PRES-0037 rev. 1

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### Using Analytics to Manage Greenfield and Brownfield Asset Integrity





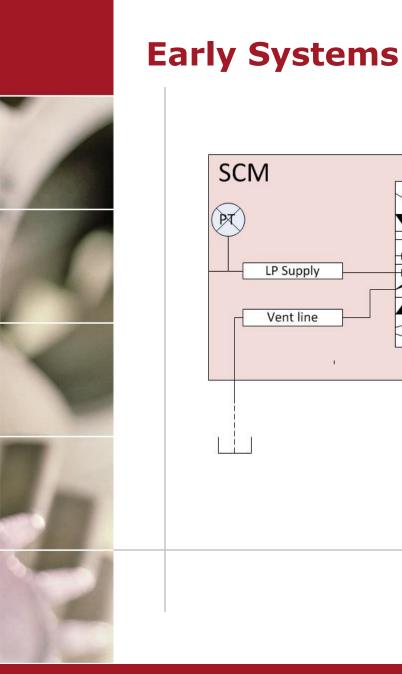
1. Understand the level of subsea instrumentation employed in a Brownfield Subsea Control System

- 2. Using modern simulation tools to access the condition and performance with the limited information available from the Subsea Control System
- 3. Applying analytics to future systems and enhancing condition monitoring of a Subsea Control System (Virtual Inspector)





