

Name	Aspect Type
Clamp Solenoid Freezes	FreezeValueFault
Clamp Solenoid Feedback Freezes	FreezeValueFault

Name	Aspect Type
Position Encoder Failure	AnalogueForceFault
Approach 180 Prox Failure	DigitalForceLowFault
At 180 Prox Failure	DigitalForceLowFault
Approach 0 Prox Failure	DigitalForceLowFault
At 0 Prox Failure	DigitalForceLowFault

Name	Aspect Type
Paint Tool Failure	AdvancedFault

Name	Aspect Type
Prox fails low	DigitalForceLowFault
Prox fails high	DigitalForceHighFault

Name	Aspect Type
Turntable Motor Slow	AnalogueMaximumValue
Encoder Drift	AnalogueDriftUpFault

Fault Framework

Name	Aspect Type
GuardDoorOpen	DigitalForceHighFault

Name	Aspect Type
Power Disconnect	DigitalForceLowFault



expanding human possibility®

Andrew Deeble, Emulate3D Product Manager

Thomas Templeton, Emulate3D Simulation Engineer



PUBLIC

Stages of Virtual Commissioning

Can we connect?

Simply connecting to the model finds issues:

Map IO to virtual equipment

Connect the HMIs

Initialize and reset alarms

Check safety feedback

Can we run in manual?

Begin testing system by forcing values:

Verify sensor feedback

Dry run motors

Test manual functions

Step through the sequence

Can we run in auto?

Create product and see how our system responds:

Run idealized cycle on auto

Reposition field sensors

Verify predicted throughput

Test safety, stops, restarts

Ready to go on site?

Wait there is more!

...Maximising Value from Virtual Commissioning

Can we connect?

Can we run in manual?

Can we run in auto?

Advanced testing

Testing in the virtual world is easier than in the real:

Inject device faults

Check alarms & diagnostics

Run varied load schedules

Stress test the system

Operator Training

Familiarize and train on an accurate model:

Familiarize with HMIs

Run training scenarios

Train on device failures

Grade operator responses

System Upgrades

Reuse the model to test potential changes:

Regression test code changes

Optimize performance

Test hypothetical scenarios

Reproduce issues virtually

File Home Arrange Visualization Package Tools Fault Framework CAD Is The Model

Select Navigate Text Find Find Next Select All Edit Custom Properties Enable Debug Reset Settings Animate Message Log Tools Layers Default View Plan View Zoom Extents Add View Remove View View Volumetric Physics IO Browser Emulation Lag Experiments Event List Analysis Simulation

FaultsCatalog

Search...

Catalogs FaultsCatalog

Advanced Faults Advanced Assertions Snappable Assertions

Fault Controller

Not Not Explic Hieran FaultsCat

Properties: FaultController

Control

- AddMessageToTable: False
- DisableAllAssertions: False
- DisableAllFaults: False
- EnableAllAssertions: False
- EnabledFaultsCount: 0
- LogMessage

Fault Schedules

- AllFaults: AllFaults (8 rows)
- ExampleFaults: ExampleFaults (2 rows)
- No Faults: No Faults (0 rows)

