Optimization, Predictive Analytics, & Real-Time Process Models

Pipeline Event Detection

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Event Detection

- Pipelines can consist of a complex network with many variables moving at the same time. Different events can occur that cause an impact on production, safety, and shipping of fluids through a pipeline.
- *OptiRamp* simulation software can detect several events that occur through the pipeline with a real-time simulation transient model.

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Event Detection

- Congealing
- Hydrate Formation
- Gas Condensation
- Sand Management
- Leak Detection
- Pigging
- Batching
- Slugging

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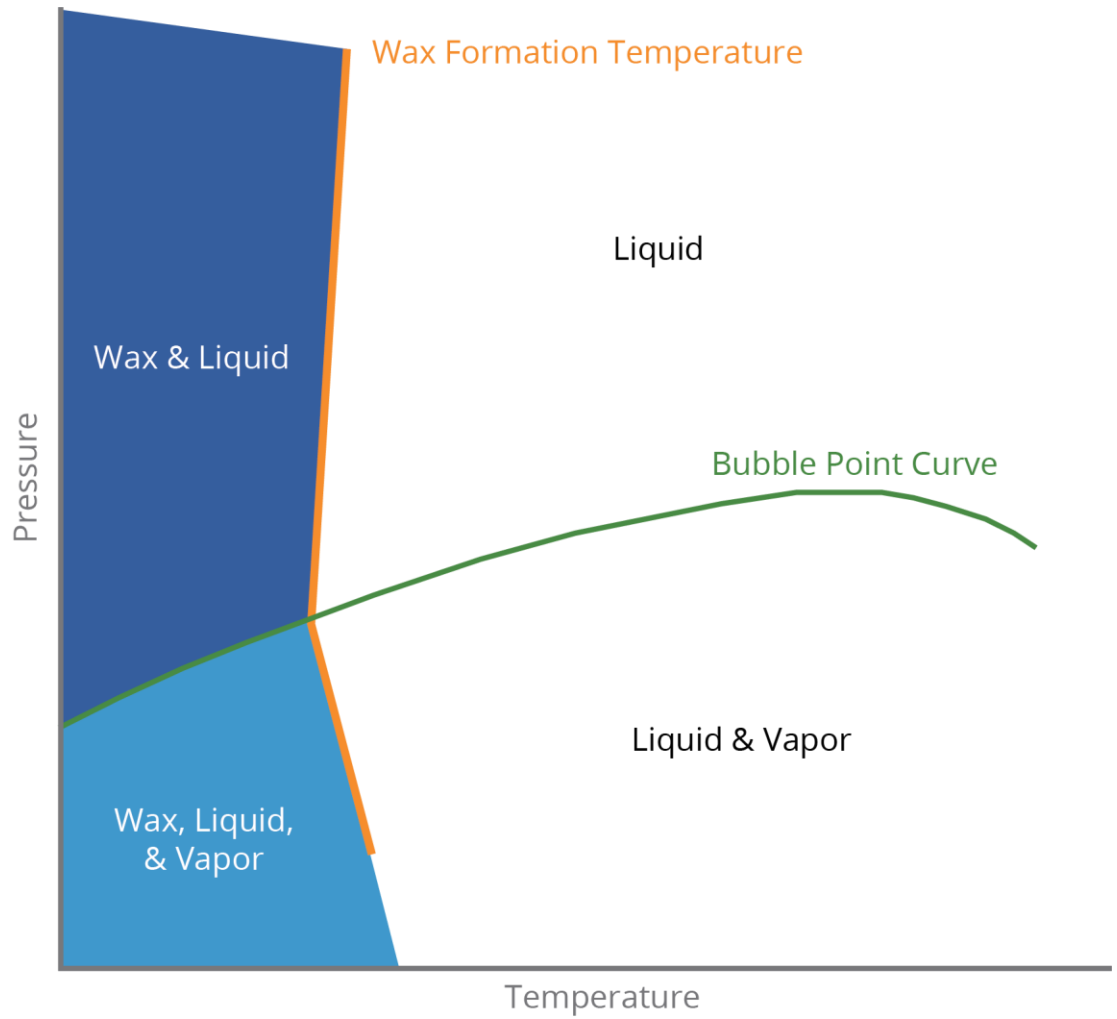
Congealing

The appearance and formation of wax solids occur due to:

- Temperature gradient between pipe wall and centerline flow
- High-yield flow stress occurring due to changes in flow behavior
- Wall temperature is below Wax Appearance Temperature