1. Understand the level of subsea instrumentation employed in a Brownfield Subsea Control System



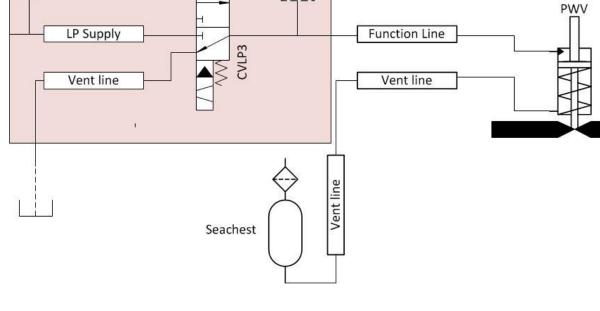
SCM

PA

# PS | **Function Line**

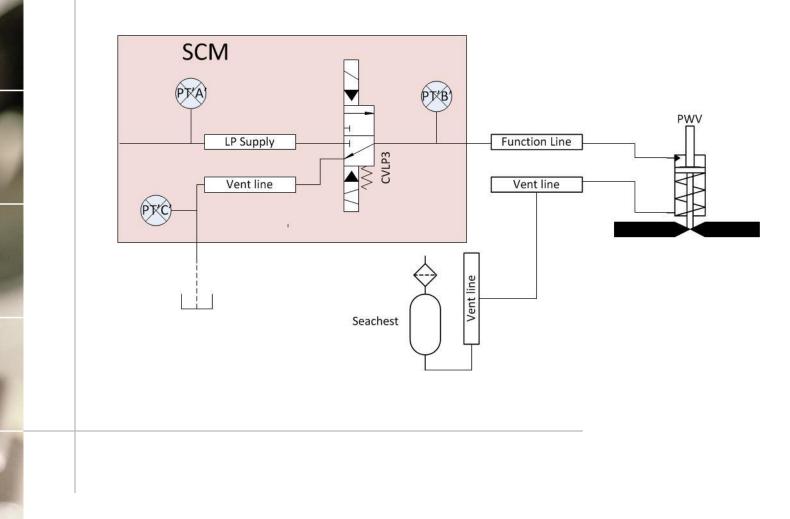
agito

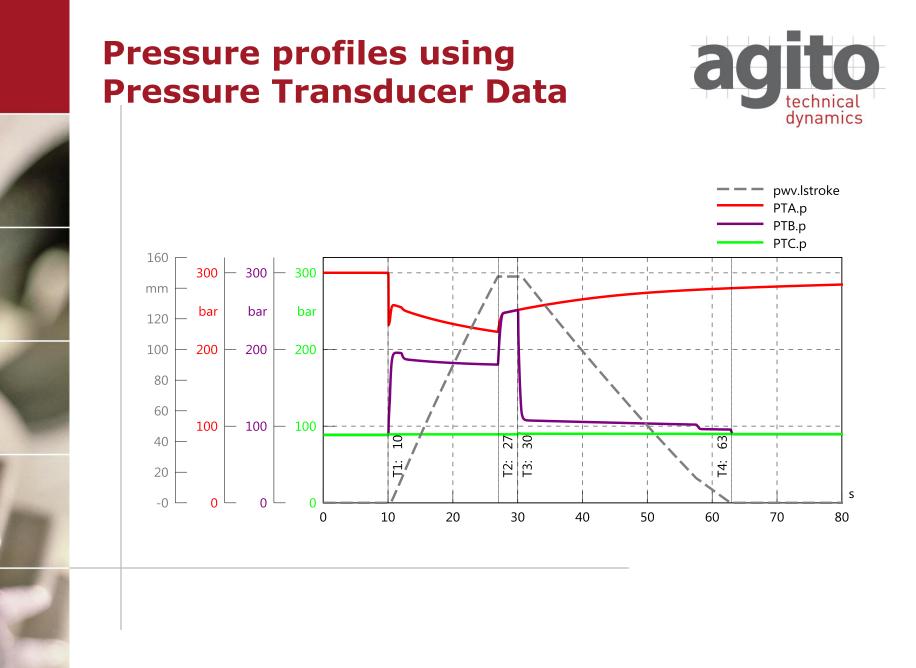
technical dynamics



### **Introduction of Pressure Transducers at the SCM**







### **Valve Position Calculations**



The valve actuator position for the subsea valves can estimated by use of two separate measurement methods

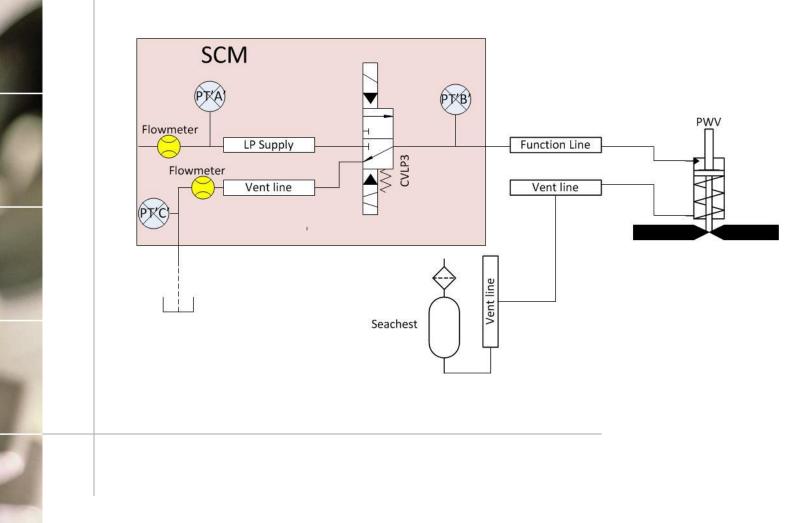
- The static valve actuator calculation is detected by comparing the actuator and supply pressure and a closed valve actuator is detected by comparing the actuator and return pressure.
- Verification of full valve actuator operation is estimated by an additional calculation performed on dynamic data collected during valve actuator movement.

Separate signature calculation method for opening and closing of valves can be implemented.

