

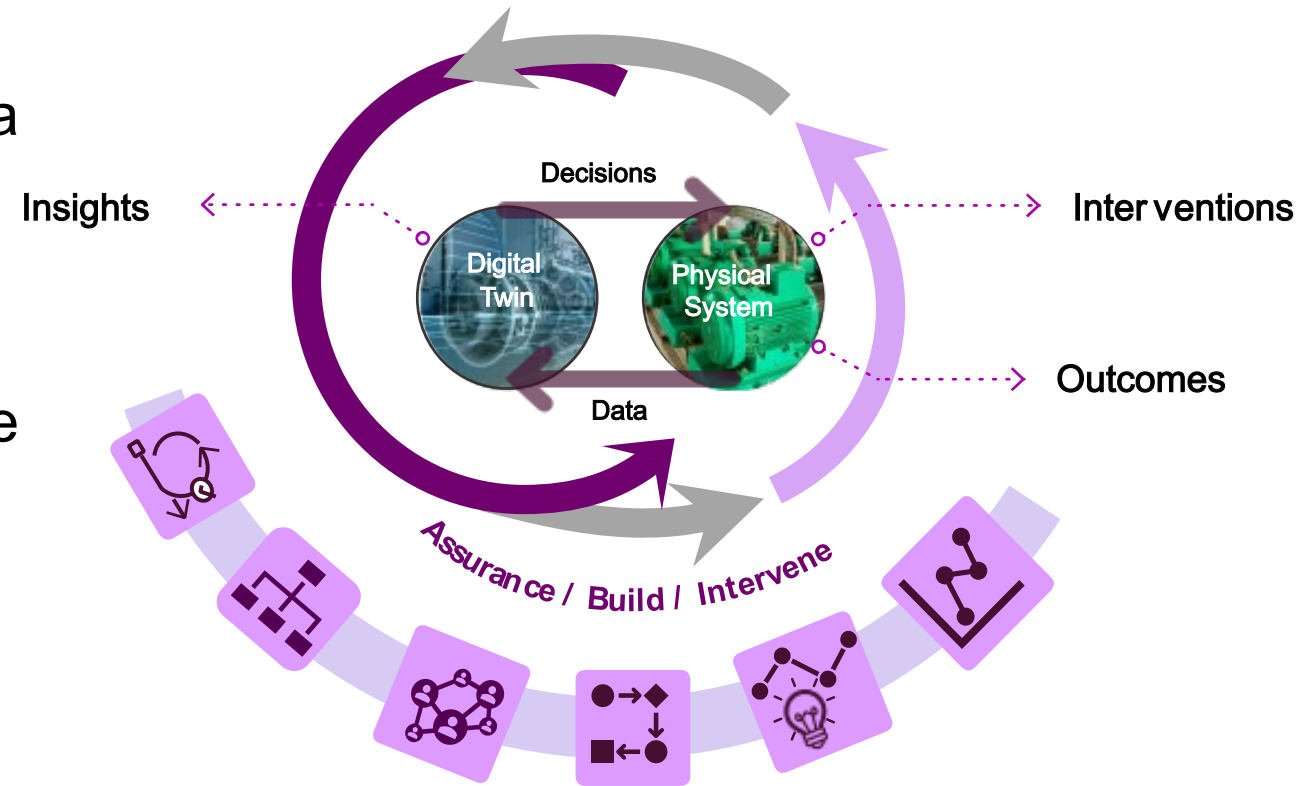
Leveraging a Digital Twin to Implement Complex Control Logic at the 3Kings Water Treatment Plant

Agenda

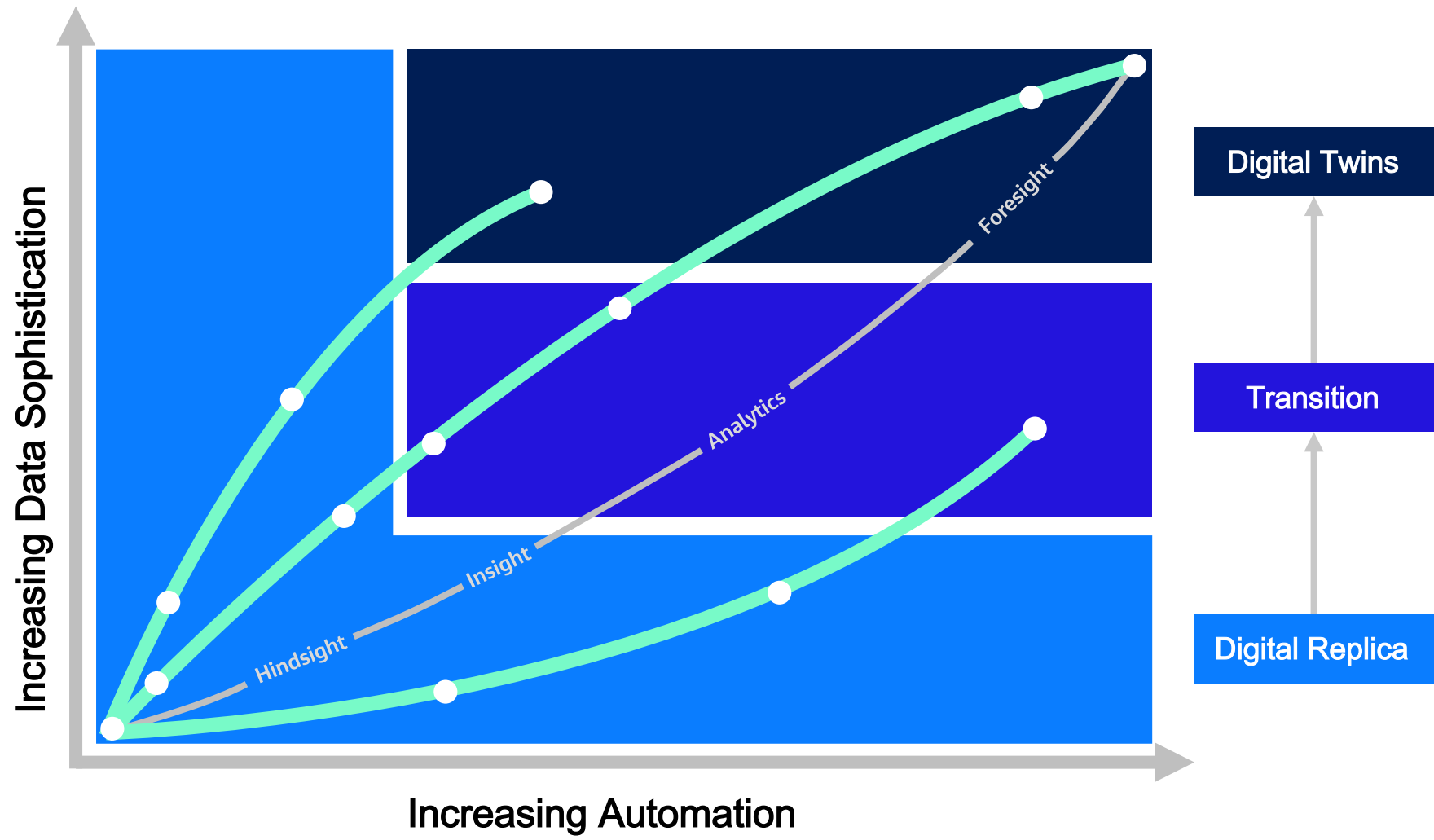
- Digital Twins Definition
 - Replica Operations Introduction
 - 3Kings Water Treatment Plant Digital Twin
-