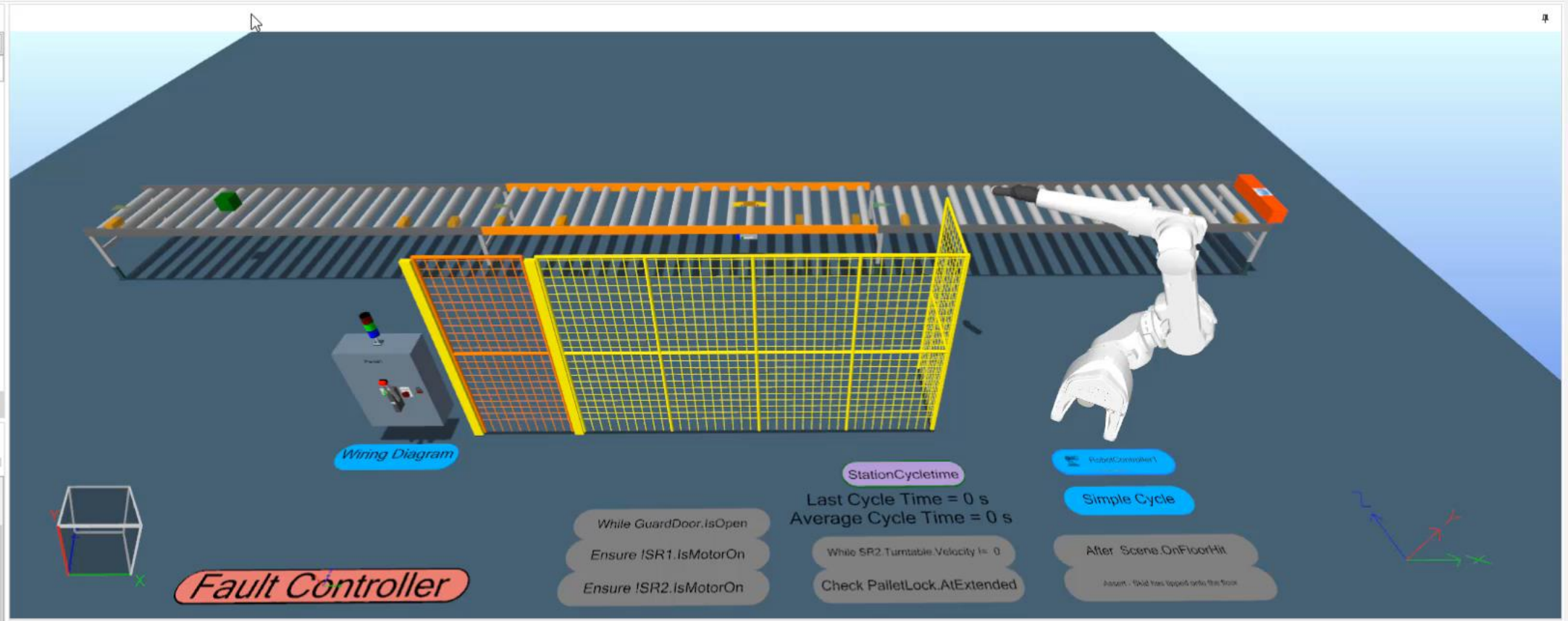
General

- Name: FaultController

Position

- World Location: 5.3001 m, 0.005 m, -5.4

ExampleFaults



MessageLog

Model	Category	Message

Fault Framework



Add fault aspects to any visual

Force and unforce any property

Prebuilt or custom QL / C# faults



Add assertions to monitor any visual

Identify incorrect model behaviour

Simple pass/fail, and detailed log



Manually inject faults to test controls

Save your test in one click for reuse

Create your own regression tests

Forcing Values with Fault Aspects

Forcing no longer affects the binding between property and tag

Now properties themselves can be forced

Add aspects to components to represent faults and force values

Emulate3D 2024 (Beta) - Faulted PE Video*

File Home Arrange Visualization Package Tools CAD Is The Model Fault Framework

Quick Search

Select Navigate Text Find Find Next Edit Custom Properties Edit Script Visual Studio Enable Debug

Reset Settings Message Log Tools Layers Default View Plan View Zoom Extents Add View Remove View

Volumetric Physics IO Browser Lag Experiments Event List Analysis Simulation

FaultsCatalog

Search... Catalogs FaultsCatalog

Advanced Faults Advanced Assertions Snappable Assertions

Fault Controller

IO Browser

Start Stop Record Import Export Add Configure

Drag a column header here to group by that column

Active	Name	Model Value	Access	Visual
* <input type="checkbox"/>	Click here to add a new row			
<input type="checkbox"/>	_Tag_SB1.PE1_IsBlocked	<input type="checkbox"/>	Write To PLC	SB1.PE1

Photoeye

IsBlocked = False

Adding Faults

Force or freeze values

Drift or limit values

Delay the updating of signals

Custom QuickLogic faults

Full API and IFault interface

The screenshot shows a software interface with three main menu items: 'Faults', 'Assertions', and 'Advanced Controllers'. The 'Faults' menu is expanded, showing a list of fault types with their respective icons:

- FreezeValueFault (wrench and snowflake icon)
- DigitalForceHighFault (wrench and green circle icon)
- DigitalForceLowFault (wrench and red circle icon)
- AnalogueForceFault (wrench and 2.7182 icon)
- AnalogueMaximumValueFault (graph with red X icon)
- AnalogueMinimumValueFault (graph with red X icon)
- AnalogueDriftUpFault (graph with red line icon)
- AnalogueDriftDownFault (graph with red line icon)

The screenshot shows the 'Advanced Faults' menu with three options:

- Advanced Fault
- Advanced Fault - Multi Fault
- Advanced Fault - Delay

Fault Framework

`add [message] to FullLog table`

Add a custom message to the FullLog table in the Analysis Window.

`disable assertion [visual] . [assertionName]`

Disable an assertion. No name needed for an Advanced Assertion.

`disable fault [visual] . [faultName]`

Disable a fault. No name needed for an Advanced Fault.

`enable assertion [visual] . [assertionName]`

Enable an assertion. No name needed for an Advanced Assertion.

`enable fault [visual] . [faultName]`

Enable a fault. No name needed for an Advanced Fault.

`evaluate [condition]`

Get the current value of a boolean expression property.

`force [visual] . [propertyName] to [value]`

Force a property to a certain value.

`is assertion [visual] . [assertionName] enabled`

Is an assertion enabled. No name needed for an Advanced Assertion.

`is fault [visual] . [faultName] enabled`

Is a fault enabled. No name needed for an Advanced Fault.

`unforce [visual] . [propertyName]`

Unforce a property.

`unforced value of [visual] . [propertyName]`

Get the unforced value of a forced property.

`wait until boolean [condition] is true`

Wait until a boolean expression property is True.

`wait until unforced value of [visual] . [propertyName] changes`

Wait until the unforced value of a forced property changes.

Name	AspectType	Property
Open Feedback fails low	DigitalForceLowFault	OpenFeedback
Open Feedback fails high	DigitalForceHighFault	OpenFeedback
Closed Feedback fails low	DigitalForceLowFault	ClosedFeedback
Closed Feedback fails high	DigitalForceHighFault	ClosedFeedback
Valve fails to open	DigitalForceLowFault	IsOpen
Valve fails in open position	DigitalForceHighFault	IsOpen
Valve stall in current position	FreezeValueFault	IsOpen
Airline fails - valve closes	DigitalForceLowFault	IsOpen
Slow	AnalogueForceFault	Slow