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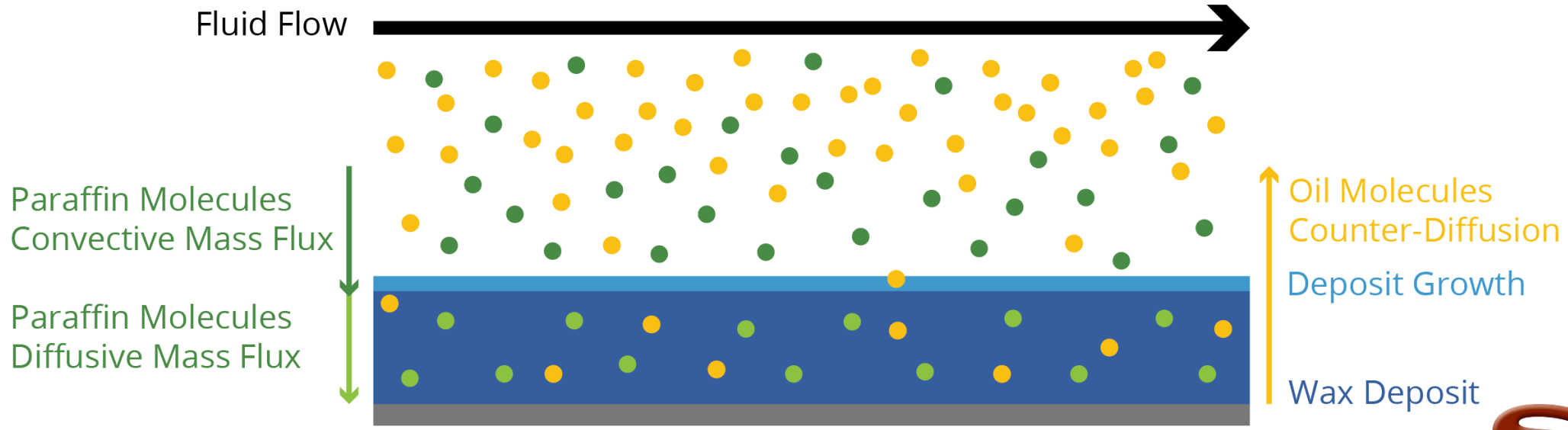
Congealing (ctd)

- *OptiRamp* Congealing detection displays in Web Analytics
- Enables real-time tracking of segments in pipeline being congealed
- Model looks for concordant precipitation in more than 2 segments prior to generating Congealing notification.



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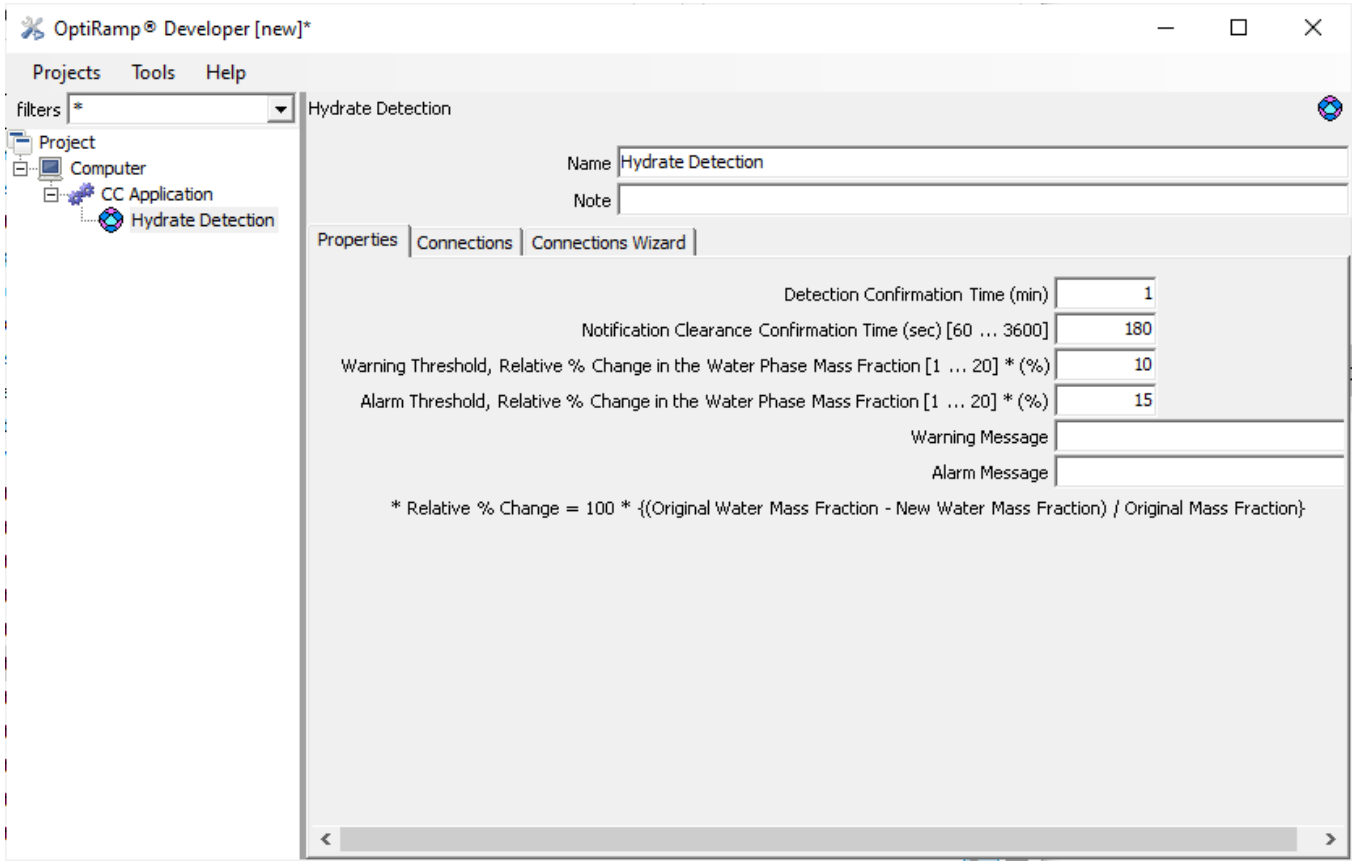
Hydrate Detection