Digital Twin Owner Benefits

- Increase the effectiveness of decision making within an organization
- Offer insights into the physical system in a risk-free environment
- Communicates and visualizes insights to provide Data Driven decision making
- Scenario Analysis and Asset Performance Management
 - Test hypothesis in zero risk, low-cost environment
 - More resilient solutions
 - Reduce start-up risk and shorten schedule
 - Predictive Maintenance
 - Optimize performance



Digital Twin Maturity



Digital Twin Approach

Establish Business Goals
Ensure Digital Twin adoption is driven by clear business needs

Define Insights
Incorporate performance metrics to meet stakeholder expectations

Identify Sponsor
The Digital Twin must be owned and actively managed

Enable Digital Twins
Single integrated source of truth

Understand Guiding Purpose
Make sure the level of digitalization matches the organization's readiness, objectives and priorities

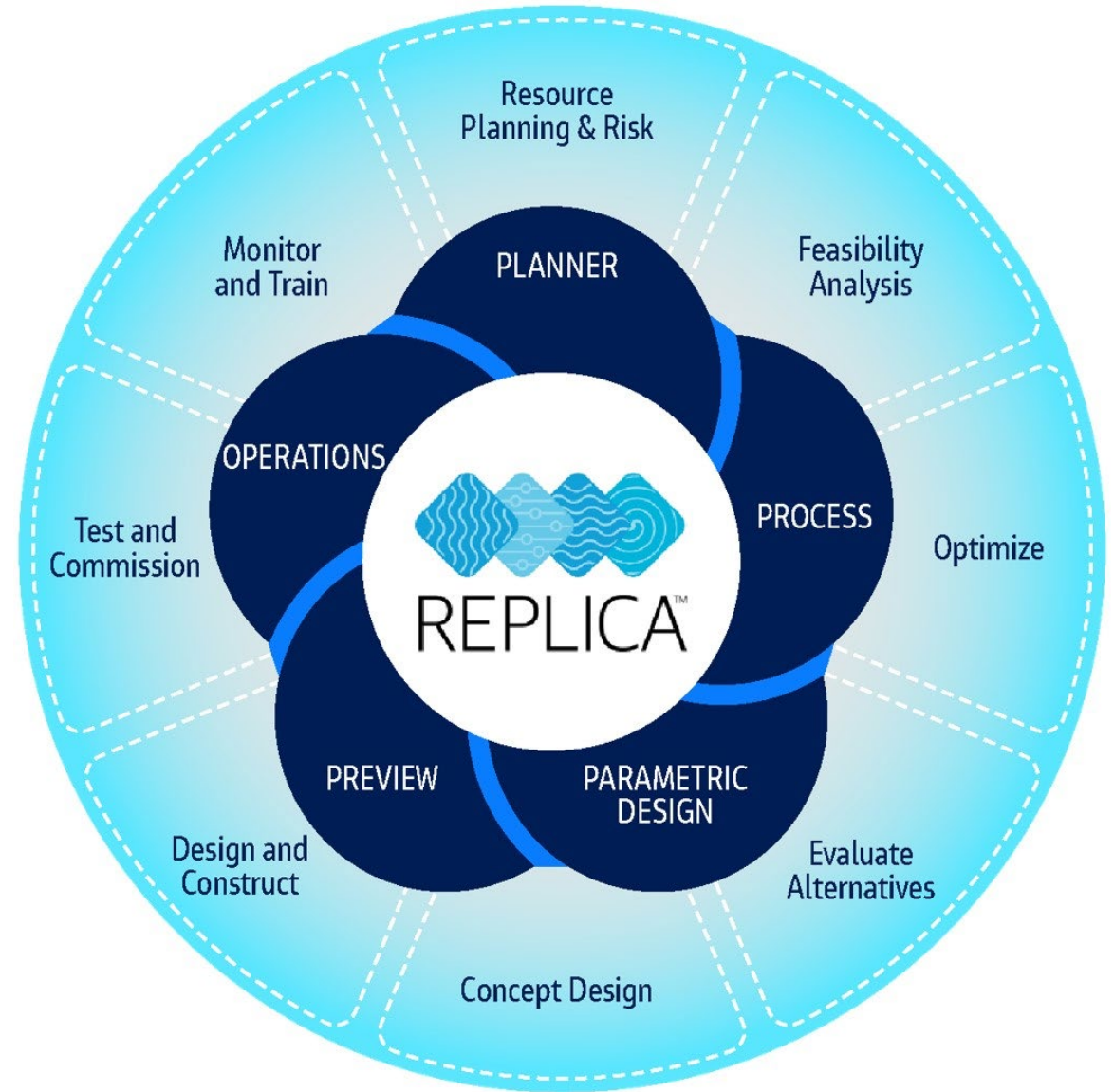
Technology
Establish which digital tools should be utilized to facilitate the process

Connect Data
Leverage the 'big data' used to inform the people, process, and technology

Evolving the Digital Twin
Keep the Digital Twin relevant throughout its lifecycle

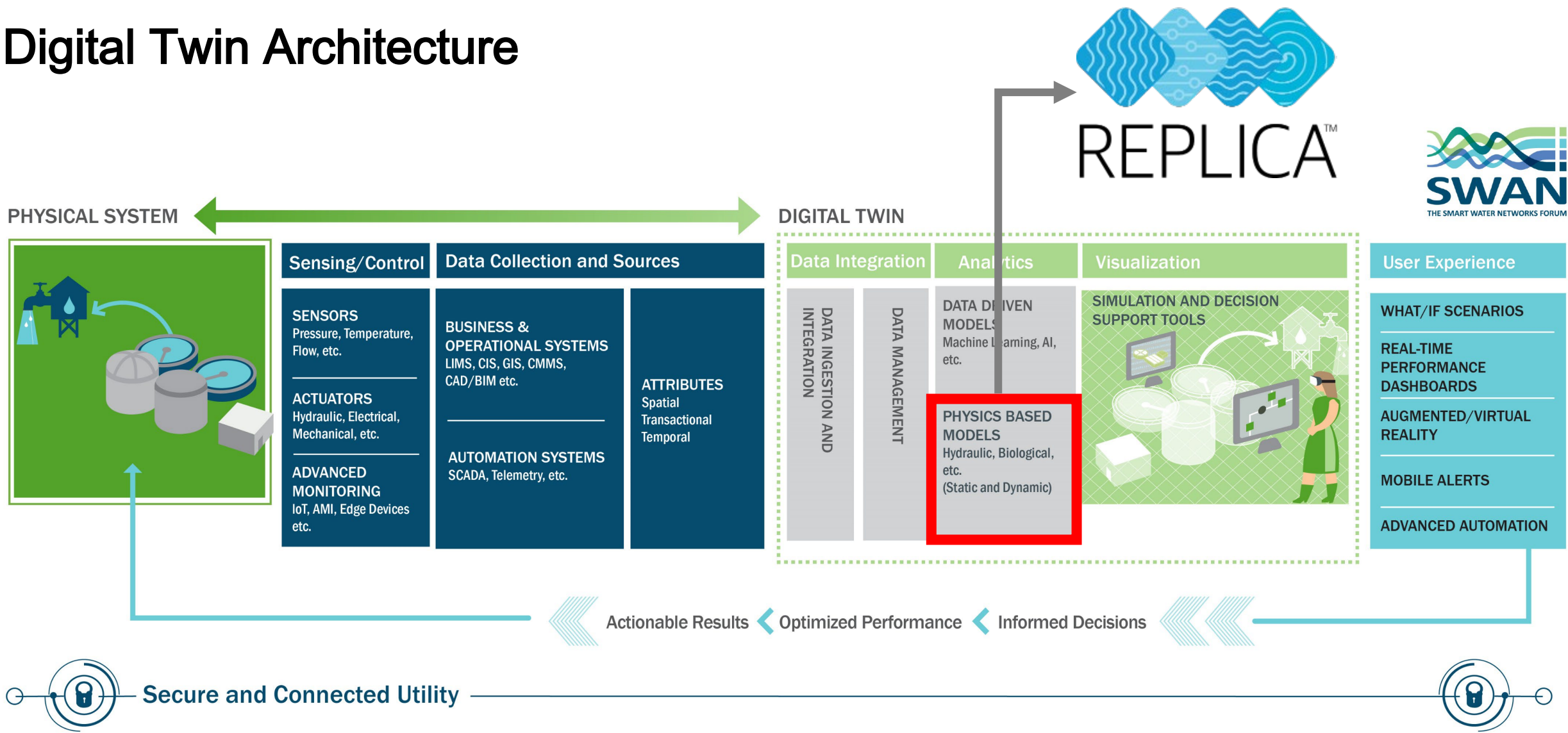
REPLICA is Jacobs' suite of software for digital twins

