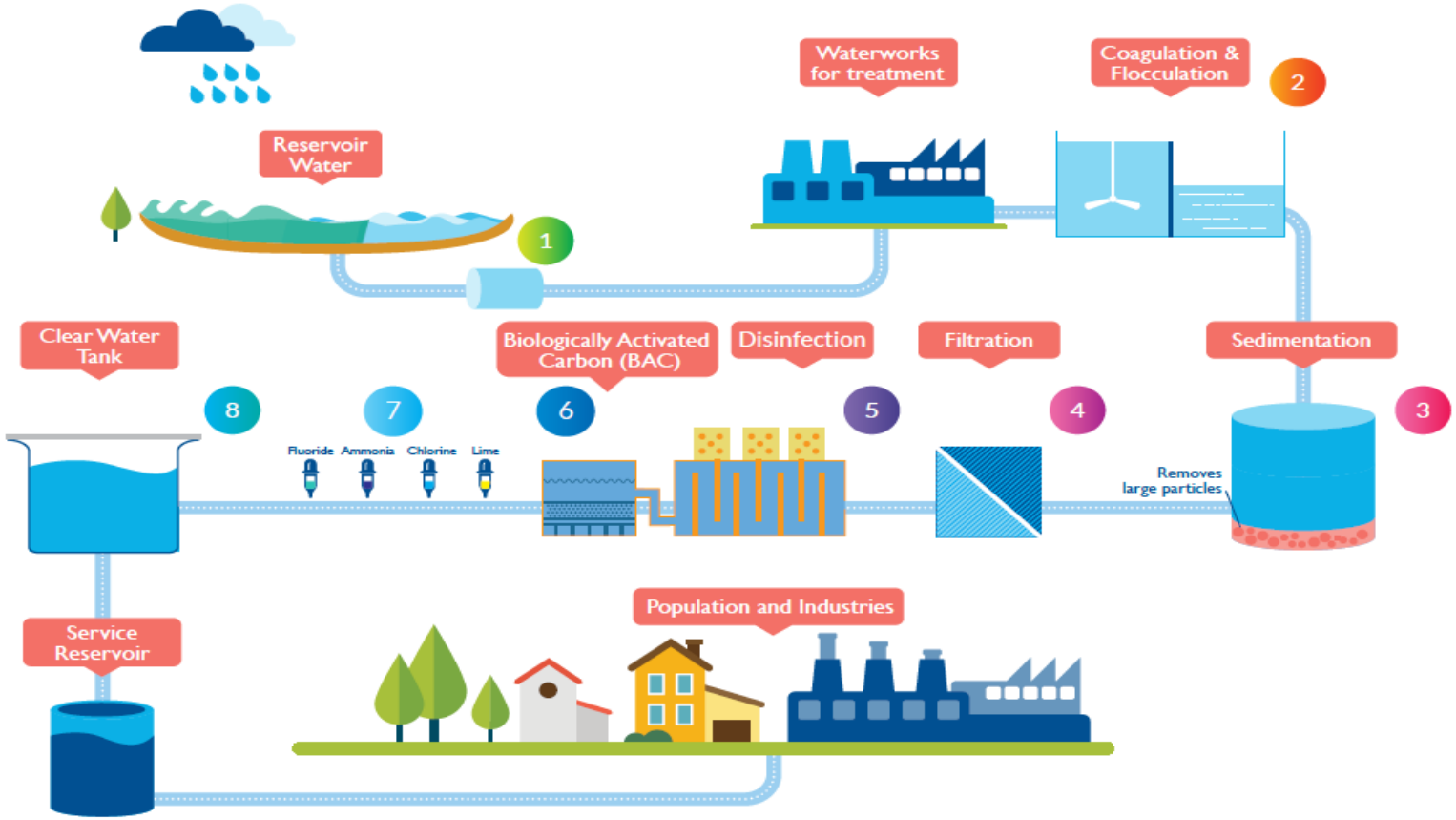
Operate and maintain Water Treatment Plants and Desalination Plants to produce safe drinking water to meet domestic and economic demand.