- Looks for hydrate nucleation
- When hydration forms it can obstruct pipeline flow
- Performs thermodynamic equilibrium calculations to determine fraction of the multiphase fluid mass that precipitates



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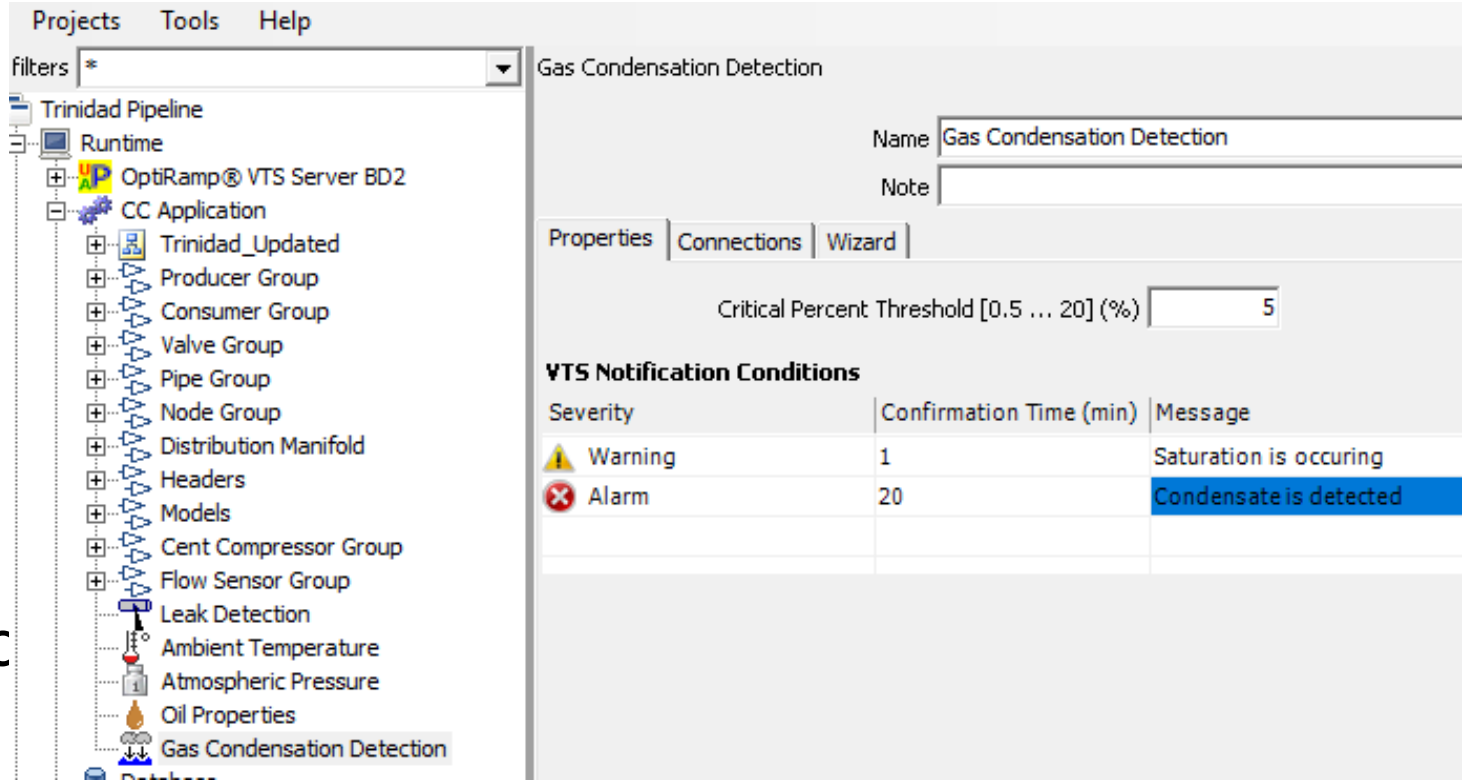
Gas Condensation

- Looks for condensation of heavy gasses
- Sensitive to live ambient temperature
- Normally found at the base of sagging sections
- Uses dew point and specific humidity to update in real time



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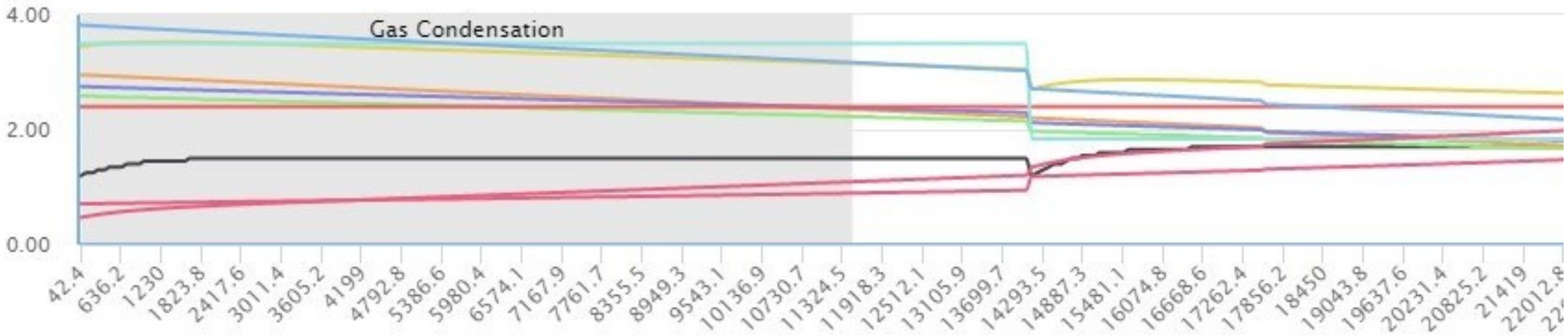
Gas Condensation Pipeline Profile