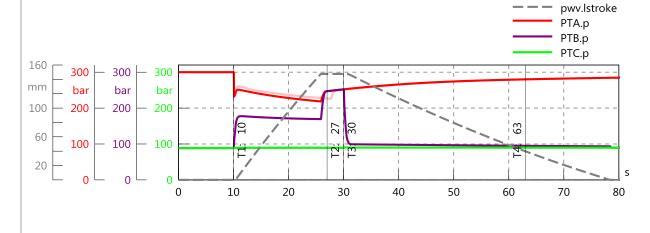
(The total number of data samples for each pressure line was typically limited to 80 samples)

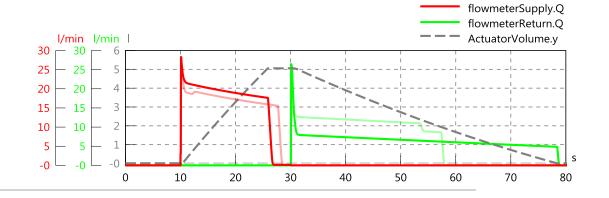
 $C_v = F \sqrt{\frac{S\overline{G}}{\Lambda P}}$ 





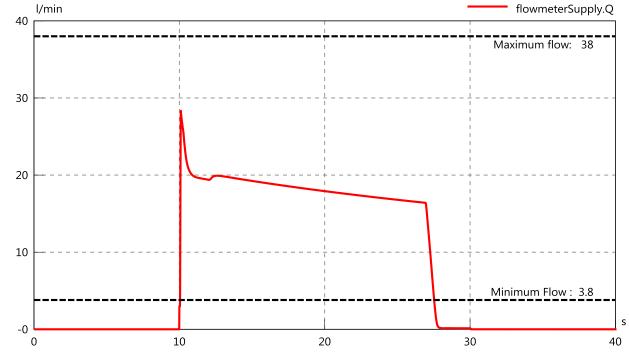






Interpreting Flowmeter data

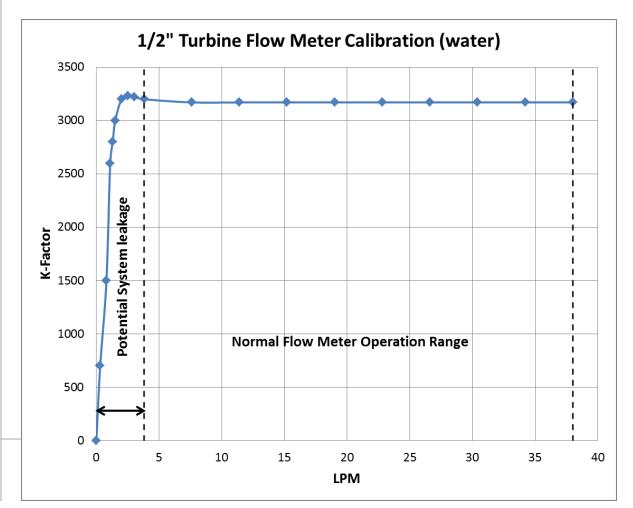




#### Typical 10:1 Turbine Flowmeter operating band during a 5" Valve Operation

Series /Order Code	End Fitting Nominal Inches	ID (mm)	10:1 Stand	lard Range	Ball Bearing /RF Pickoff	Ball Bearing Mag Pickoff	Journal Bearing /RF Pickoff	Journal Bearing /Mag Pickoff	Max	K Factor	Maximum Frequency Approx.
			Min LPM	Max LPM	Min LPM	Min LPM	Min LPM	Min LPM	LPM	P/L	Frequency
FT-08	0.5	11	3.8	38	0.38	0.76	0.95	1.1	38	3170	2000





Typical 10:1 Flowmeter operating band during a 5" Valve Operation

### **Instrumentation Summary**



#### Study the selected instrumentation and;

- Recognise and consider potential errors
- Consider if the instrument was/is fit for purpose
- Realise its potential





2. Using modern simulation tools to access the condition and performance with the limited information available from the Subsea Control System

Some major system changes to consider:

- System Leakage
- Accumulator Pre-charge decay
- Umbilical line and hose ageing
- Well bore pressure





Performing an evaluation of the Production Control System with a simulation tool

Points to consider:

- ISO acceptance criteria
- Company specific acceptance criteria
- Third party acceptance criteria





#### System Trend Analysis of a field development

#### Advantages:

- Identify system performance degradation
- Reduce the risk of production loss
- Reduce risk to people and the environment
- Non-intrusive





#### Using SimulationX® to predict failures in a control system

Value added by Analytics:

- Predicts degradation trends
- Helps Establish a mitigation strategy
- Improves field predictive maintenance





System Risk assessment

The risk assessment should:

- Identify critical components in the system
- Identify potential modes of failure



### Life Cycle Changes



#### **Field Evaluation**

## *In-depth study is conducted with attention to:*

- Sub components individual degradation
- Fatigue and life cycle characteristic changes
- Field operational data collection



### Life Cycle Changes



#### **Field Evaluation**

Challenges:

 Historically, field data has proved difficult to obtain, but it is already being produced by the system but needs to be actively recorded



### What is SimulationX®



SIMULATION X

Powered by ITI

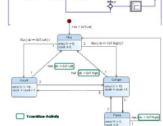
System Simulation Software

### SimulationX - Versatile modeling

- Multi-body systems (rigid, elastic) •
- Networking elements (multi-physics)
  - Linear, rotary, planar mechanics
  - Hydraulics, pneumatics •
  - Thermics, thermal fluidics
  - Electronics, magnetics ۲
  - Acoustics (*New in 3.6*)
- Blocks, controls, statecharts
- Modelica packages www.modelica.org •
  - Modelica Standard Library •
  - Hybrid, Green Building, Industrial Utilities etc.

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### **SimulationX® Libraries**



Dedicated Subsea Libraries for Fluid Power and Electrical Power/Signal Systems

SimulationX now adopted by most control system vendors







### **SimulationX**®



The following physical effects are included in the mathematical model for hydraulic systems:

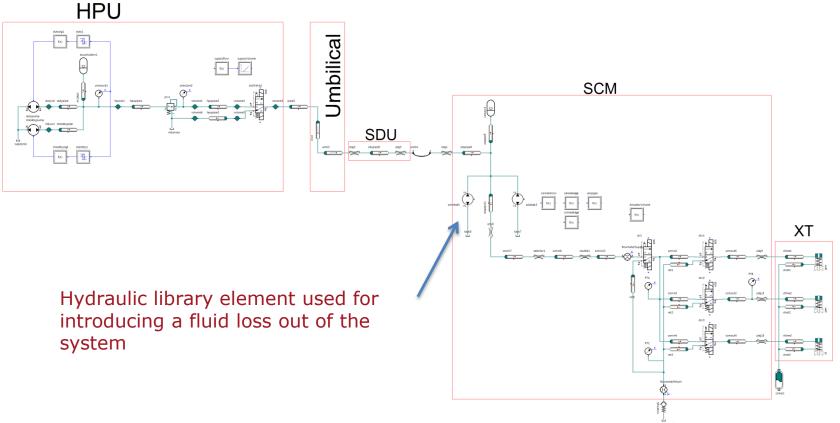
- Pressure loss due to wall friction in lines
- Pressure loss due to changes in fluid velocity in valves, couplers and fittings
- Time delay due to wall elasticity in lines combined with fluid elasticity
- Water depths and local temperature of deployed units
- Variable external umbilical pressure
- Pressure and temperature dependent fluid viscosity and Bulk modulus.
- Real gas properties of nitrogen using the modified Bender state equation