- Developed for >20 years
- Capabilities across the project lifecycle
- Built on a foundation of domain knowledge, computational power, data connectivity, and intuitive interfaces



<https://www.jacobs.com/insights/digital-twin-technologies>

Digital Twin Architecture



Replica Operations/Process

Process

- Track components (Water Quality)
 - Treatment processes
 - Separation
 - Reactions
- Linkage
 - SOURCE
 - Dynamic Pro2D

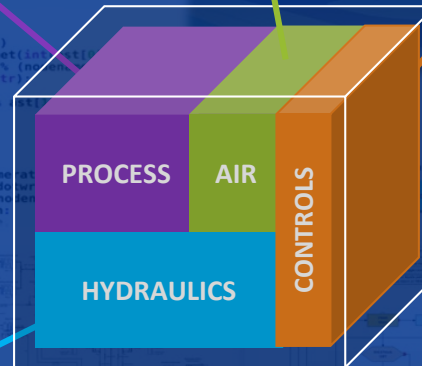
Air

- Model compressible fluids through system
 - Blowers
 - Conduits
 - Valves

Controls

- Drives system operation
 - Measuring devices
 - Transmitters
 - Control Algorithms
 - Controls Tuning
- Linkage with Control Software
 - Rockwell
 - Ovation
 - Siemens

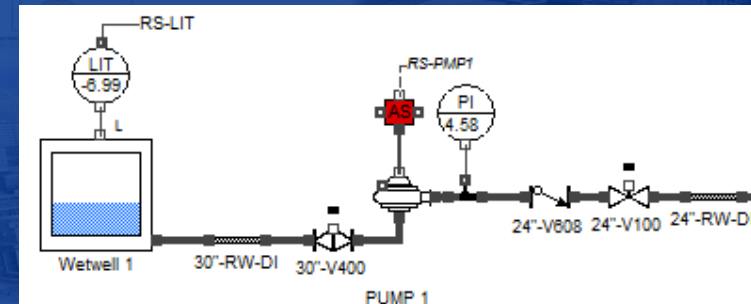
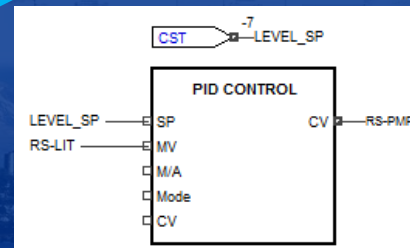
COMPLETE DYNAMIC PROCESS MODEL



OPTIMIZATION

Hydraulics

- Move fluids through system
 - Pipes
 - Pumps
 - Valves
 - Storage
 - Channels



Park City, UT

3Kings Water Treatment Facility

Replica Operations



3Kings Water Treatment Facility

- Construction of greenfield 8.0 MGD drinking water facility
- Complex control strategies to:
 - Utilize several water sources of varying qualities
 - Provide multiple treatment bypasses
 - Fully automate all filter service control and associated backwashes



Objectives

Operational Requirements

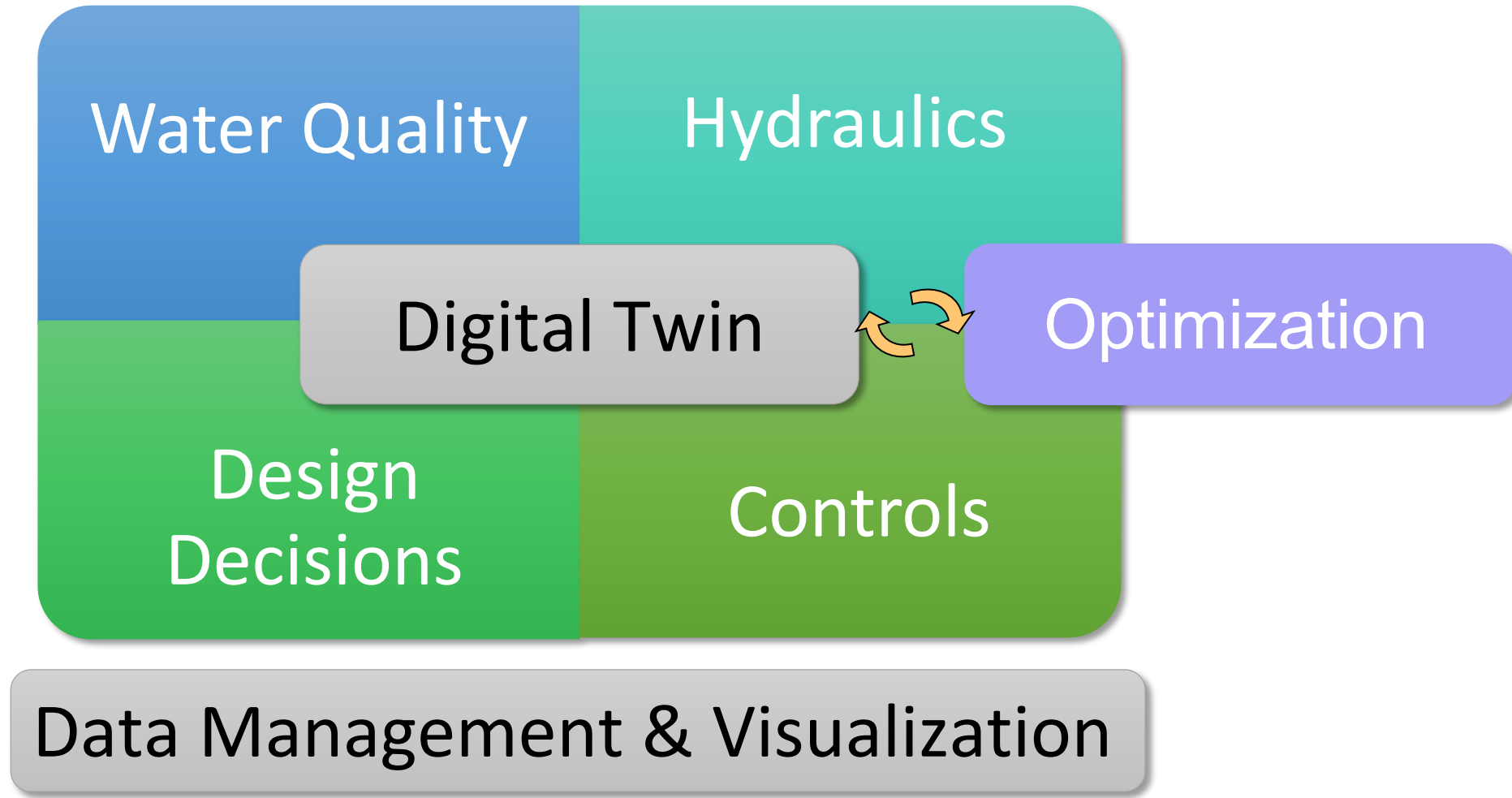
1. Treat water from 3 different sources, including treatment of 100% of Judge mine water
2. Meet customer demand
3. Automatically bring filters and adsorbers online based on loading rates