- *OptiRamp* Condensation detection displays in Web Analytics
- Enables real-time tracking of segments in pipeline that have the potential for condensation



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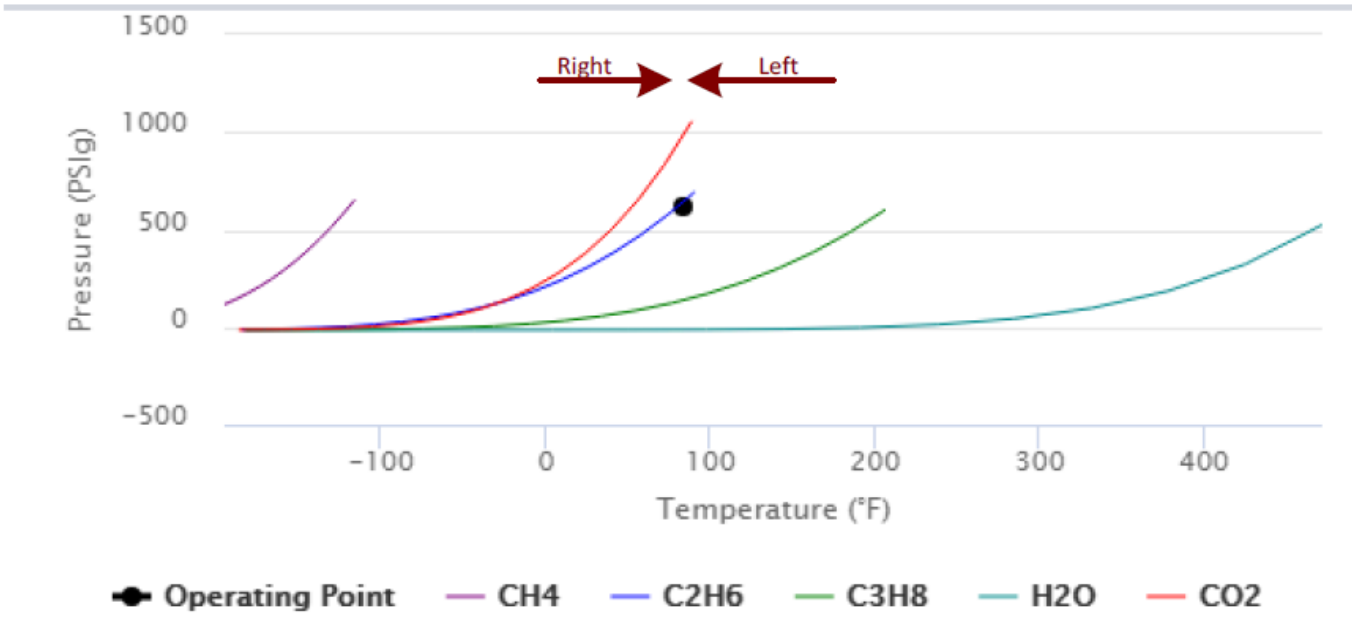
Gas Condensation Phase Diagram

- Helps users understand which components exist in which phases
- Consists of two main items
  - Operating Point
  - Individual Component Curves
- Example shows Methane, Ethane, Propane, Water, and Carbon Dioxide
- Everything to the right is in liquid phase and everything to the left is in gaseous phase



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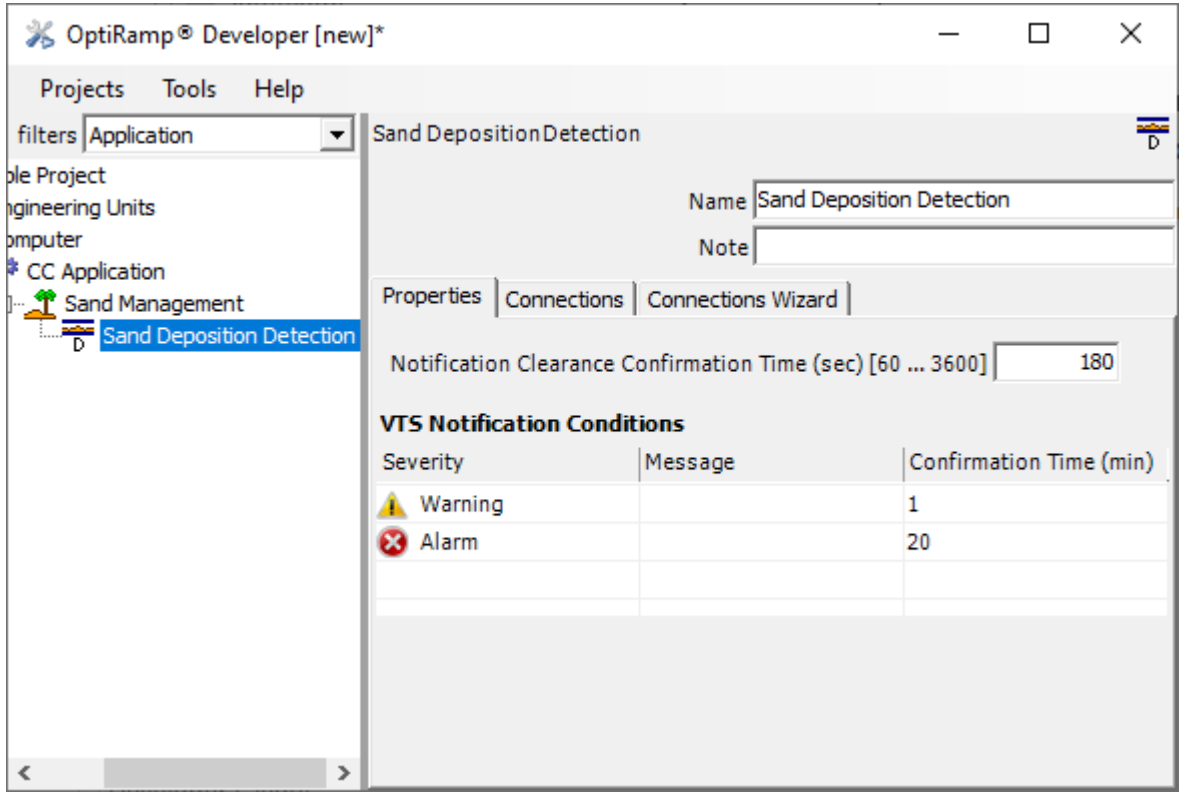
Sand Management