## 4 National Taps



# From Source to Tap: PUB's Water Treatment and Water Quality Monitoring Process

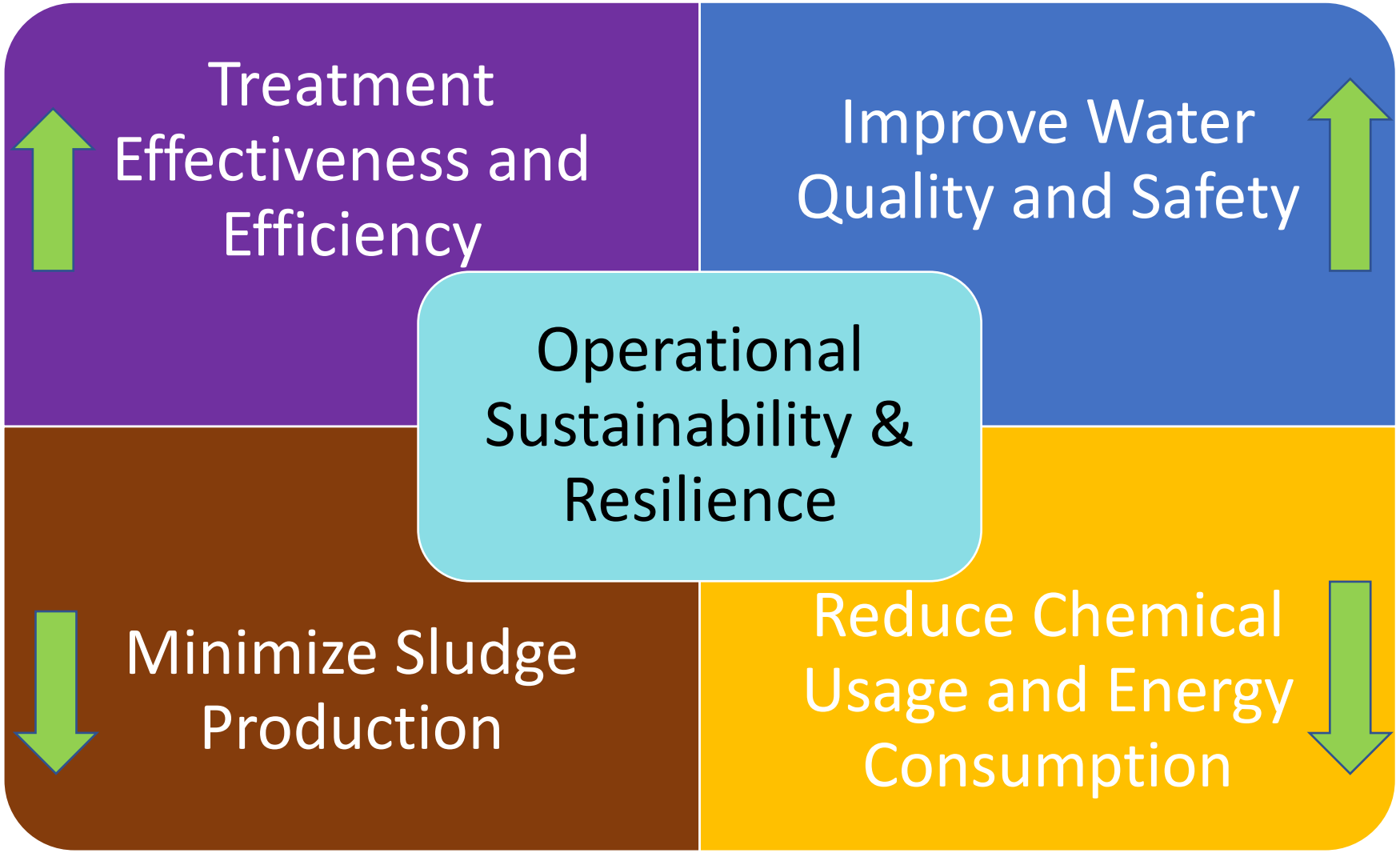
In Singapore, raw water from reservoirs is conveyed by pipelines to the waterworks where it is chemically treated, filtered and disinfected. The treatment process removes harmful bacteria and suspended particulate matter, making the water clear, sparkling , odourless, colourless, and safe for drinking. This multi-barrier water treatment process, together with our comprehensive on-line monitoring, sampling and control system, ensures water that arrives at our taps is well within the World Health Organisation (WHO) guidelines for clean drinking water.