The Challenge:

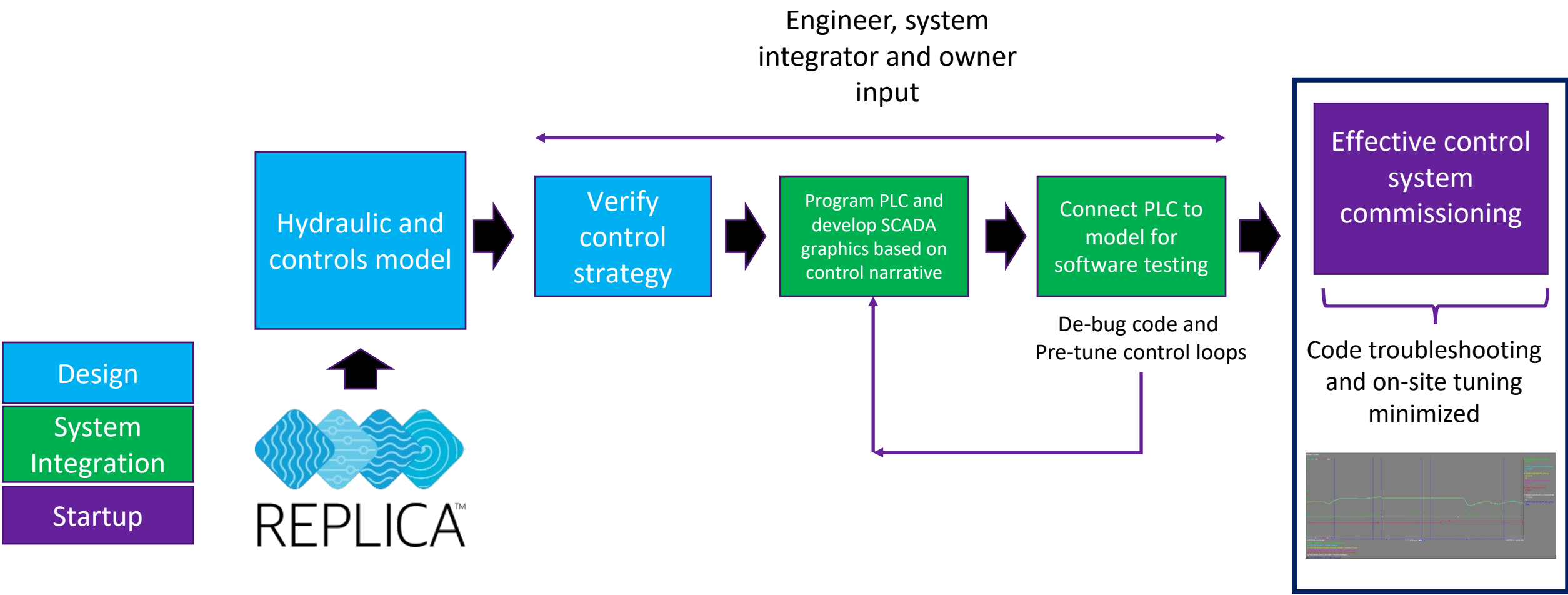
Commission complex controls on tight schedule.