- Sand can cause several risks
  - Frictional pressure loss
  - Erosional damage
  - Equipment failure
- *OptiRamp* detects sand deposition and sand erosion
- Based on 14E of API



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Leak Detection

- Finding leaks
  - Material balance equations for every transportation network segment
    - *Input = Output + Accumulation* $\sum_i X_i(t) = \sum_j Y_j\left(t + \tau_j\right) + \sum_p Z_p(t)$
    - Binary response prediction: logistic regressions, artificial neural networks
    - User-selected system sensitivity thresholds & corresponding curves
  - Live data to simulate pipeline pressure, temperature, velocity profile
  - Improve models based on confirmation/rejection of detected leaks
  - Based on API RP 1130

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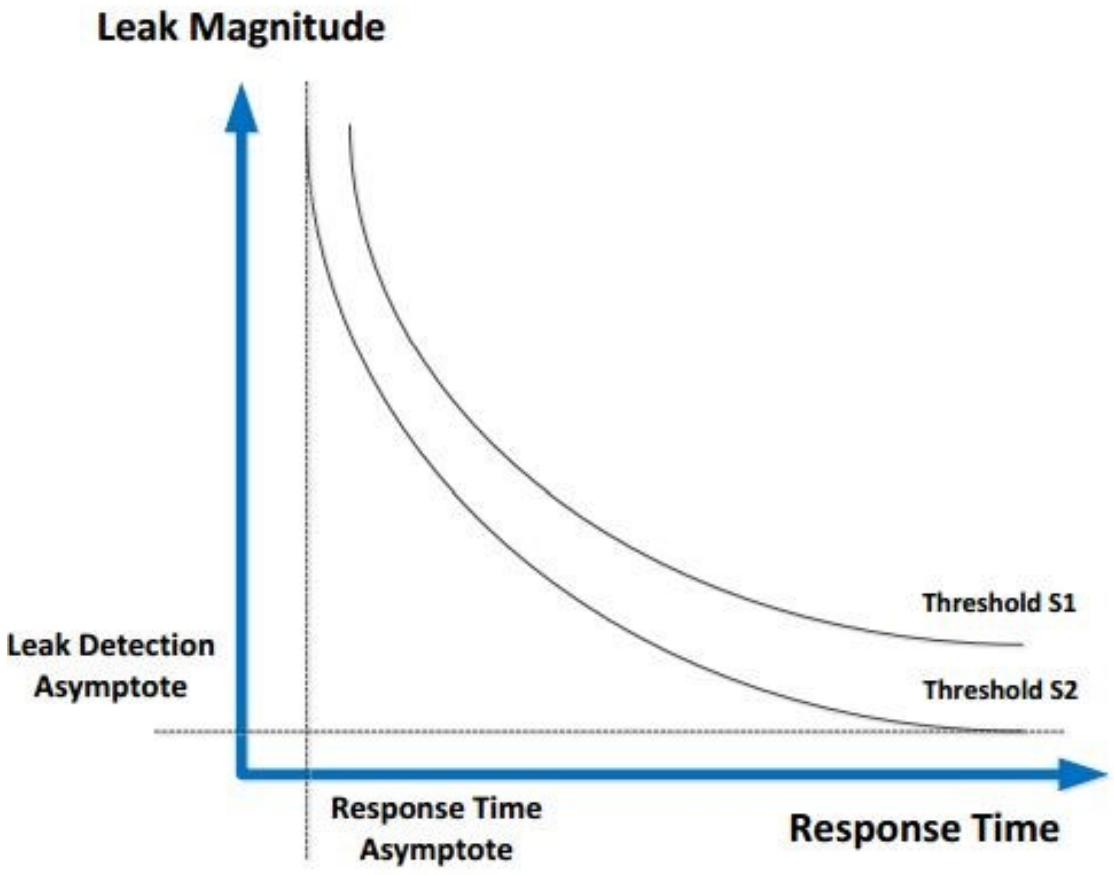
Leak Detection Sensitivity Threshold



