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# Digital Twin Development Implementation, and Results for the Changi WRP, Singapore

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# What is a Digital Twin?

- A digital representation of a physical system coupled with real-time data, that can be used for synthetic data generation, scenario analysis, performance prediction and operational optimization
- It is more than "just" a fancy model, it has automated real-time data input



## Changi Water Reclamation Plant (CWRP) Singapore



- Operated by Singapore Public Utilities Board (PUB)
- Currently treating an average of approximately 920,000 m3/d of used water
- Fed by a deep-tunnel sewer system
- Currently four bioreactor trains. Each train includes primary treatment and a parallel MBR and 5-pass step-feed bioreactor
- Most effluent is used for indirect potable reuse
- Solids include thickening, mesophilic anaerobic digestion, dewatering and drying

# **Changi WRP Digital Twin Research Project**

- A research collaboration between PUB and Jacobs in the development and application of a Digital Twin of CWRP
- The Digital Twin includes models of:
  - Full plant Hydraulics (liquids and solids)
  - All major process controls
  - Biochemical Process
- All implemented on a dedicated server with realtime data feed



### **Overall Digital Twin Structure**



#### **Changi WRP Process Flow Diagram Overview**



# **CWRP Replica™ Hydraulics and Control Model**



#### **CWRP Sumo Process Model**

• 169 biological reactors and imports 1,200 SCADA/LIMs tags



#### **CWRP Sumo Process Models**

 Reduced Models, with settings from full DT Model are used for Scenario Analysis (left) and Performance Forecasting (right)

![](_page_8_Figure_2.jpeg)

# Live Automated Data feed defines a Digital Twin

- Outlier detection identify anomalous data through various analytical methods
- Infilling: Both on-line and laboratory bad/missing data
- Process Deviations

![](_page_9_Figure_4.jpeg)

![](_page_9_Figure_5.jpeg)

#### **CWRP Influent Soft Sensor**

Use the model to estimate dynamic raw influent concentrations based on data from other locations

![](_page_10_Figure_2.jpeg)

# **Soft Sensor Results**

- 6 months of results
- Blue dots are measurements
- Orange are daily average results
  - Top: COD
  - 2<sup>nd</sup>: TKN
  - 3<sup>rd</sup>: Ammonia
  - 4th: Total Phosphorus

![](_page_11_Figure_8.jpeg)

# **Full DT Model Results**

- Influent from the Soft sensor is fed into the full DT model and model results are compared against historical measured values
- Results are plotted on the operations graphical user interface

![](_page_12_Figure_3.jpeg)

# **Scenario Evaluation**

- Each day, three operational scenarios are automatically evaluated to provide operations with information on the ability of the plant to handle planned and unplanned outages
  - 1. A basin is taken out of service
  - 2. A secondary settling tank is taken out of service
  - 3. WAS is limited/halted

![](_page_13_Figure_5.jpeg)

#### **CWRP DT Forecast Data Path**

![](_page_14_Figure_1.jpeg)

#### **CWRP Forecast Examples from GUI**

![](_page_15_Figure_1.jpeg)

- 5<sup>th</sup>%ile = Dashed Blue
- Median = Green
- 95<sup>th</sup>%ile = Dashed Red

![](_page_15_Figure_5.jpeg)

#### **Current Status**

- The digital twin will not have any direct control authority and operate in an ADVISORY ONLY mode (for now)
- It is important that the trust of management and operations is in place prior to any active control functions
- COVID...
  - The CWRP Digital Twin servers were installed in February at CWRP
  - Currently running

# Conclusions

Changi WRP Digital Twin replicates all significant aspects of a facility on a digital platform, Hydraulics, I&C, Process

Benefits:

- Increasing Productivity with: Real-time operation insights and process trouble-shooting.
- Enhancing Resilience of Operations by: Moving from Reactive to Proactive
- Optimize critical operation scenarios

![](_page_17_Figure_6.jpeg)

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# **QUESTIONS?**

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Bruce R. Johnson, PE, BCEE, IWA Fellow Singapore International Water Week 2022

![](_page_19_Picture_3.jpeg)

![](_page_19_Picture_4.jpeg)