Digital Twin – Integrate Multiple Tools/Data Sources for Decision Support

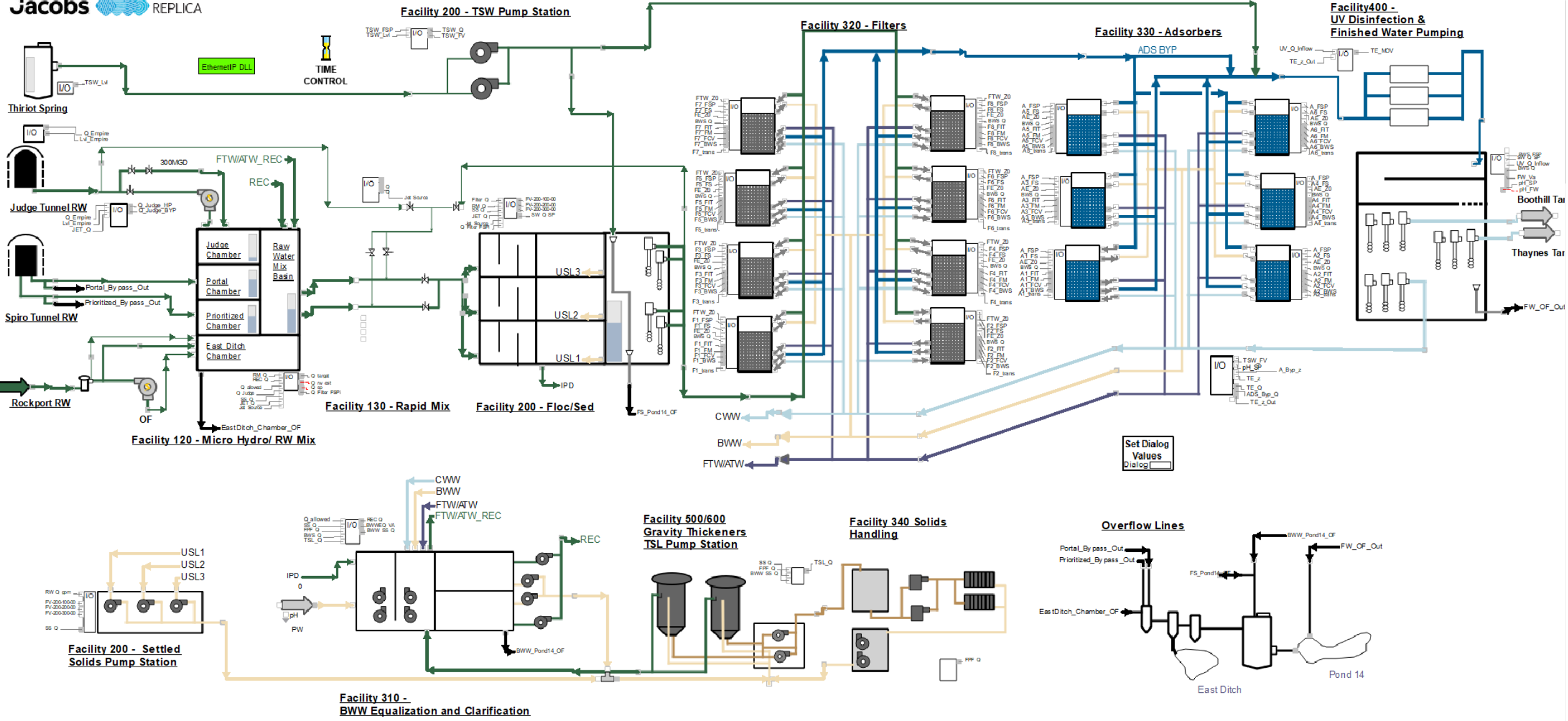


Digital Twin Workflow

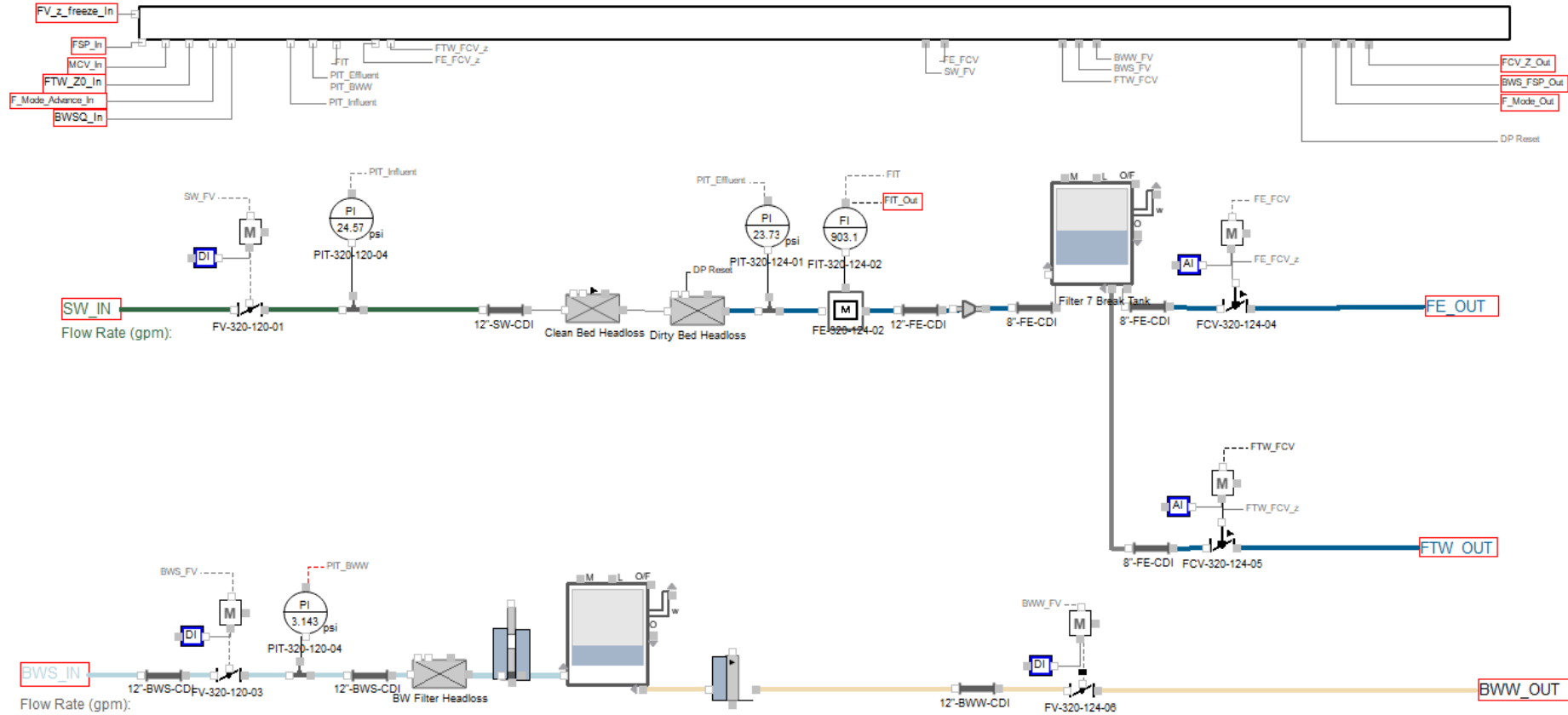


3Kings Digital Twin – Overview Screen

Jacobs REPLICA

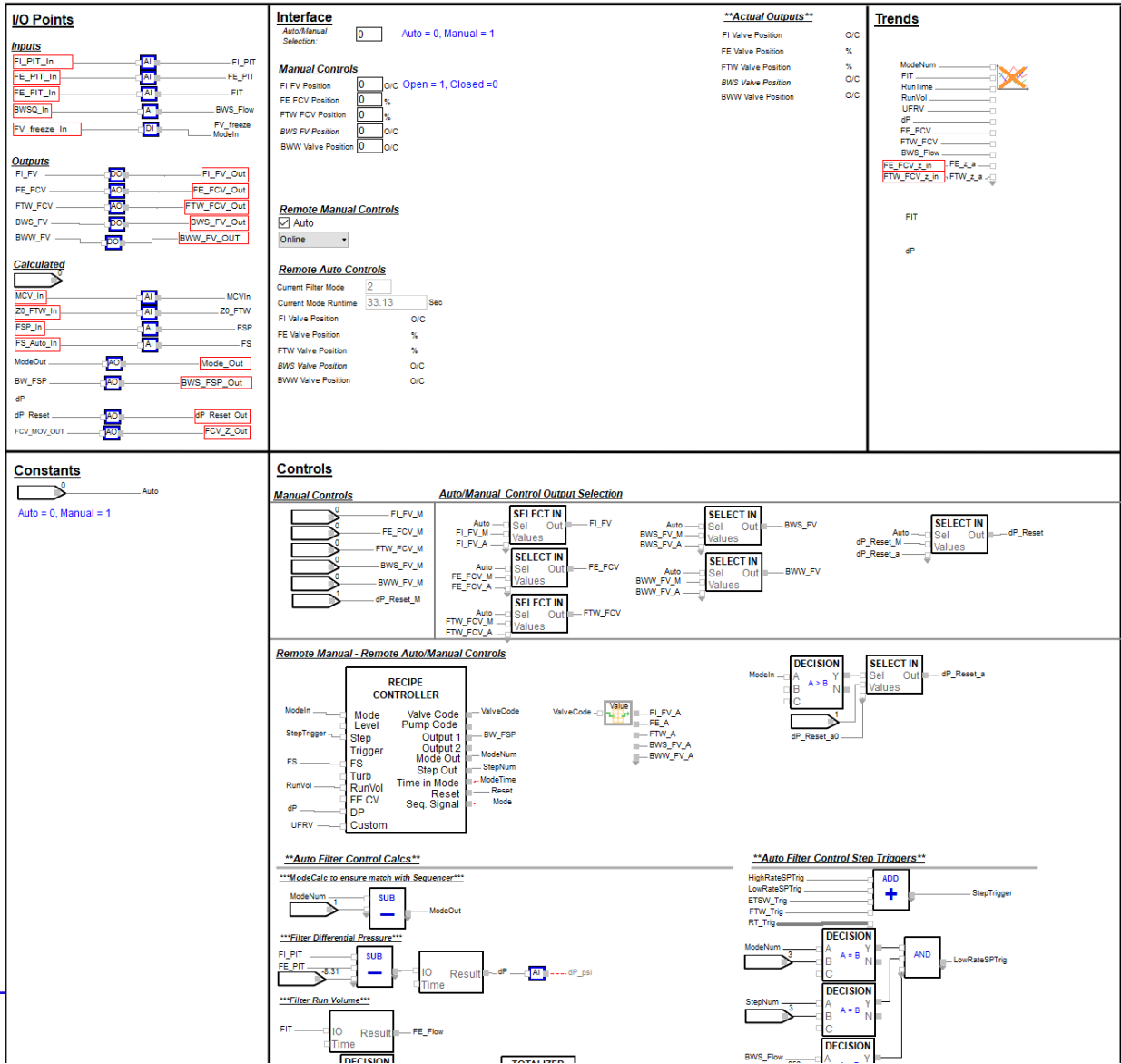


3Kings Digital Twin – Filter 1 Hydraulics



PRELIMINARY NOT FOR CONSTRUCTION	DSGN			DESCRIPTION	Jacobs  REPLICA			SHEET
	DR	NO.	DATE					DWG
	CHK			REVISION				DATE
	APVD	NO.	DATE					PROJ