Name	AspectType	Property
High Level Switch fails high	DigitalForceHighFault	Switch1 AtLevel
High Level Switch fails low	DigitalForceLowFault	Switch1 AtLevel
Low Level Switch fails high	DigitalForceHighFault	Switch2 AtLevel
Low Level Switch fails low	DigitalForceLowFault	Switch2 AtLevel
Mixer - Level transmitter fails to 100%	AnalogueForceFault	Fill_Inst
Mixer - Level Transmitter fails to 15%	AnalogueForceFault	Fill_Inst
Mixer - Level Transmitter value freezes	FreezeValueFault	Fill_Inst
Temperature Transmitter 1 fails to 100	AnalogueForceFault	LiquidTemperatureInst1
Temperature Transmitter 1 fails to zero	AnalogueForceFault	LiquidTemperatureInst1
Temperature Transmitter 1 freezes	FreezeValueFault	LiquidTemperatureInst1
Temperature Transmitter 2 fails to 100	AnalogueForceFault	LiquidTemperatureInst2
Temperature Transmitter 2 freezes	FreezeValueFault	LiquidTemperatureInst2
Temperature Transmitter 2 Fails to zero	AnalogueForceFault	LiquidTemperatureInst2

Flowmeter freezes at current value	FreezeValueFault	Flow
Flowmeter fails to zero	AnalogueForceFault	Flow

Temperature Sensor freezes	FreezeValueFault	ValueNumeric
Temperature Sensor fails to zero	AnalogueForceFault	ValueNumeric

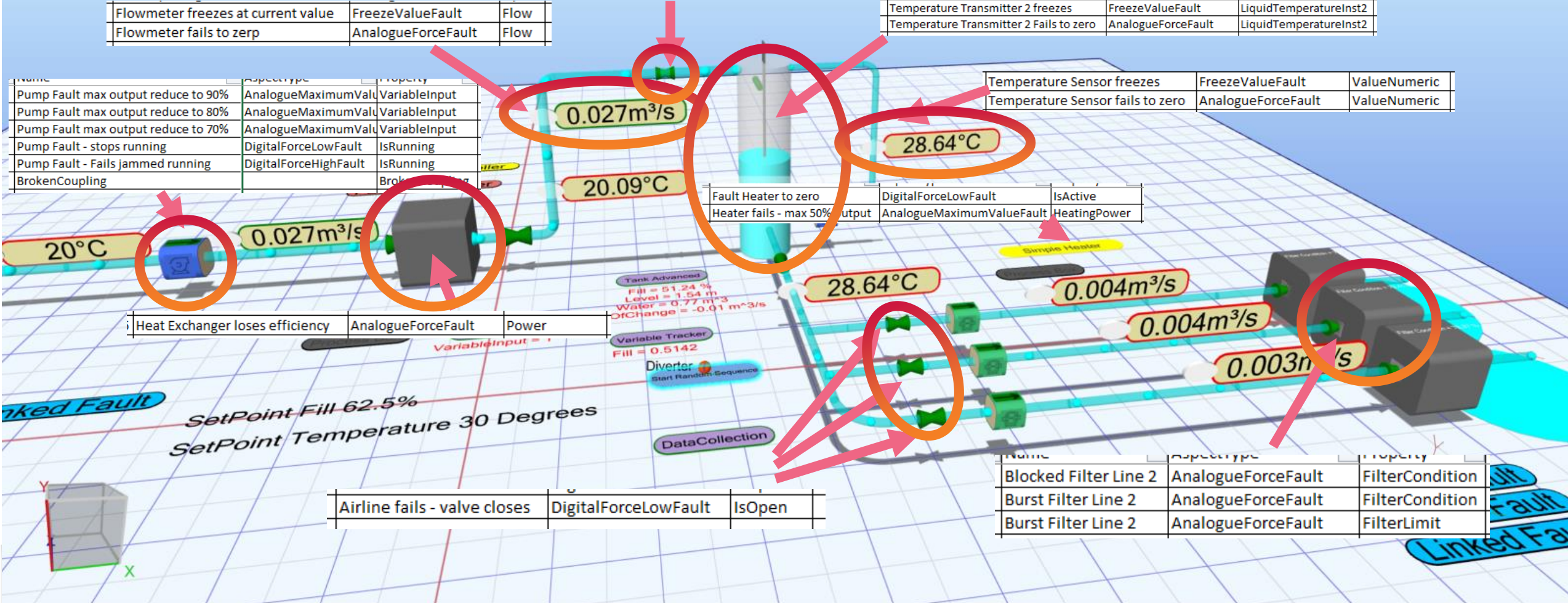
Name	AspectType	Property
Pump Fault max output reduce to 90%	AnalogueMaximumValueFault	VariableInput
Pump Fault max output reduce to 80%	AnalogueMaximumValueFault	VariableInput
Pump Fault max output reduce to 70%	AnalogueMaximumValueFault	VariableInput
Pump Fault - stops running	DigitalForceLowFault	IsRunning
Pump Fault - Fails jammed running	DigitalForceHighFault	IsRunning
BrokenCoupling		BrokenCoupling

Fault Heater to zero	DigitalForceLowFault	IsActive
Heater fails - max 50% output	AnalogueMaximumValueFault	HeatingPower