### **SimulationX**®



#### Single Well System Model in Simulation X $\ensuremath{\mathbb{R}}$





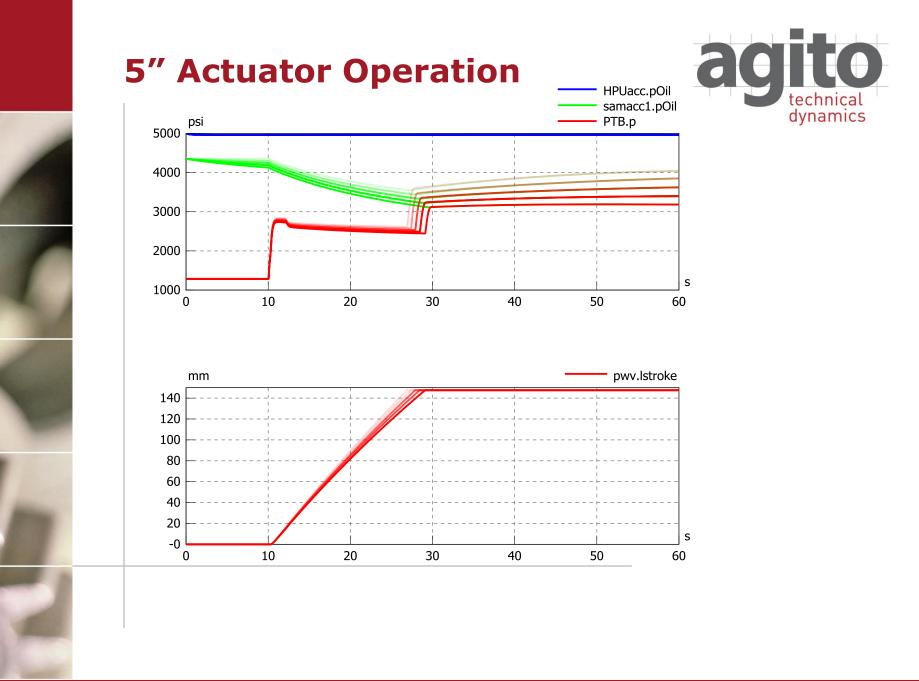
### **Trend Analysis**



Sensitivity runs are performed based on inputs such as hydraulic leaks, changes in friction, accumulator pre-charge decay, and connector failure. This will establish performance results such as;

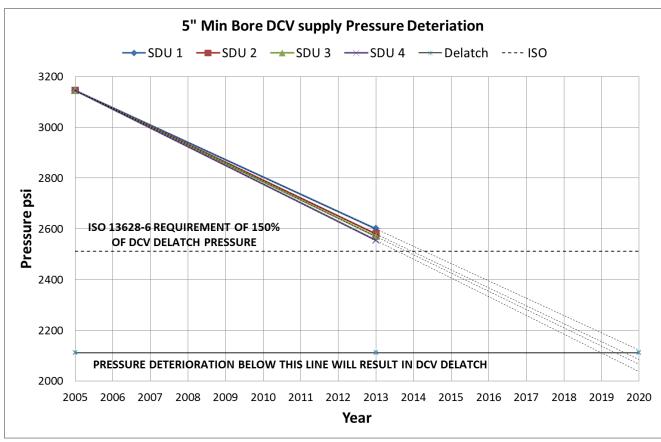
- System Charge Up times
- Valve actuator operation
- System behaviour

Results plotted along with the results obtained from the baseline system analysis, establish trends and help in identifying potential failures in the system before they occur, minimizing the effects of an unscheduled production shutdown



### **5" Actuator Operation**









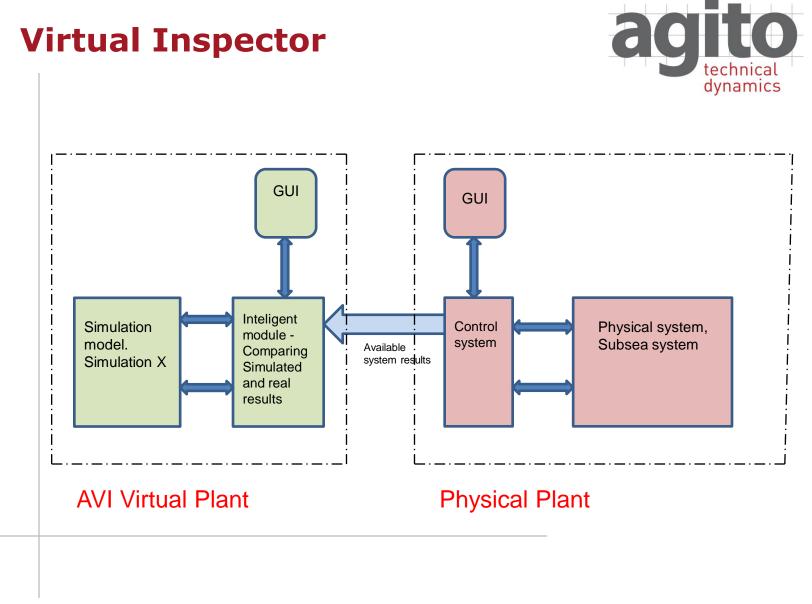
3. Applying analytics to future systems and enhancing condition monitoring of a Subsea Control System (Virtual Inspector)