3Kings Digital Twin – Filter 1 Controls



Main **Backwash Triggers**

Recipe DB Name: 3KingsFilters

Mode: Backwash ☒ Auto ☐ Signal Reset on Simulation Start

Time in Current Mode: 0.00 min

Current Level: 6.3791 ft

MODE TABLE

Mode#	Mode Name	Lock	Next Mode
0	1	BWQ	0
1	2	Online	0
2	3	Backwash	0
3	4	Standby	0
4	5	Offline	0
5	6	FTW	0
6			
7			
8			
9			

Link < >

RECIPE TABLE

Custom Name	Duration	Level Trigger	Valve Code	Pump Code	Output 1	Output 2
0	Close FI FV	0.25	NA	6	0	0
1	Close FE FCV	0.5	NA	6	0	0
2	Drain to BWW	2	NA	7	0	0
3	LRAS Ramp	NA	NA	8	0	885
4	LRAS	5	NA	8	0	885
5	HRW Ramp	NA	NA	8	0	3144
6	HRW	20	NA	8	0	3144
7	ETSW Ramp	NA	NA	8	0	885
8	ETSW	6.16	NA	8	0	885

3Kings Digital Twin – Filters User Interface

INFO ONLY AVAILABLE IN MODEL

OPERATOR SETPOINTS/CONTROLS

SDADA OUTPUT DATA

Useful Operational Information

FACILITY 320 - FILTER CONTROLS

REMOTE AUTO SETPOINTS

RECOMMENDED NUMBER OF ONLINE FILTERS

6

Standard Ops Loading Rate:

6.5

gpm/sf

DESIRED NUMBER OF ONLINE FILTERS

6

0 = AUTO SELECT BASED ON LOADING RATE
>0 = MANUALLY SELECT NUMBER OF FILTERS ONLINE

Auto Sequencer

Next Online

Filter 4

Next Backwash

Filter 5

Last Filter Backwashed

PLANT FLOW DATA

RW Flows

4829.29

gpm

REC Flow

680

gpm

Jet Injection Flow

0

gpm

RM Flow

5509.26

gpm

Filter Flows

5497.76

gpm

Loading Rate

9.6614

gpm/sf

Recommended number of filters online is based on design filter loading rate.

Max Permitted Loading Rate:

10.00

gpm/sf

Design Filter Loading Rate:

9.66

gpm/sf

Design Filter Flow Rate:

917.00

gpm

Standard Operating Filter Loading Rate:

6.50

gpm/sf

Standard Operating Filter Flow Rate:

617.00

gpm

Auto Controls Filter Transition Flows

Filter Effluent Flow Set Point (gpm)

Number of Filters

0.00 < FSP < 617

1

617 < FSP < 1234

2

1234 < FSP < 1851

3

1851 < FSP < 2468

4

2468 < FSP < 3085

5

3085 < FSP < 5507

6

Automatic Backwash Triggers

Unit Filter Run Volume

= 11,000 gallons/sf

Run Volume

= 0.76 million gallons

Differential pressure

> 15.2 psi

Run Time

> 30 hours

If operations determine more filters than recommended are to be online it should be noted that a loading rate of >2.5 gpm/sf should be maintained to prevent preferential flow paths from being created.

FACILITY 330 - ADSORBER CONTROLS

REMOTE AUTO SETPOINTS

RECOMMENDED NUMBER OF ONLINE ADSORBERS

5

Standard Ops Loading Rate:

8.76

gpm/sf

DESIRED NUMBER OF ONLINE ADSORBERS

0

0 = AUTO SELECT BASED ON LOADING RATE
>0 = MANUALLY SELECT NUMBER OF ADSORBERS ONLINE

ADSORBER BYPASS CONTROLS

Control Mode

0

0 = auto, 1 = manual

REMOTE MANUAL

REMOTE AUTO

Bypass FCV Position

0

%

Bypass Percent Split

0

%

Bypass Data

Filter Effluent Flow

5497.8

gpm

Ads Effluent Flow

3501.2

gpm

Loading Rate

6.7719

gpm/sf

Bypass Flow

1669.1

gpm

Bypass FCV Position

36

%

Auto Sequencer

Next Online

N/A

Next Backwash

N/A

Last Adsorber Backwashed

Recommended number of adsorbers online is based on adsorber loading rate.

Design Adsorber Loading Rate:

9.73

gpm/sf

Design Adsorber Flow Rate:

1101.00

gpm

Standard Ops Ads Loading Rate:

8.76

gpm/sf

Standard Ops Ads Flow Rate:

990.90

gpm

If operations determine more adsorbers than recommended are to be online it should be noted that a lower loading rate corresponds to a greater EBCT, which may lead to a reduction in the life expectancy of the adsorber media.

FCV-330-104-01

36

%

Adsorbers

Calculated

5497.8

gpm

Calculated

3501.2

gpm

Calculated

5453.2

gpm

FIT-330-104-02

1669.1

gpm

Trends

Filter Flows

Filter FCV Positions

Filter Number	1	2	3	4	5	6	7	8
Trends	Filter 1	Filter 2	Filter 3	Filter 4	Filter 5	Filter 6	Filter 7	Filter 8
Filter Control Mode	0 ✓ Auto	0 ✓ Auto	0 ✓ Auto	0 ✓ Auto	0 ✓ Auto	0 ✓ Auto	0 ✓ Auto	0 ✓ Auto
REMOTE MANUAL CONTROLS								
Filter Influent Iso Valve	1	1	1	1	0	1	0	0
Filter Effluent FCV	50	50	50	50	0	50	0	0
Filter To Waste FCV	0	0	0	0	0	0	0	0
Backwash Supply Iso Valve	0	0	0	0	0	0	0	0
Backwash Waste Iso Valve	0	0	0	0	0	0	0	0
REMOTE AUTO CONTROLS								
Filter Mode Selection	Standby	BWQ	BWQ	Standby	BWQ	Online	Online	Online
Filter Mode	Standby	Online	Online	Standby	Online	Online	Online	Online
Time Remaining In Mode (min)	0	0	0	0	0	0	0	0
Time In Mode (min)	366.5	343.62	243.45	367.07	169.45	334.87	315.92	316.08
Filter Flow (gpm)	0	921.7	923.08	929.48	916.69	0	903.24	904.1
Filter Loading Rate (gpm/sf)	0	9.699	9.7135	9.7809	9.6463	0	9.5048	9.5139
Filter Run Time (hr)	16.748	19.792	19.407	17.04	19.806	11.571	2.8894	2.435
Filter Run Volume (MG)	1.171	1.274	1.2019	1.5193	1.1576	0.8588	0.1221	0.0978
Unit Filter Run Volume (gal/sf)	12322	13406	12647	15987	12182	9036.8	1284.5	1028.8
Inlet Pressure (psi)	25.071	24.397	24.635	24.415	24.583	19.281	24.574	24.472
Outlet Pressure (psi)	25.632	21.482	21.835	20.794	24.347	20.237	23.736	23.677
Differential Pressure (psi)	6.516	6.516	6.4035	7.2221	3.8421	2.6484	4.4422	4.4002
Effluent Valve Position (%)	0	58	54	68	44	0	45	46
FTW Valve Position (%)	0	0	0	0	0	0	0	0