Heat Exchanger loses efficiency	AnalogueForceFault	Power
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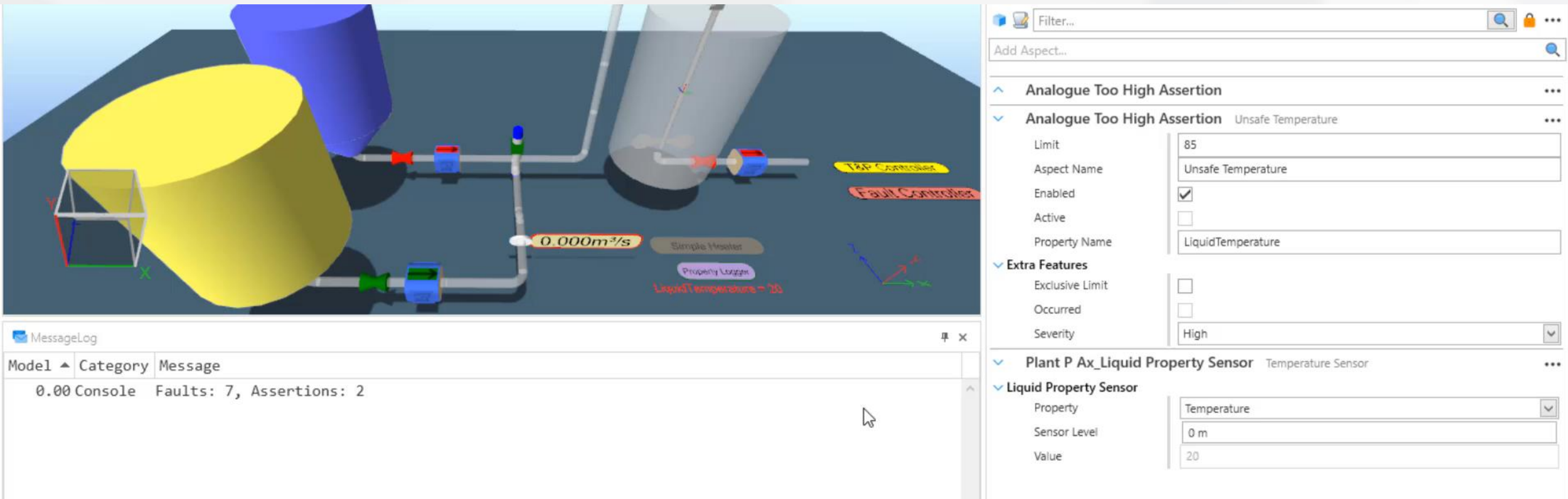
Name	AspectType	Property
Blocked Filter Line 2	AnalogueForceFault	FilterCondition
Burst Filter Line 2	AnalogueForceFault	FilterCondition
Burst Filter Line 2	AnalogueForceFault	FilterLimit

Airline fails - valve closes	DigitalForceLowFault	IsOpen
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Adding Basic Assertions

- Monitor values to see if they go out of range
- Assign severity levels, None - Low - Medium - High
- Log test results in the Analysis window and CSV output



The screenshot displays a 3D visualization of a process with a yellow tank, a blue tank, and a central grey tank. A pipe network connects them, with a flow rate of $0.000\text{m}^3/\text{s}$ and a liquid temperature of 20 . Labels include 'TAP Controller', 'Fault Controller', 'Simple Heater', and 'Property Logger'. The right-hand side shows the configuration for two assertions:

- Analogue Too High Assertion** (Unsafe Temperature):
 - Limit: 85
 - Aspect Name: Unsafe Temperature
 - Enabled:
 - Active:
 - Property Name: LiquidTemperature
 - Extra Features:
 - Exclusive Limit:
 - Occurred:
 - Severity: High
- Plant P Ax_Liquid Property Sensor** (Temperature Sensor):
 - Property: Temperature
 - Sensor Level: 0 m
 - Value: 20

The MessageLog window at the bottom shows the following message:

Model	Category	Message
0.00	Console	Faults: 7, Assertions: 2

Adding Assertions

Assertion Aspects, same as Fault Aspects

Advanced Assertions with QuickLogic Widgets

Snappable Assertions can be chained together

Permissives, waits, and restarts enable other assertions

Interlocks and Assertions monitor values

Choose colours and severity levels

The screenshot displays the 'Snappable Assertions' catalog in the Rockwell Automation software. The catalog is organized into a grid of widgets, including 'Permissive - While', 'Permissive - After', 'Permissive - Event', 'Interlock - Ensure', 'Assertion - Check', 'Assertion - Wait', 'Assertion - Instant', 'Continue - Wait', 'Continue - Log', 'Restart', and 'End'. The 'Permissive - While' widget is currently selected. Below the catalog, the 'Properties: Interlock1' window is open, showing the configuration for the selected widget. The configuration is divided into three sections: Configuration, Control, and Display.

Configuration	
AssertionSeverity	Medium
Condition	<code>!BluePump.IsRunning</code>
Procedure	Procedure
Target	<None>

Control	
AssertionActive	False
AssertionEnabled	False
AssertionOccurred	False

Display	
ConditionFalseColor	Red
ConditionTrueColor	Green

File Home Arrange Visualization Package Tools CAD Is The Model Fault Framework Tanks & Pipes

Select Navigate Text Find Find Next Find Next Select All Edit Custom Properties Edit Script Visual Studio Enable Debug Reset Settings Animate Tools Message Log Layers View Default View Plan View Add View Remove View Zoom Extents Volumetric Physics IO Browser Lag Experiments Event List Analysis Simulation

Snappable Assertions

Search...