- Thresholds determine locations for leak magnitude and detection response time
  - Locations indicate minimum detectable leak magnitude & attainable response time to identify leak
- S&C helps determines values during Leak Detection commissioning

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Leak Detection Accuracy

	Leak Exists	Leak Does Not Exist
Leak Detected Alarm	True Positive	False Positive Type I Error
Leak not Detected	False Negative Type II Error	True Negative

- *OptiRamp* has leak probability analyzer
  - Drive by statistical models
  - Identify segment where leak occurred
  - Leak detect occurs if passes True Positive/True Negative threshold
  - True Negative minimized through historical analytics (operations note if leak actually detected)
- Accuracy depends on quantity of live data sensors (mainly pressure) on pipeline
  - Recommend minimum of 1 sensor/30 km
  - *Accuracy = 1 – (Type I Error Rate + Type II Error Rate)*

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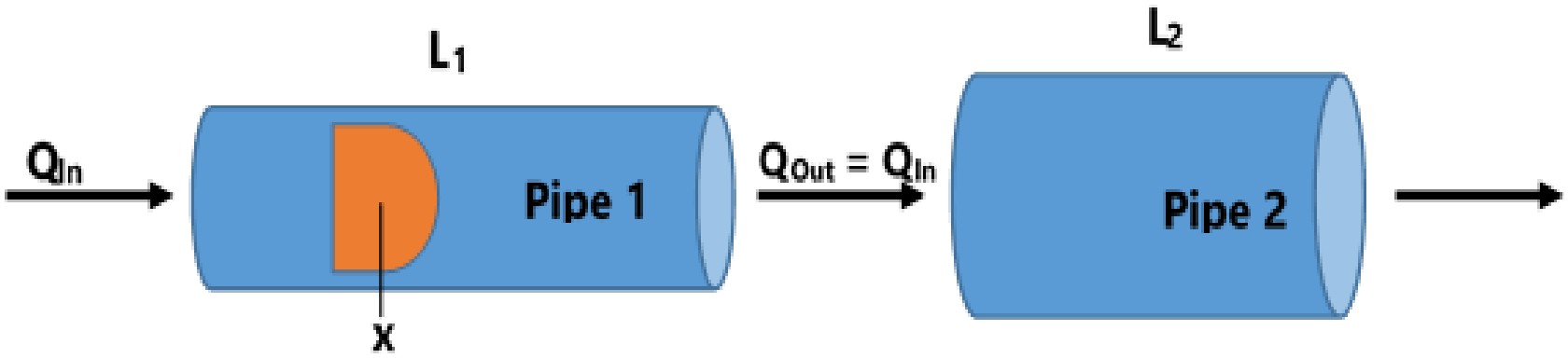
Pipeline Inspection Gauge (Pigging)

The terms used to compute Pig position are as follows:

- $Q = Q_{In} = Q_{Out}$: Fluid volumetric flow rate along the pipe.
- L_1 and A_1: Length and cross-sectional area of Pipe 1 (the pipe that currently holds the pig at time t_{n-1})
- L_2 and A_2: Length and cross-sectional area of Pipe 2 (the pipe immediately downstream of Pipe 1)
- $x(t_{n-1})$ and $x(t_n)$: Pig position at time t_{n-1} and t_n
- V_1 and V_2: Pipe 1 and 2 internal volumes



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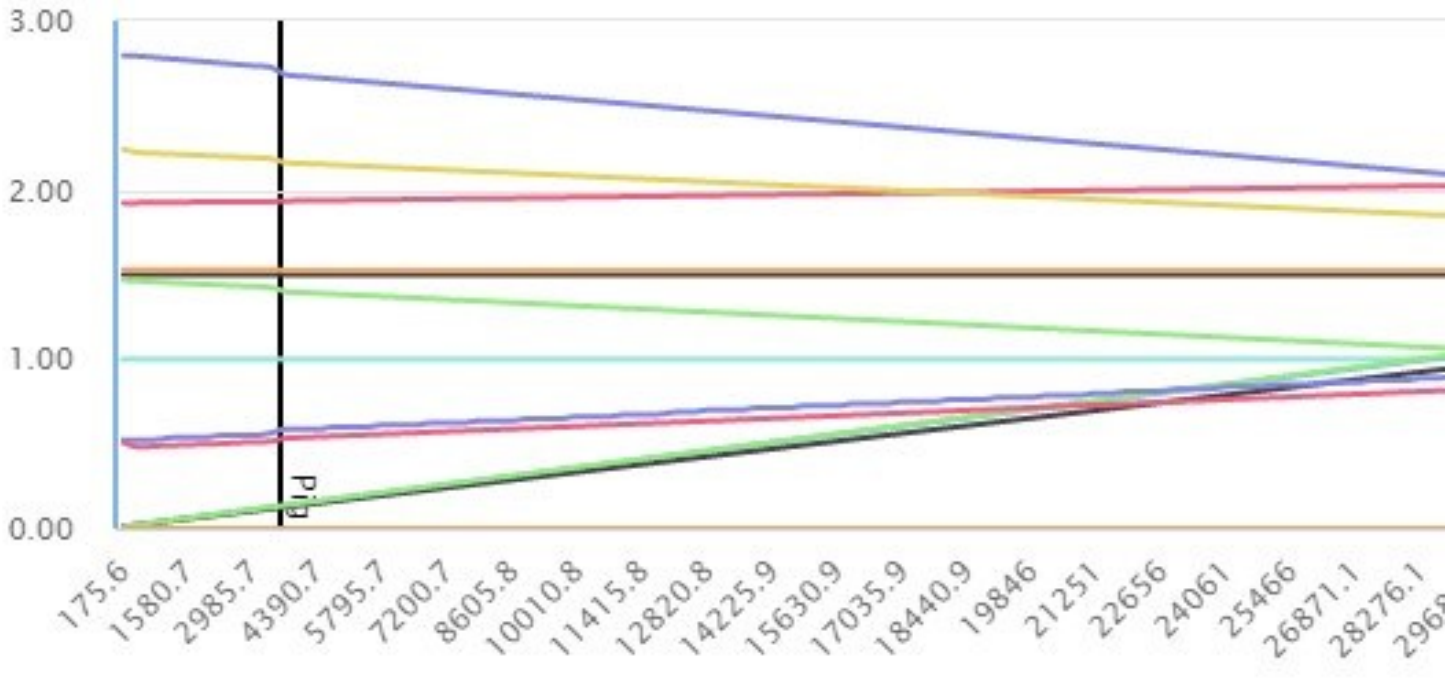
Pipeline Inspection Gauge (Pigging)