1. **Screening:** Water is pumped through self-cleaning screens to remove particles greater than 1mm.
2. **Coagulation & Flocculation:** Coagulants and coagulant-aids like alum (aluminium sulphate) are added to bind or "flocculate" smaller suspended matter and particles, such as silt and sand, to form larger and heavier clumps.
3. **Sedimentation:** Particles combine into larger clumped particles that settle to the bottom of the tank and are removed.
4. **Filtration:** The water then passes through either rapid sand filter or membranes to remove the finer residual particles of up to 0.02 microns.
5. **Disinfection:** After filtration, the water is disinfected with chlorine or ozone to kill all harmful bacteria and viruses.
6. **Biologically Activated Carbon (BAC):** Granular activated carbon filters remove natural organic matter, making the water biologically-stable.
7. **Residual Treatment:** The water is dosed with lime (to balance the pH of water), chlorine and ammonia (to maintain the water quality in the distribution system), as well as fluoride (to prevent tooth decay).
8. **Clear Water Tank:** After residual treatment, water is stored in the clear water tank, before pumping to the service reservoirs for distribution to customers.

*Figure: PUB's Water Treatment Process and Water Quality Process, reference from [www.pub.gov.sg](http://www.pub.gov.sg)*

# WSP R&D Key Drivers



# New Process: Ceramic Membranes


Waterworks:

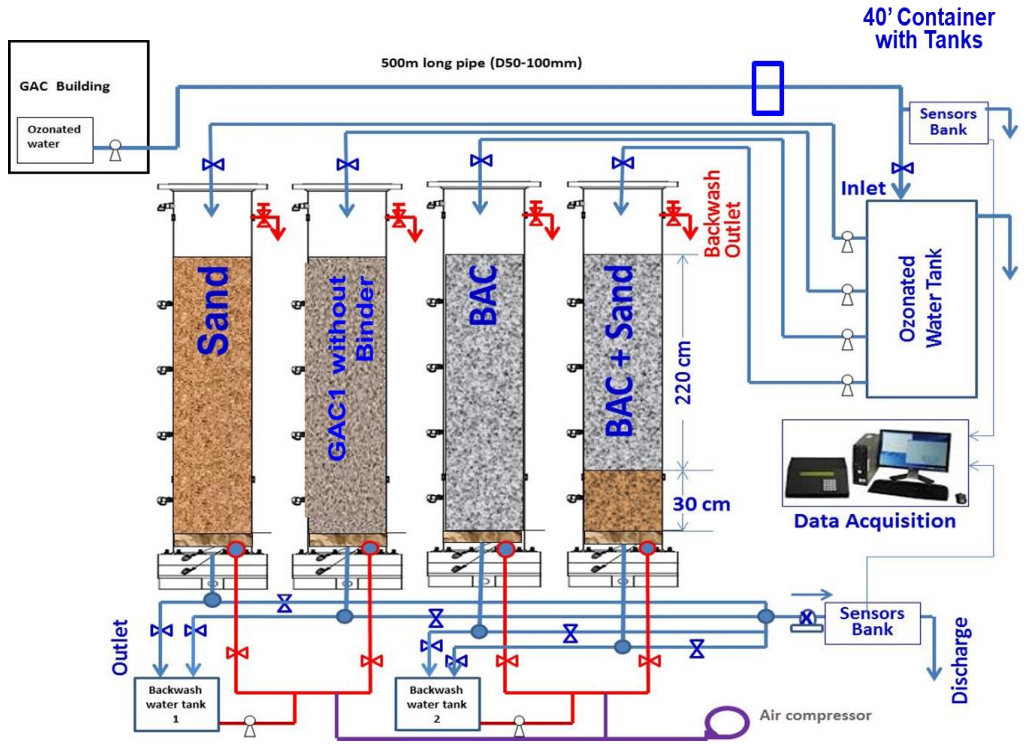
- CCKWW: World Largest Ceramic Membrane Plant
- Investigation and optimization of ozone ceramic membrane process

Desalination Plants:

- Ceramic Membrane  Pre-treatment for RO Desalination

# Optimization of existing process: Ozone – Biological Activated Carbon (BAC)

- To enhance the biological stability of final treated water
- Evaluation of various media types
- Optimization of existing process




# PUB Global Innovation Challenge: Seamless Coagulation Control

## Challenge Statement:

How might we determine the required coagulant dosage in water treatment processes using new means that are faster, connected and automatic?