Snappable Assertions

- Permissive - While
- Permissive - After
- Permissive - Event
- Interlock - Ensure
- Assertion - Check
- Assertion - Wait
- Assertion - Instant
- Continue - Wait
- Continue - Log
- Restart
- End

Note Not Explor Hierarc Snap

Properties: Scene

Floor

- Default Floor <None>
- Delete Loads After 10 s

Lighting

- Ambient Light Gray

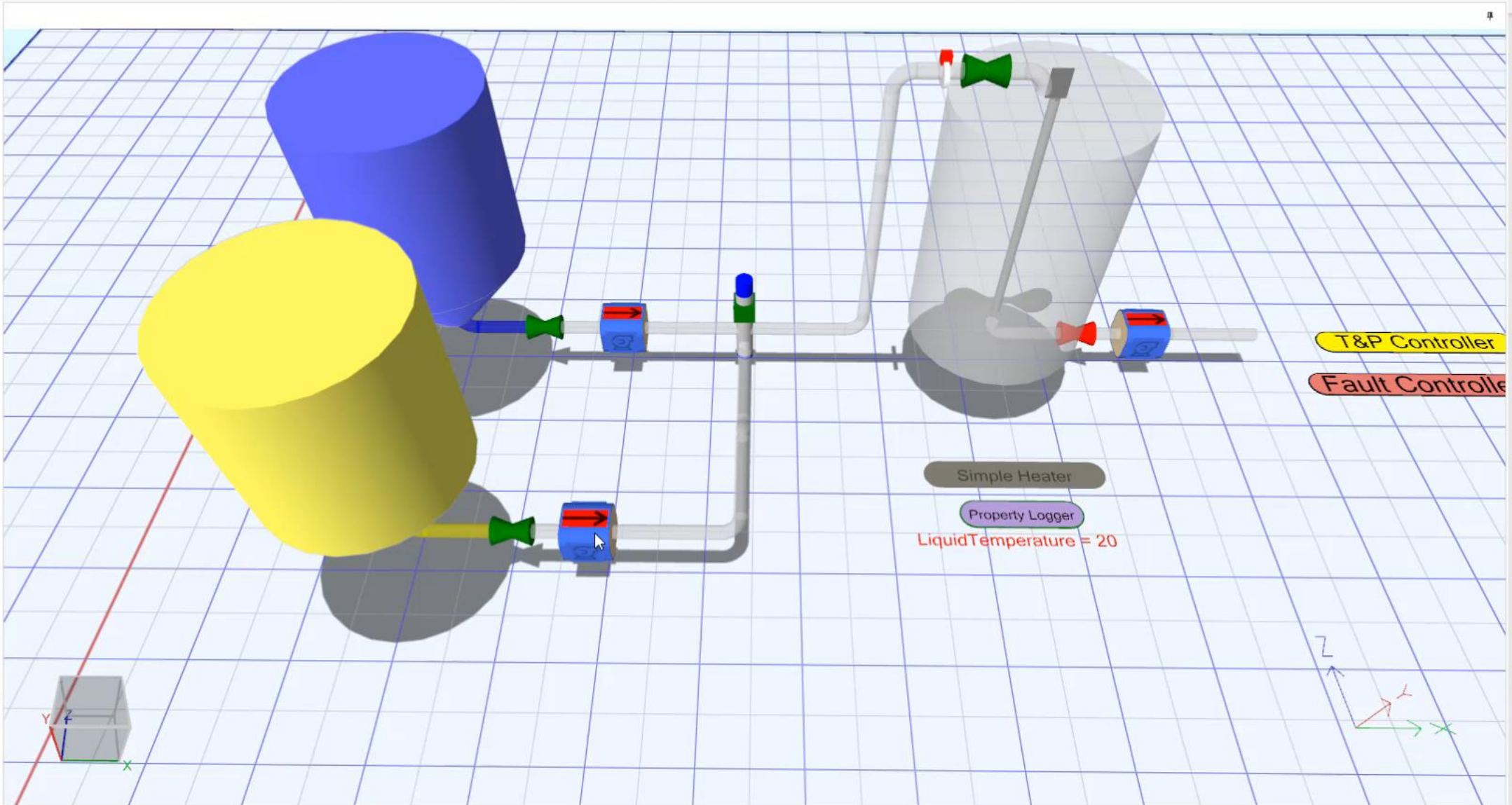
Offsets

- Align Offset 0 m, 0 m, 0 m
- Paste Offset 1.5 m, 0 m, 1.5 m

Align Offset

Add this as a world offset to any align operation using a control point or axis restricted drag of an o...

Properti Properti Connect Events



New Schedule Name

 Create New Schedule
 Import Schedule

 Min Time

Current Schedule - All Faults ▾

 Delete Current Schedule
 Open Current Schedule

 Max Time

Run Mode - Random - Timed ▾

 Add All Faults To Schedule

 Save Faults Report To Schedule

Schedules

Schedules

Create test schedules which enable and disable faults

Manually run a test and then save it out in one click

Run the test to a schedule, step through manually, or run randomly

Table - Test1 ⌵

📁 📄 📊 📅 Edit Schema | 🔍 Edit In Analysis

Drag a column header here to group by that column ⌵

	VisualType	FaultType	VisualName	FaultName	PropertyName	ForceValue	EnableTime	DisableTime
1	MixProofValve	DigitalForceHigh	MixProofValve	MixProofStalledOpen	Open	True	1.2520338	5.4112612
2	MixProofValve	DigitalForceLow	MixProofValve	MixProofStalledClosed	Open	False	6.7814875	16.6707762

Snappable Assertions

Search...