Trends

Adsorber Flows

Adsorber FCV Positions

Adsorber Number	1	2	3	4	5	6
Trends	Adsorber 1	Adsorber 2	Adsorber 3	Adsorber 4	Adsorber 5	Adsorber 6
Adsorber Control Mode	0 ✓ Auto	0 ✓ Auto	0 ✓ Auto	0 ✓ Auto	0 ✓ Auto	0 ✓ Auto
REMOTE MANUAL CONTROLS						
Adsorber Influent Iso Valve	1	0	1	1	0	0
Adsorber Effluent FCV	40	0	40	40	0	0
Adsorber To Waste FCV	0	0	0	0	0	0
Backwash Supply Iso Valve	0	0	0	0	0	0
Backwash Waste Iso Valve	0	0	0	0	0	0
REMOTE AUTO CONTROLS						
Adsorber Mode Selection	Online	Online	Online	Online	Online	Standby
Adsorber Mode/Step	Online	Online	Online	Online	Online	Standby
Time Remaining In Mode (min)	0	0	0	0	0	0
Time In Mode (min)						
Adsorber Flow (gpm)	934.75	865.07	867.76	0	833.59	0
Adsorber Loading Rate (gpm/sf)	8.2648	7.6488	7.6725	0	7.3704	0
Adsorber Run Time (hr)	1194.5					
Adsorber Run Volume (MG)	4.1583	1.311	1.5097	1.0708	3.5152	0
Unit Adsorber Run Volume (gal/sf)	0	0	0	0	0	0
Inlet Pressure (psi)	14.518	14.435	14.364	14.464	14.227	14.474
Outlet Pressure (psi)	15.186	15.316	15.252	18.344	15.189	27.859
Differential Pressure (psi)	3.1619	3.0964	3.1082	-0.129	3.0418	-9.632
Effluent Valve Position (%)	62	63	64	0	66	0
FTW Valve Position (%)	0	0	0	0	0	0

Adsorber Sequencing

Adsorbers will be manually sequenced based on total volume treated.

Auto Controls Adsorber Transition Flows

ADS Effluent Flow Set Point (gpm)

of Adsorbers

0.00 < FSP < 991

1

991 < FSP < 1982

2

1982 < FSP < 2973

3

2973 < FSP < 3964

4

3964 < FSP < 5507

5

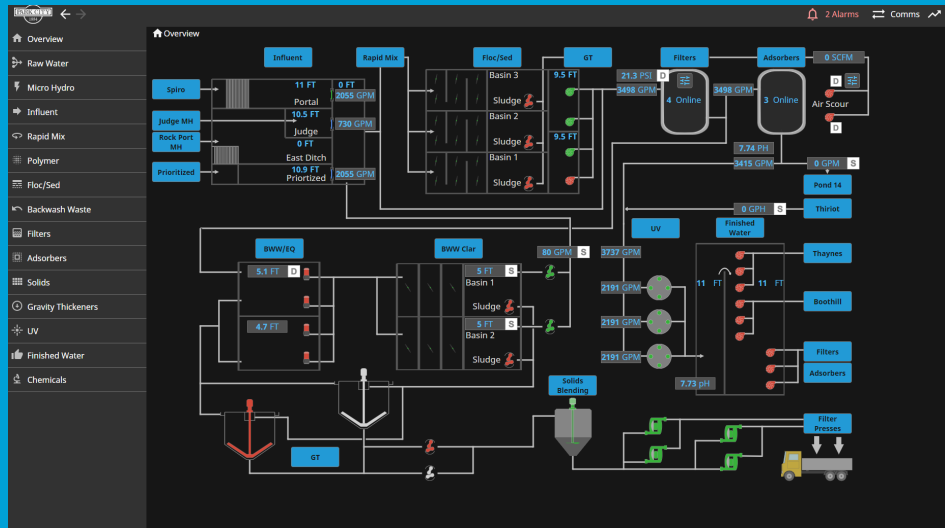
Functional Acceptance Testing (FAT)

- Traditional FAT
 - Force bits and values in the code
 - Visualization at SCADA
 - No system response
- Dynamic FAT
 - Test updated PLC code using calibrated model rather than live WTP

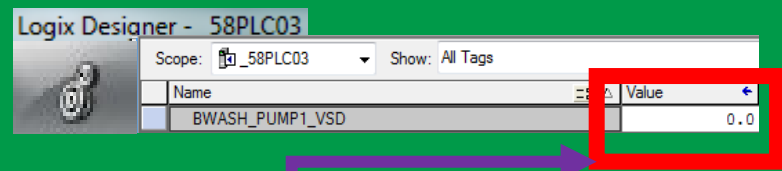


Traditional FAT

SCADA



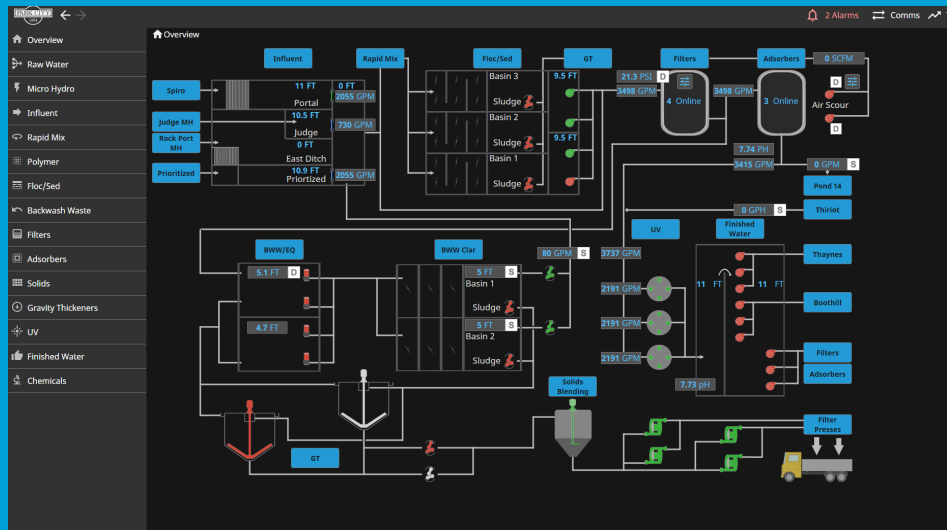
PLC



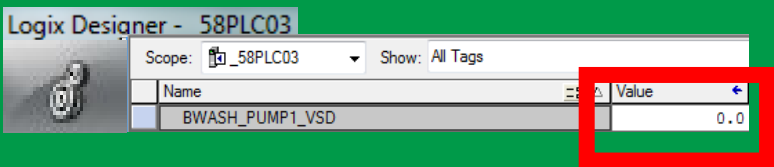
Values of PLC tags manually changed with no process feedback

Dynamic FAT

SCADA



PLC



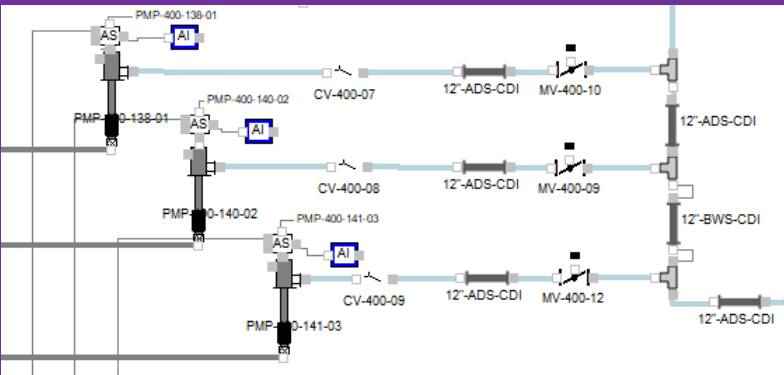
Inputs (Flow, level, pressure...)