## Project Outcome:

A prototype system validated at one of PUB facilities to provide real-time continuous predictions of optimal coagulant with at least 85% correlation with jar test results. The proposed solution should target a reduction of 20% in coagulation costs while maintaining water quality under fluctuating raw water quality conditions.

# Opportunities for Collaboration

- Innovations in process control for better water treatment operations
- Innovative membrane applications (ceramic membranes, ozone-resistant polymeric membranes, what else?)
- Alternative desalination pretreatment process (smaller footprint, better treatment efficacy)
- Resource recovery, waste as resource (recover chemicals from brine, recover nutrients and metals from sludge…)

# WSP's SMART Plants: Ready for the Future

## Smart WSP Plants

Address manpower constraints

Reduce energy consumption and chemical usage

More effective operations, Optimise Asset Management

Enhance workplace safety and security

### SMART OPERATIONS

Artificial Intelligence
IoT Sensors
Data Analytics

### SMART MAINTENANCE

Data-driven
IoT Sensors
Machine Learning
Robotics

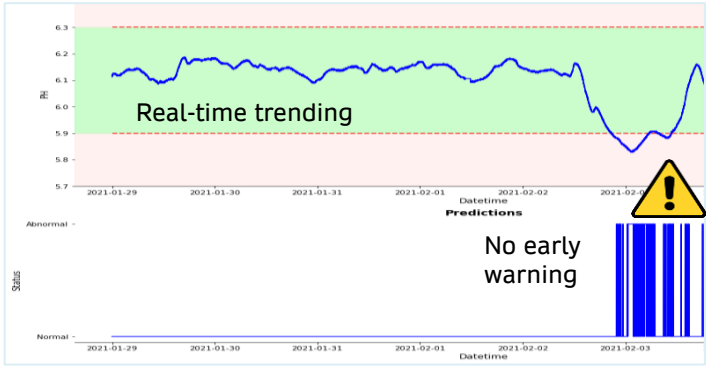
### SMART SAFETY & SECURITY

Video Analytics & Automation
Robotics

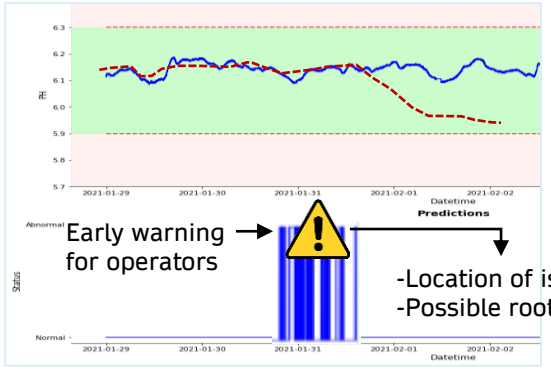
## Technology as key enabler

# Process Digital Twin with Predictive Capabilities

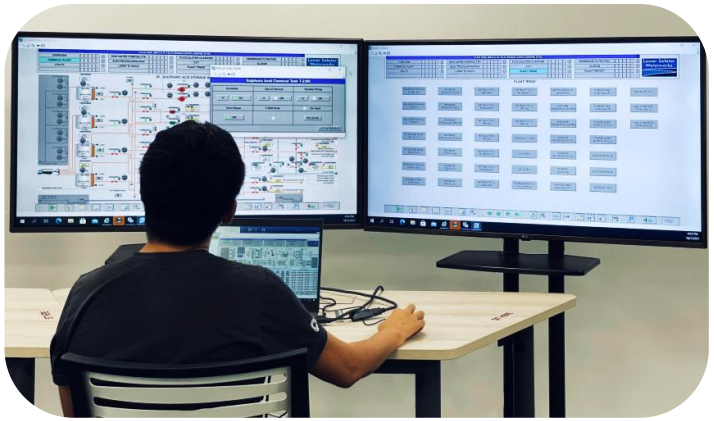
## *From Response-based to Prediction-based Operational Control*




**Today** Operators react to operational alerts when anomalies are detected. Experience of operators to pre-empt ensuing issues is decisive.