### **Virtual Inspector**



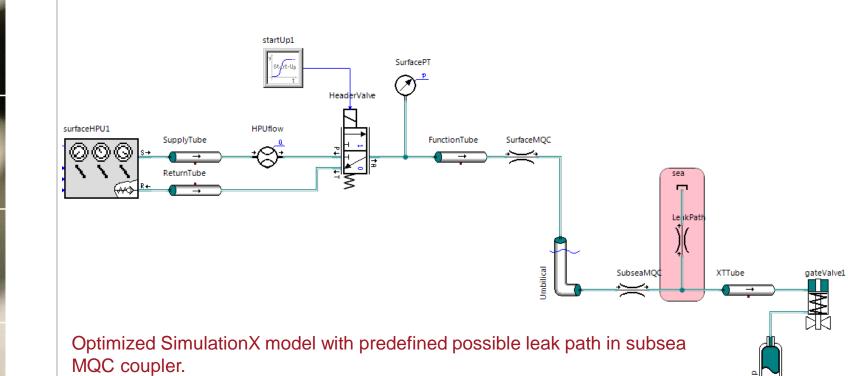
AVI shall perform the following tasks:

- Continuously monitors the behavior of complex dynamic systems and reports deviations with respect to normative behavior.
- Detects and locates degradations in components and systems and then provides early warning of components failures.
- Suggests action plans when problems or failures are detected such as, help in localizing system leaks.
- Front end application to run real system simulations in manual mode based on the facilities engineers/ technical experts needs.



### **Virtual Inspector**

### SimulationX® Representing the **agito** Physical Plant



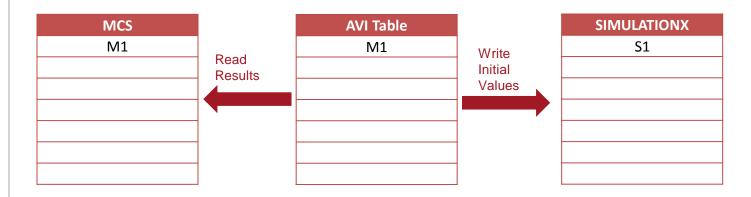
Associately in structure and stick in this associately is Quarters DT and UDU flavores to