- Can allow users to know how much liquid is in the pipeline
- Send notifications to let users know it’s time for a pigging exercise
- Help save pipeline operators manual hours and resources from futile pigging operations



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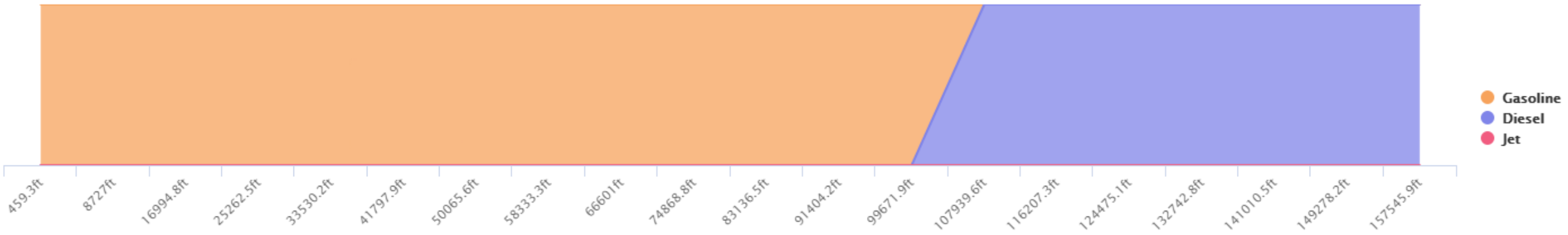
Real-Time Batching

- Displays the batch barrier in pipeline profile
- Track product movements
- Can include multiple sources for mixing
- Calculates time for batch to move through the pipeline



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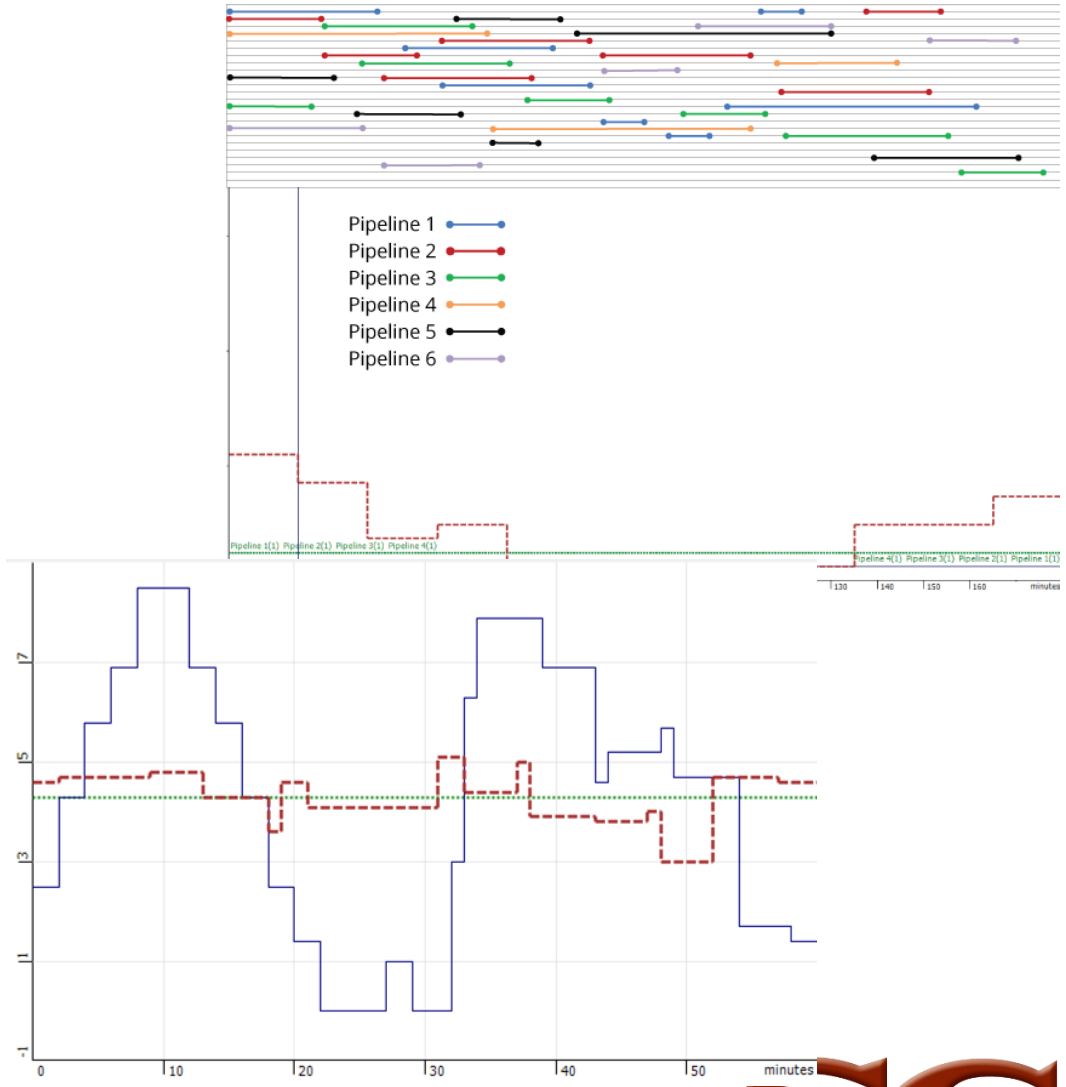
Batching Optimization