Operator Training Simulator



**Future**

- Synchronizes with plant monitoring system to provide real-time water quality predictions
- Double up as training simulator to continuously upskill operators with existing and new operational scenarios

✓ **Less output disruptions with Process Digital Twin**
✓ **Shorten learning curves with Training Simulator**

# Re-engineering and Automating Operations

***From Semi-auto Chemical Operations to Fully Automated Chemical Management***


Chemical Delivery


Forklift Transfer


Ordering/ Scheduling → Delivery/ Payment → Batching

Data driven | Automated weigh bridge | Robotics System

- Eliminate manual tasks with process re-engineering
- Reduce manual intervention by leveraging on technology
- Improve work safety and eliminates hazardous work environment risks

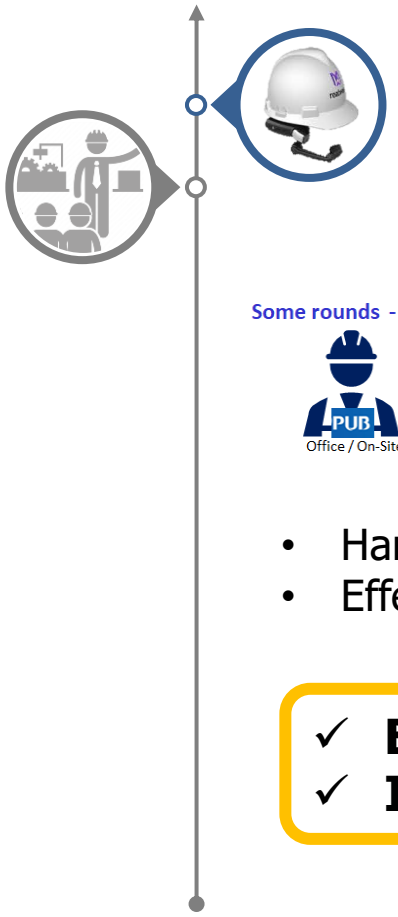
✓ **Safer work environment**
✓ **Automated tracking of chemical consumption**

# On-the-Go Remote Supervision Capabilities

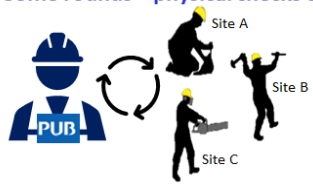
## *From On-site Supervision to On-the-go Supervision*

*All Rounds (AM, PM) – physical checks at site

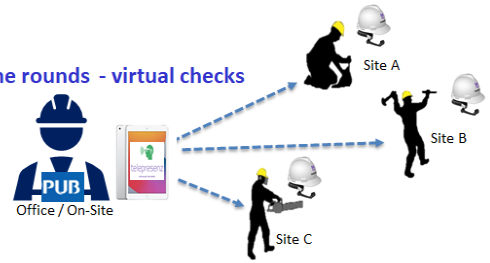

On-site supervision



Some rounds – physical checks on-site




Some rounds - virtual checks




Worker at Site A

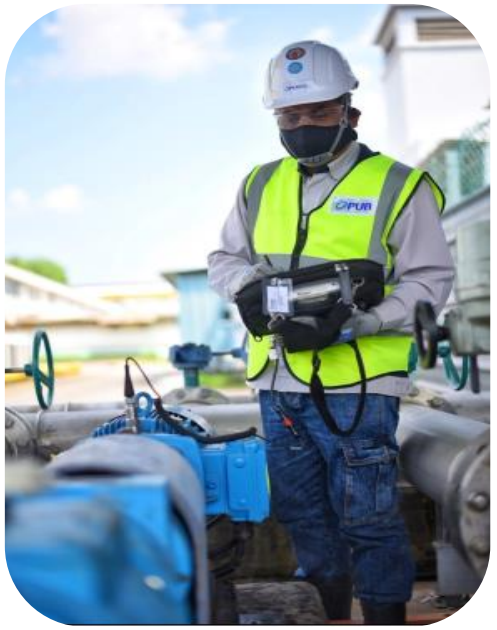
Plant officer at Site B conducting virtual checks on Site A via iPad