Available instrumentation in this example is Surface PT and HPU flow meter



### **Initiation of SimulationX**®

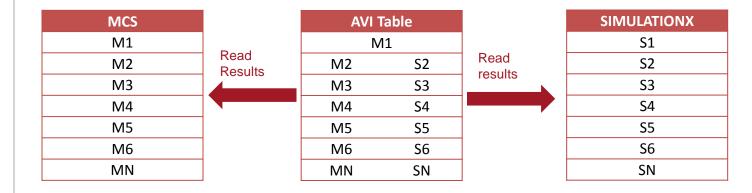




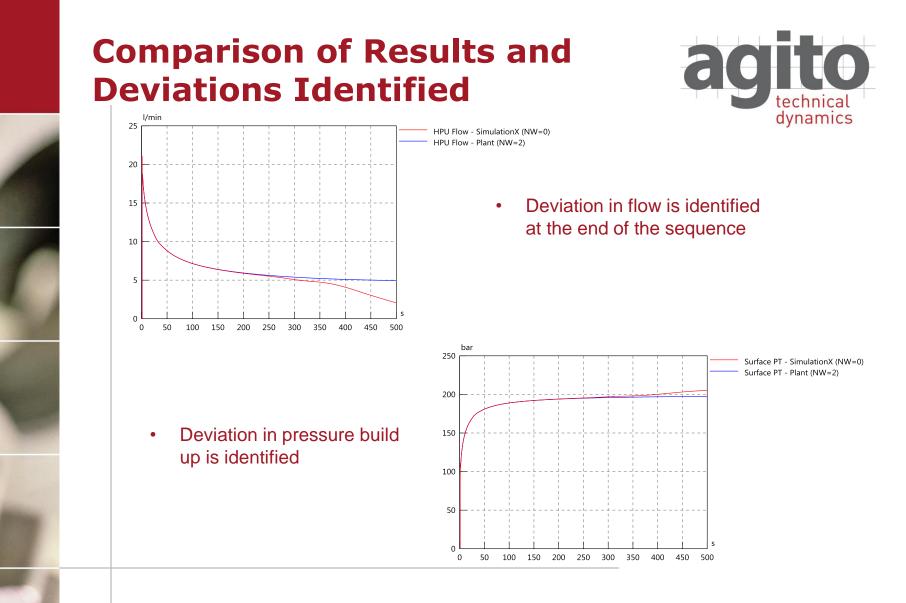
- The AVI Table <u>reads</u> results from the Master Control Station (MCS).
- The AVI Table <u>writes</u> the first line to SimulationX as system initial values and starts the simulation in parallel with the physical plant.

## Parallell Operation of Physical Plant and SimulationX®



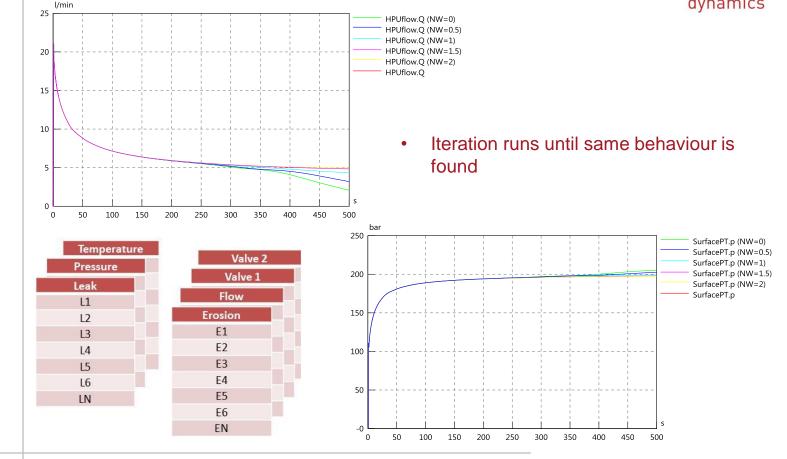


- The AVI Table <u>reads</u> results from the Master Control Station (MCS).
- The AVI Table <u>reads</u> results from SimulationX model from line two.



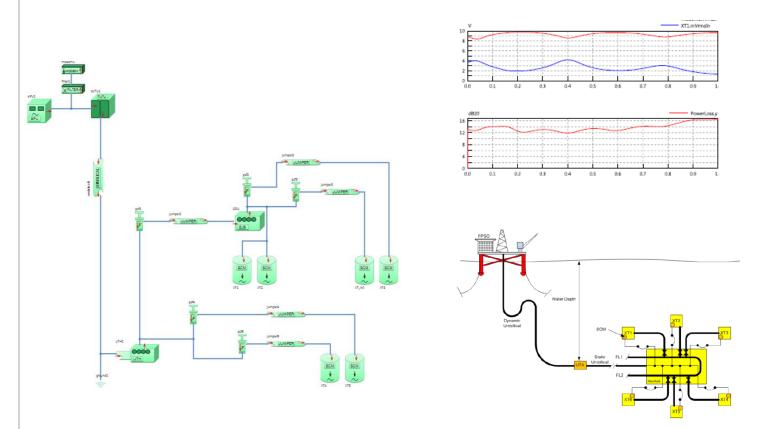
### **Iterations Start and Possible Faults Tested**





### Subsea Electrical Analysis in SimulationX®





Asset Integrity using Analytics can now be employed on Subsea Power and Communication Systems





### Thank you for your attention