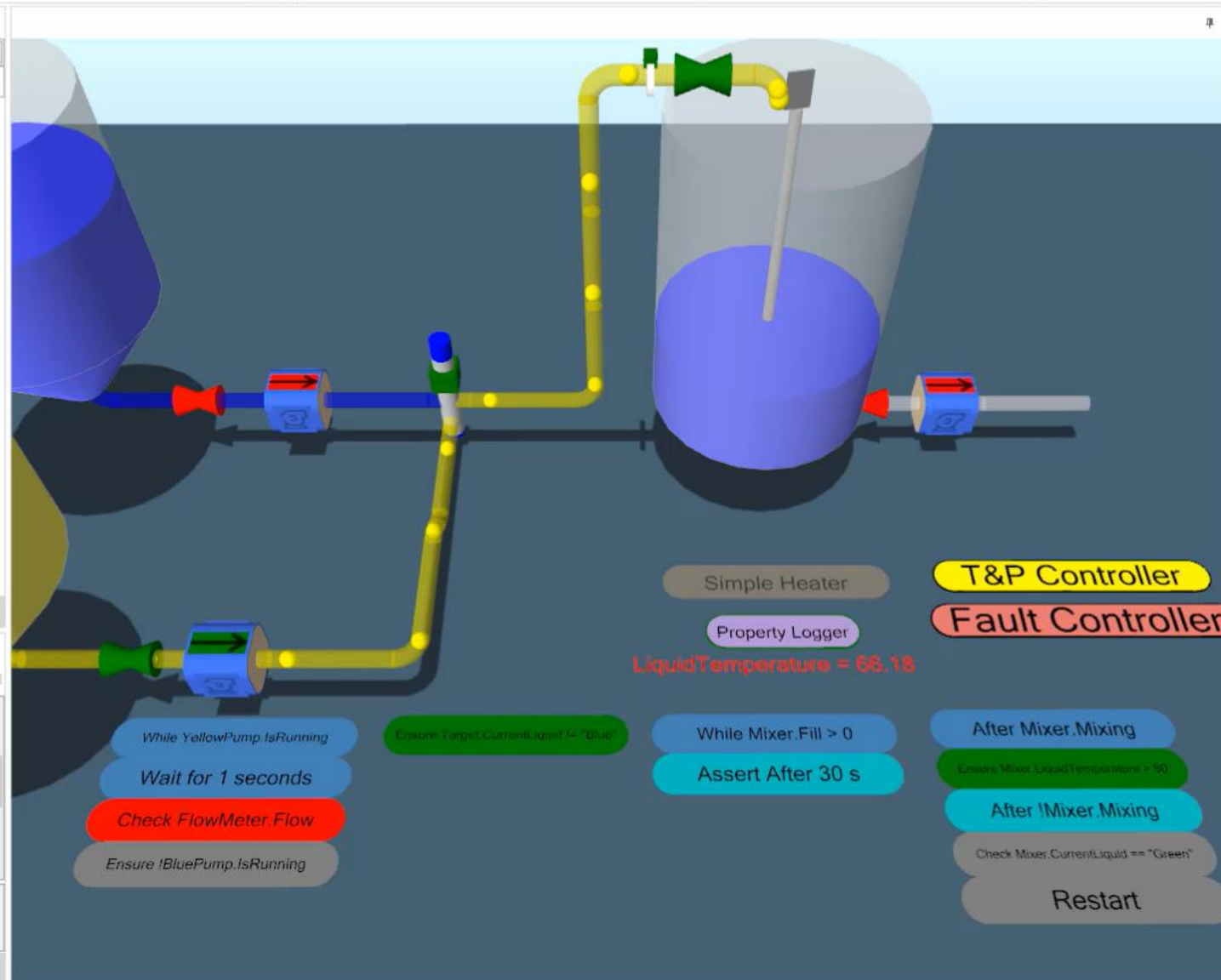
Snappable Assertions

- Permissive - While
- Permissive - After
- Permissive - Event
- Interlock - Ensure
- Assertion - Check
- Assertion - Wait
- Assertion - Instant
- Continue - Wait
- Continue - Log
- Restart
- End

Properties: MixProofValve

WashViaTopPipe	False
Dimensions	
PipeDiameter	0.15 m
PipeLength	0.2 m
Fault Simulation	
FullStall	False
General	
Name	MixProofValve

Name
A non-unique name used when defining actions for this object.



Aspect Viewer: MixProofValve

Filter...

Add Aspect...

Visual Info

Digital Force High Fault MixProofStalledOpen

Aspect Name: MixProofStalledOpen

Enabled:

Property Name: Open

Extra Features

Digital Force Low Fault MixProofStalledClosed

Aspect Name: MixProofStalledClosed

Enabled:

Property Name: Open

Extra Features

2 new errors

Operator Training Examples

The screenshot displays the Emulate3D 2024 interface for a "Buffer Tank 0-E Beta (E3D 2024)" simulation. The main 3D view shows a complex piping system with a central tank, pumps (P-7001, P-7002, P-7003, P-7010, P-7020, P-7030), and valves (XV-7001, XV-7030). Data readouts for flow rates and temperatures are visible: 20°C, 0.074 m³/s, 46.781°C, 0.037 m³/s, 0.000 m³/s, and 0.000 m³/s. A "Simple Heater" is also present. On the left, a "Properties: P7001" panel shows configuration, control, and fault simulation parameters. A "Tools" menu is open, listing various simulation and analysis tools. On the right, two "Property Logger" graphs show "Liquid Temperature = 46.78380649060738 Temperature (Deg C)" and "Fill = 69.80668938936519". The bottom status bar indicates FPS: 24.99, Speed: 1.00 / 1.00, Size: 1608x831, and Time: 0:00:50:09.83.