Outputs (Valve position, pump speed...)

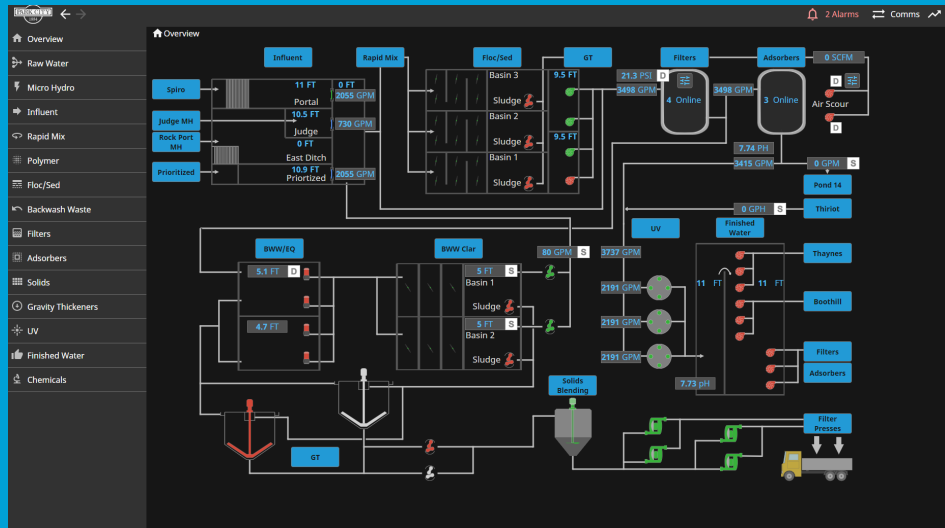


Replica

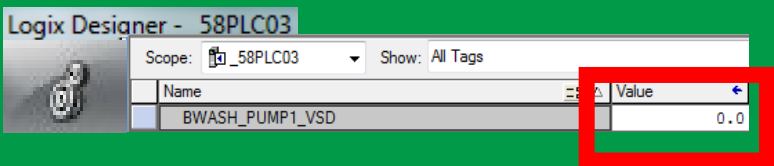


On Site Start Up

SCADA



PLC



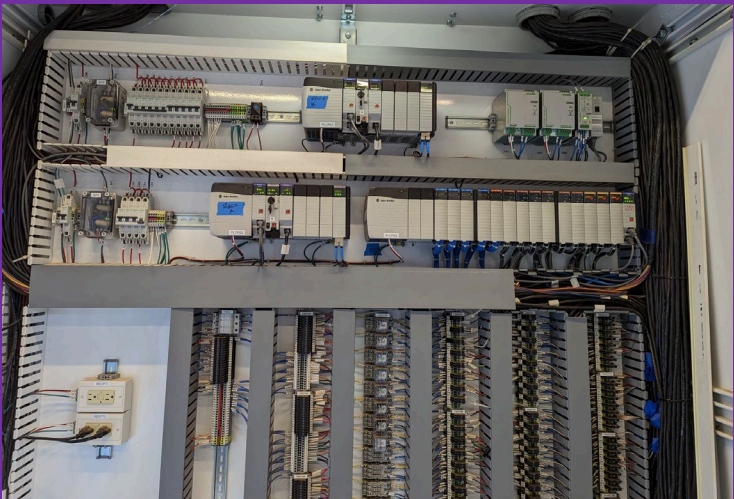
Inputs (Flow, level, pressure...)



Outputs (Valve position, pump speed...)



Control Panel



Dynamic FAT benefits

- Reduce risk during start up
- Troubleshoot and identify code errors prior to plant implementation
- Test code across variety of 'what if' scenarios
- Effective communication between design engineer, system integrator and operations staff
- Gain better understanding of code and system



Challenge

Operational Requirements

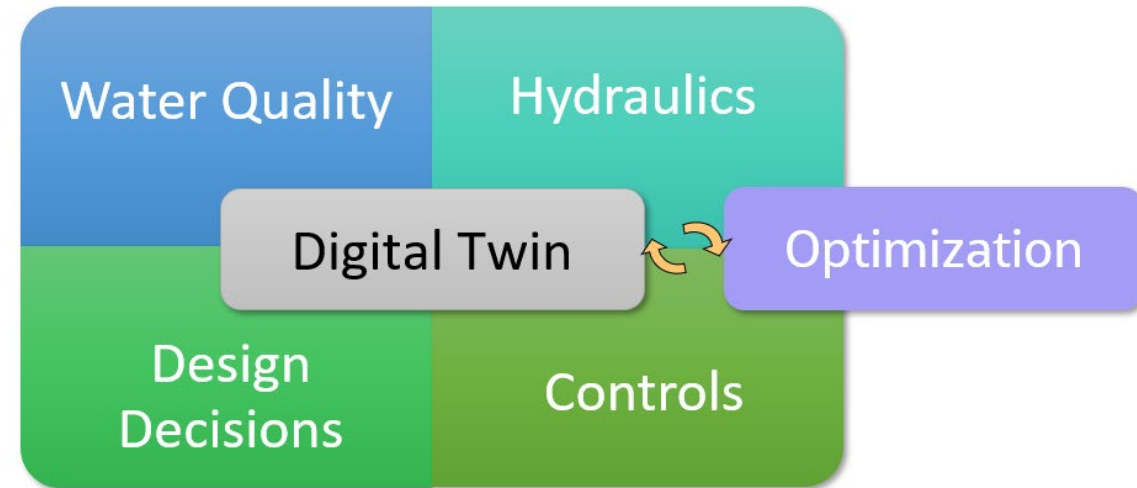
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The Challenge:

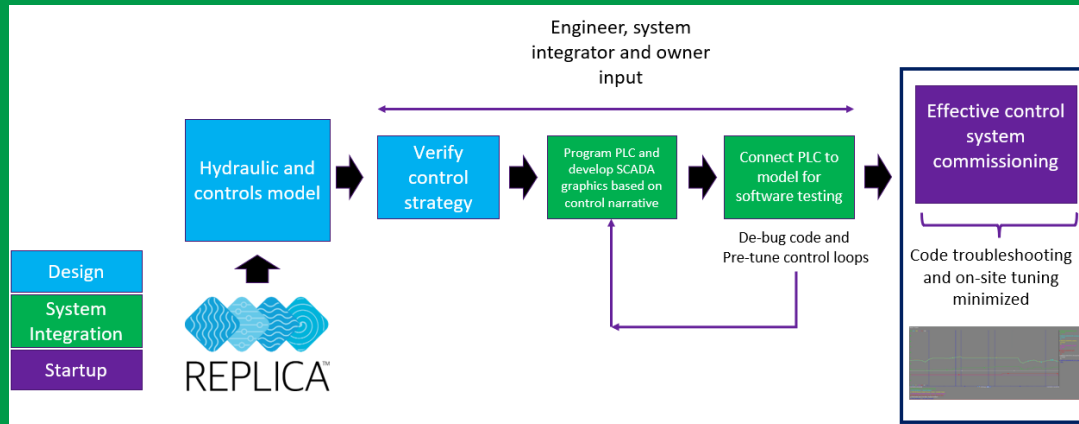
Commission complex controls on tight schedule.



Value



Solution



Thank You

Questions?