- Hands-free smart headsets to assist and guide maintenance work on-the-go
- Effective real-time remote supervision of multiple work sites

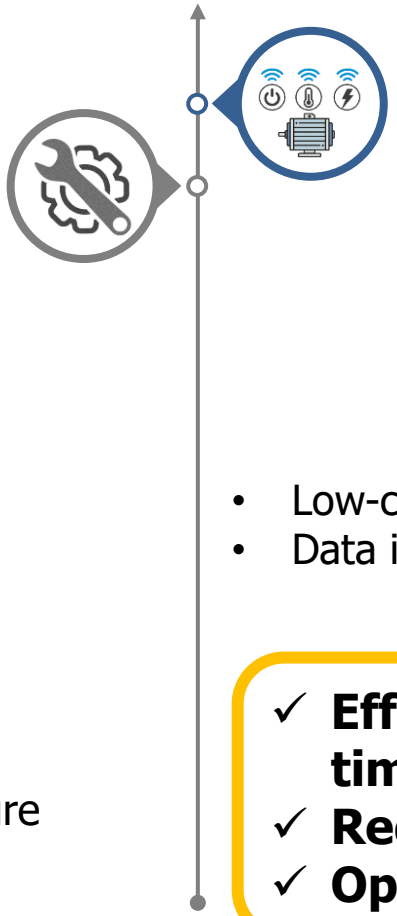
✓ **Enable effective remote work supervision**
✓ **Improved situational awareness**

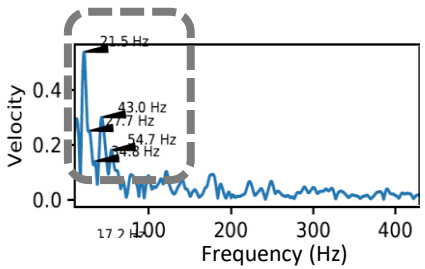
# Predictive Maintenance with IoT Sensors

***From Periodic Preventive maintenance to Online Predictive maintenance***

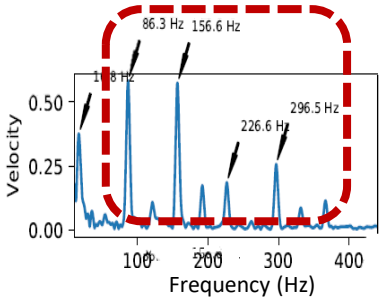


Pumps periodically serviced to ensure operational readiness and reliability






Normal condition:
Vibration spectrum with peaks at normal motor operation



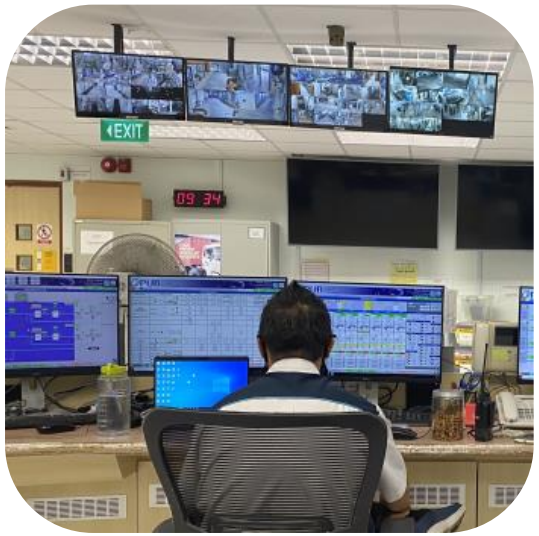

Motor after operation for some time:
Vibration spectrum with new peaks at higher frequencies

- Low-cost IoT sensors with performance and condition monitoring analytics
- Data insights to inform maintenance and asset management guidelines

✓ **Effective decision support tool to inform accurate time-based and performance-based maintenance**
✓ **Reduce unplanned equipment breakdown**
✓ **Optimise maintenance costs & asset management**