Tools Menu:

- Analyze Static Visuals
- Aspect Viewer
- Bill of Materials
- Browse WebGL
- Catalog Explorer
- Connectors Window
- Control Panel
- Create Control Panel
- Customize Quick Access Toolbar
- Differences Window
- Events Window
- Explorer
- Feed Manager
- Immediate Window
- IO Grid
- License
- Log File
- Mesh Profiler
- Notes Window
- Package Explorer
- Properties Window
- Property Paster
- Quick Properties
- Resource Explorer
- Script Profiler
- Search Results
- Update CAD
- View Window
- Visual Hierarchy
- Web Console

Properties: P7001:

Configuration	
AddToScenario	False
TargetPressure	10000 Pa
Control	
CurrentPressure	0 Pa
IsRunning	False
Start	False
VariableInput	5 %
Fault Simulation	
BrokenCoupling	False
ElectricalFault	False
General	
Name	P7001
Position	
World Location	-6.84 m, 0.6 m, 3.39 m

Status Bar: FPS: 24.99 | Speed: 1.00 / 1.00 | Size: 1608x831 | Default Display | World Location: X: 1 m, Y: 1.92 m, Z: 2.5 m | Line 3 Supply valve | Line 3 Water Supply | 0.00 Hz | Reset Layout | Connections: 1 | Loads: 0 | Time: 0:00:50:09.83

Snappable Assertions*

Search...

Snappable Assertions

- Permissive - While
- Permissive - After
- Permissive - Event
- Interlock - Ensure
- Assertion - Check
- Assertion - Wait
- Assertion - Wait
- Continue - Wait
- Continue - Log

Properties: SB6

Config: Appearance

- ColorCodeSideProfile: True
- Dimensions: Custom
- IsNarrowBelt: False

Config: Control

- ControlMode: None
- DisableProtocol: False

Dimensions

- ConveyorHeight: 0.83 m
- Length: 4.0869 m
- Width: 0.616 m

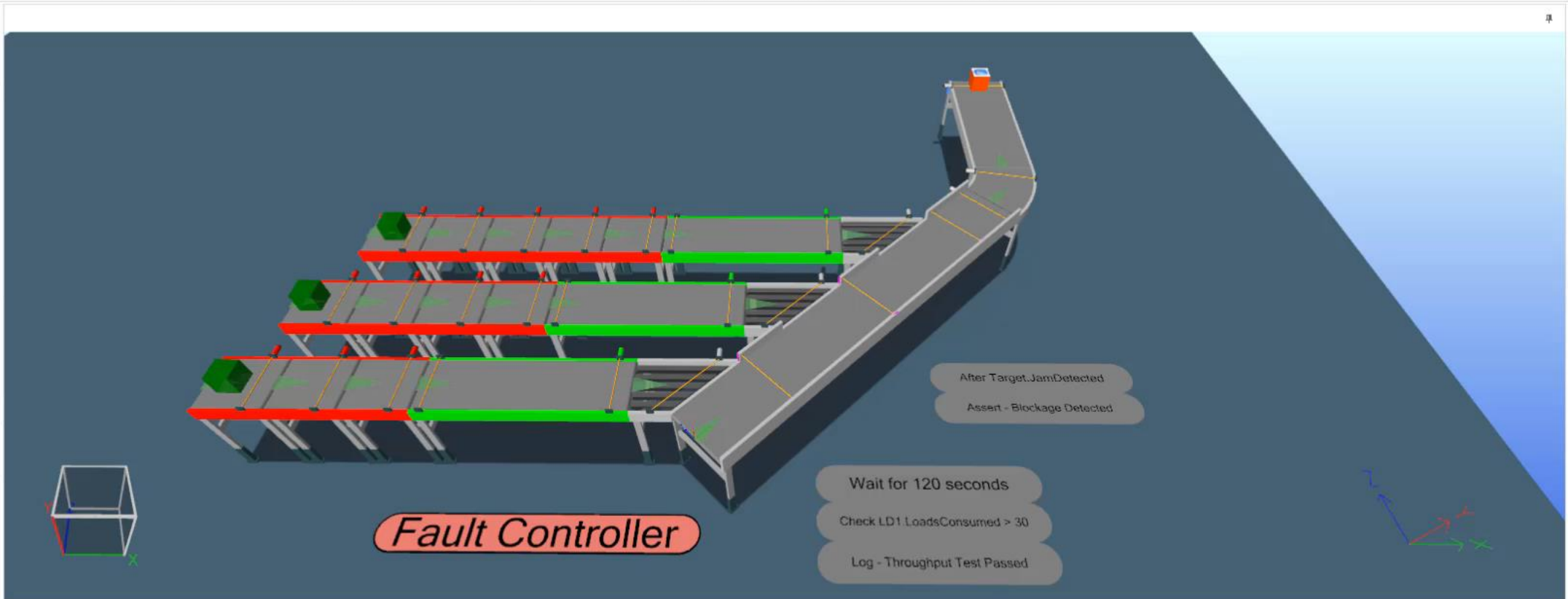
General

- Name: SB6
- Type: Transport Belt Conveyor

Motor

Name

A non-unique name used when defining actions for this object.



Experiments

Run Selected Run Selected In Parallel New Add Experiment Property Delete Options Cancel

Run	Experiment	Fixed Time	Start Time	Run Duration	Reset	Status	FaultController.C
<input checked="" type="checkbox"/>	1	<input checked="" type="checkbox"/>	00:00:00	00:02:10	<input checked="" type="checkbox"/>	Complete	Test1
<input checked="" type="checkbox"/>	2	<input checked="" type="checkbox"/>	00:00:00	00:02:10	<input checked="" type="checkbox"/>	Complete	Test2
<input checked="" type="checkbox"/>	3	<input checked="" type="checkbox"/>	00:00:00	00:02:10	<input checked="" type="checkbox"/>	Complete	Test3
<input checked="" type="checkbox"/>	4	<input checked="" type="checkbox"/>	00:00:00	00:02:10	<input checked="" type="checkbox"/>	Complete	Test4
<input checked="" type="checkbox"/>	5	<input checked="" type="checkbox"/>	00:00:00	00:02:10	<input checked="" type="checkbox"/>	Complete	Test5