- Build forecasting model
- Determine most efficient operating mode across asset
- Predict future probabilities or behaviors
- Balance inputs & output (mass balance reconciliation)
- Schedule & allocate based on forecasted constraints & requirements



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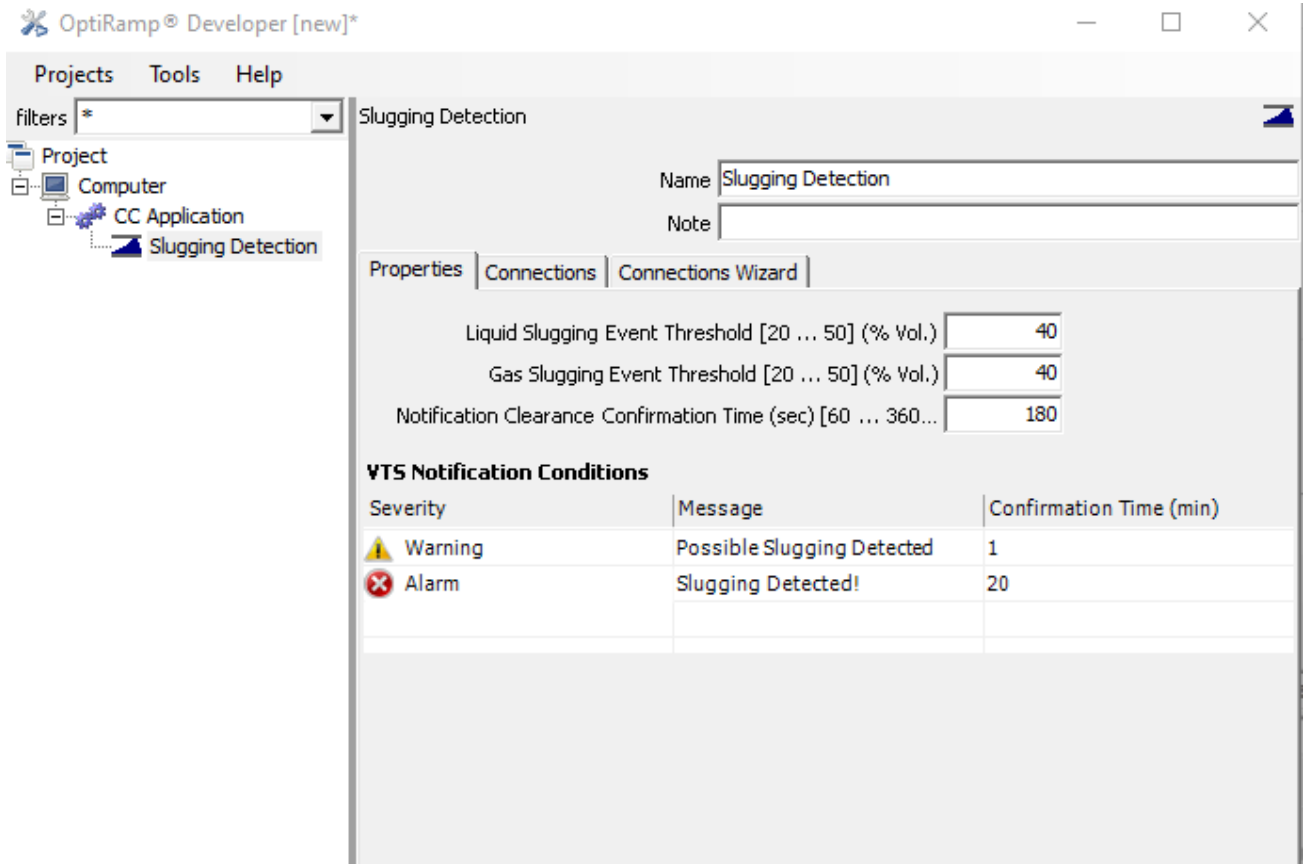
Slugging Detection

- Factors that contribute to slugging
  - Superficial velocities of liquid and gas in the pipe
  - Pressure of the fluid
  - Design of the pipeline
- *OptiRamp* detects slugging situations
- Extended periods of slugging can result in poor separation between oil, water, and gas components



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