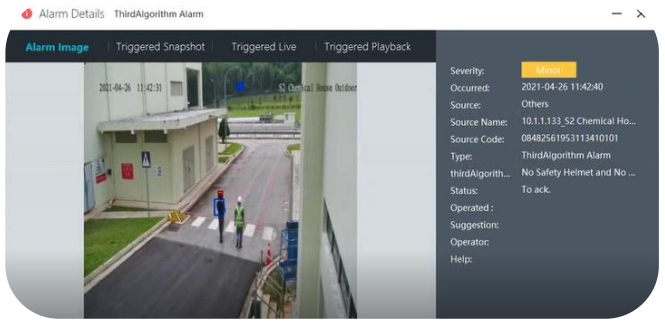
# 24/7 Surveillance with Video Analytics

***From Manual footage inspection to CCTV with Video Analytics capabilities***

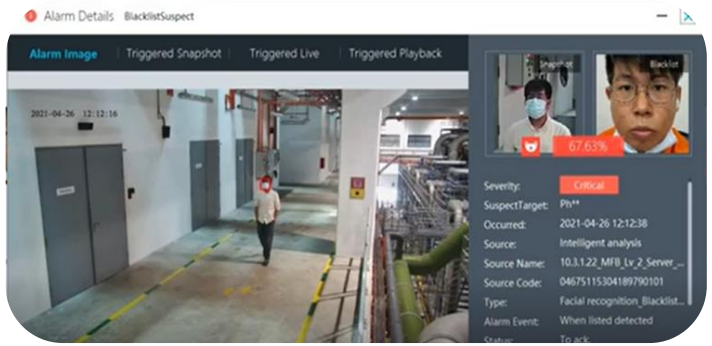



Footages manually reviewed for security breaches, unsafe acts

**Able to detect personnel not wearing proper Personal Protection Equipment (PPE)**




**Facial recognition & Tripwire → Able to detect unauthorised entry within the plant**



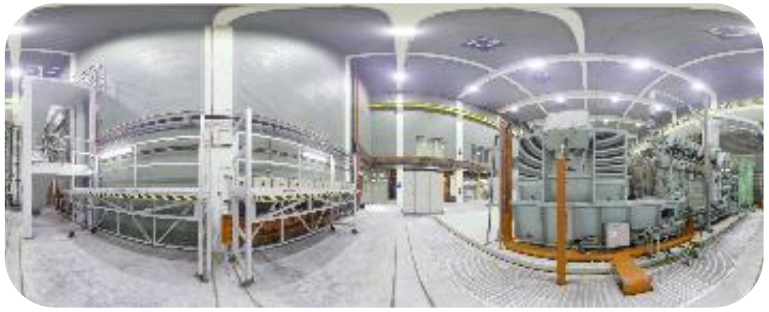

- Video analytics automatically detect and flag out security and safety infringements
- Enhance work safety and plant security surveillance

✓ **Real-time alerts leveraging on video analytics to enhance workplace safety and plant security**
✓ **Staff can focus on higher value work**

# 3D Structural Digital Twin & Smart Wearables

***From Manual on-site verification to Remote sensing and verification***


Operators in control room or office might be unaware of incidents at site



3D Structural Digital Twin to navigate and view site situation at real-time

Smart Wearables for location tracking & vitals tracking

- Immediate alerts to notify control room of safety incidents
- Navigate remotely using 3D visualisation to verify site conditions

✓ **Immediate alerts on safety incidents**
✓ **Enable swift response to emergencies**
✓ **Improve situational awareness and appreciation**

# Opportunities for Collaboration

**Smart Water Treatment Plants:**

- Predictive operational control systems – AI, data analytics, acoustics, image and video analytics
- Automation and Robotics in chemical operations and water quality sampling/ testing
- IoT sensors with data insights for predictive maintenance and asset management
- SMART tech for workers' safety and plant security

**Upcoming Tenders:**

i. Supply, Delivery, Installation & Commissioning of Instruments, Analysers, Wifi Infrastructure & Network Cameras at Tuas South Desalination Plant – 4Q 2021
ii. Various tenders on Chemical Systems at Plants – 4Q 2021
iii. Choa Chu Kang Waterworks Reconstruction – 2Q/3Q 2022
iv. Various tenders on Instrumentation and Control Systems at Plants -3Q 2022

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# THANK YOU