Fault Framework

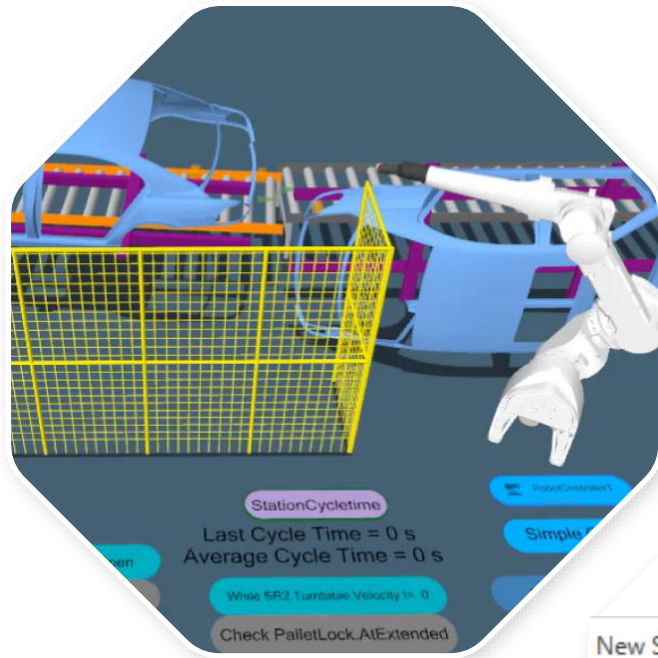
Faults
Assertions
Advanced Controllers
Aspects

New Schedule Name
Current Schedule
Run Mode - None

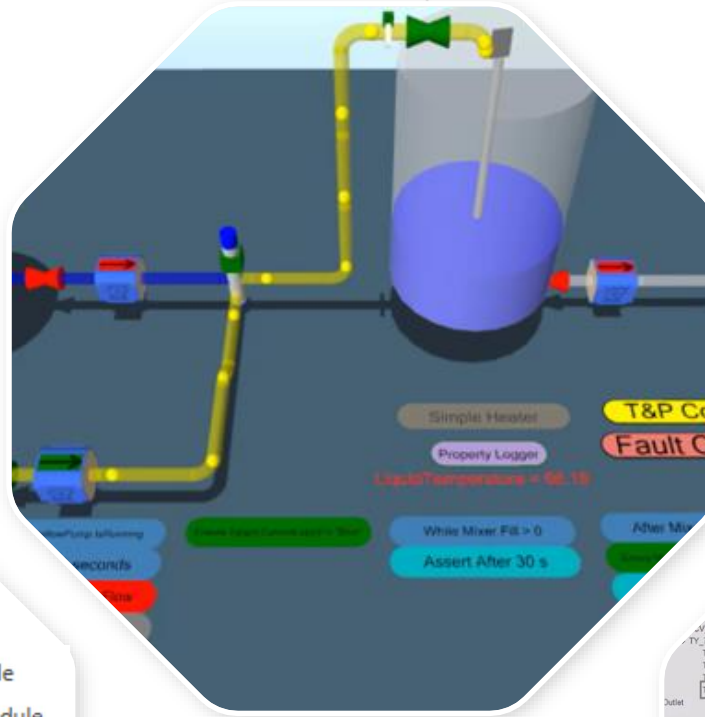
Create New Schedule
Delete Current Schedule
Add All Faults To Schedule
Import Schedule
Open Current Schedule
Schedules

Min Time 5
Max Time 10
Start
Step

Schedule State: not started.
Disable All Assertions
Reset Schedule
Disable All Faults
Log Message
Enable All Assertions
Add Message To Table
Enabled Faults Count 0
Operator Training Mode



Add Faults to Any Model

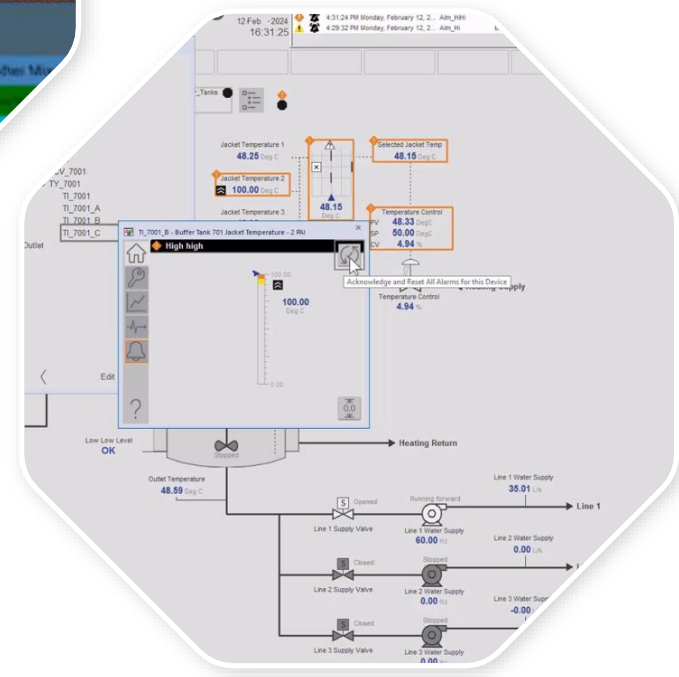


Create Operator Training Scenarios

New Schedule Name
Current Schedule
Run Mode - None
Create New Schedule
Delete Current Schedule
Add All Faults To Schedule
Import Schedule
Open Current Schedule
Save Faults Report To Schedule

Record Regression Tests

Verify Model Behaviour



THANK YOU!
Any Question?



expanding **human possibility**[®]



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