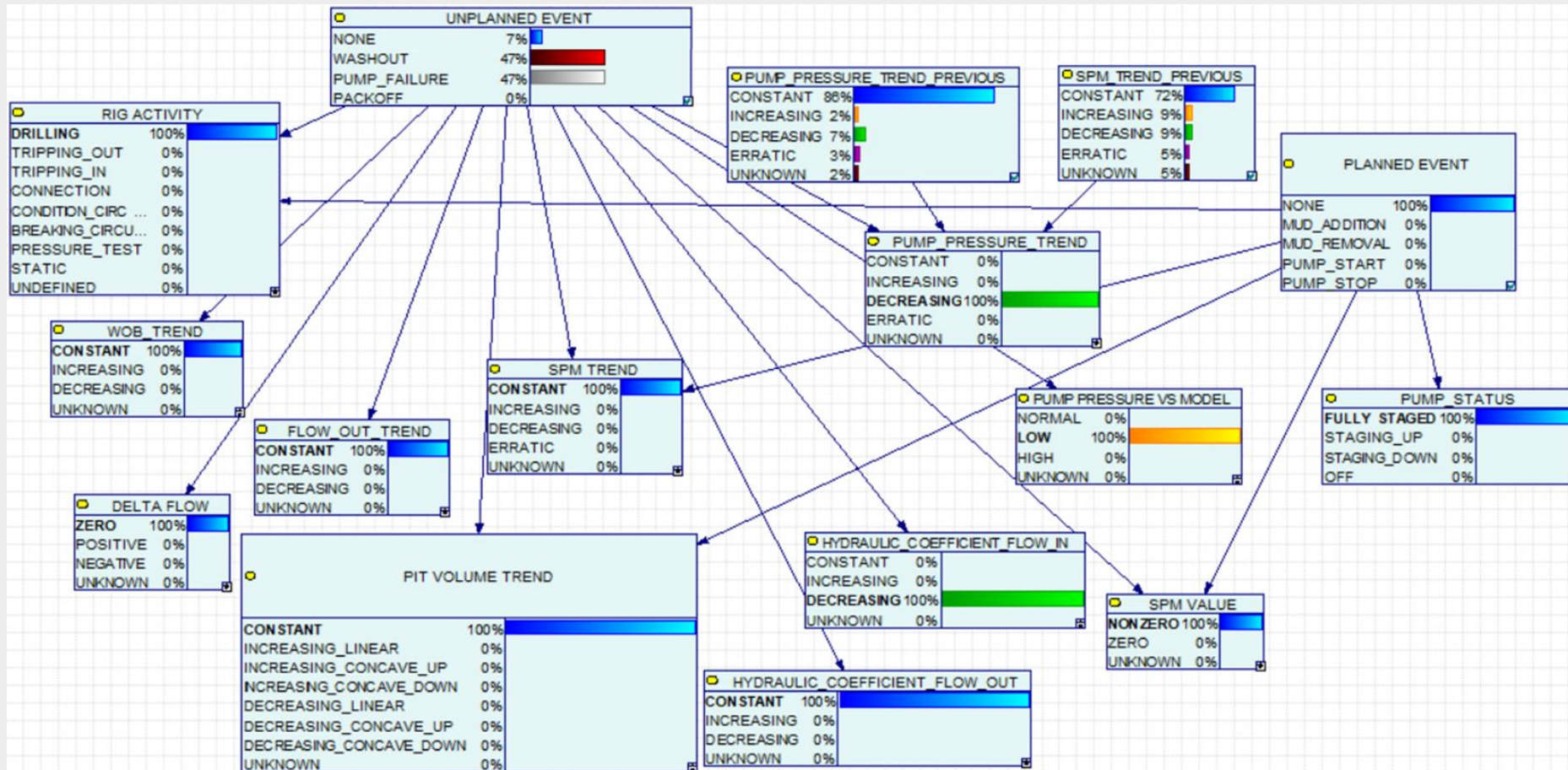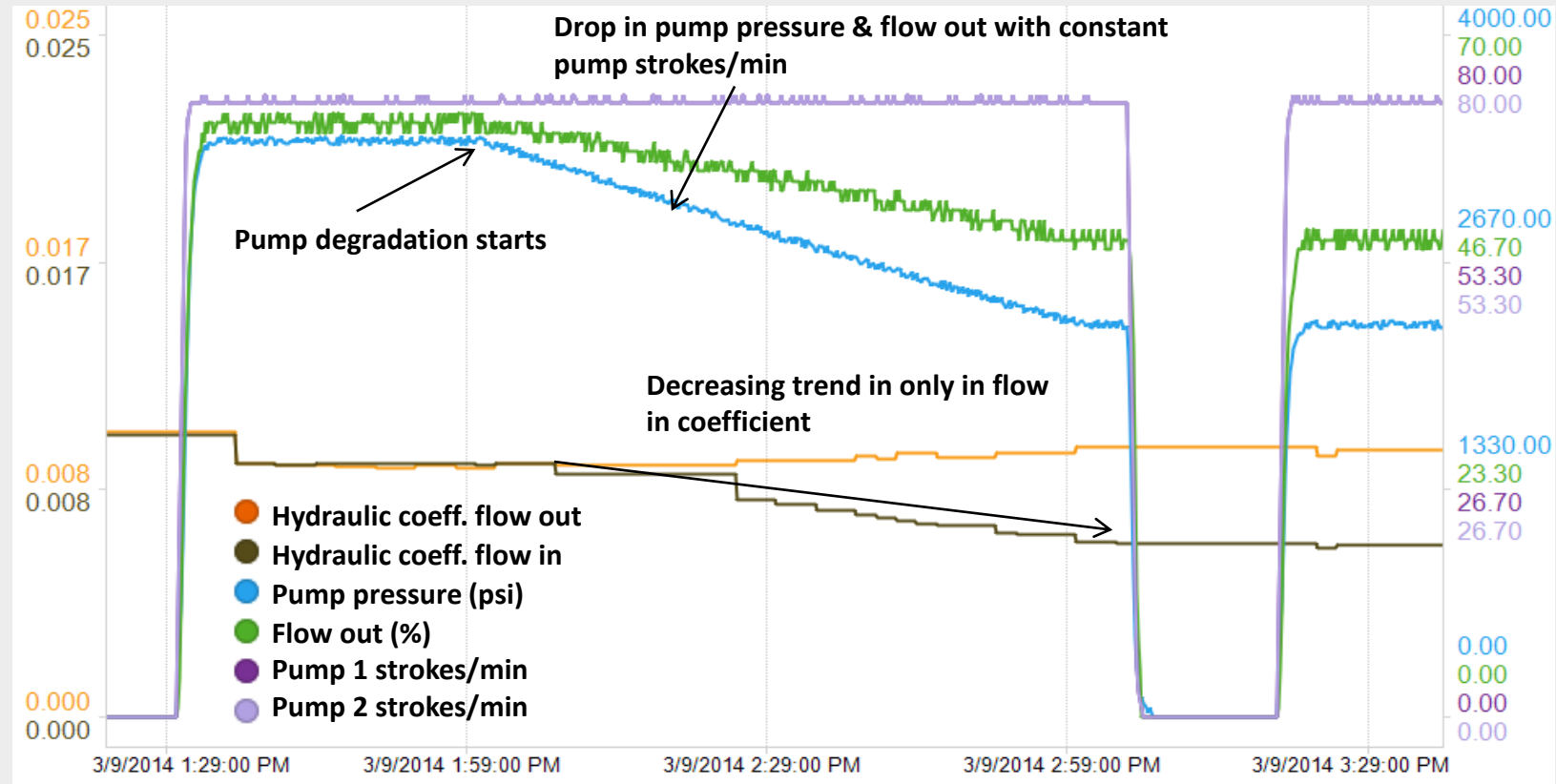# Bayesian Network Model for Pump Failure Detection

Real-Time Data Trends During Pump Failure

Pump Failure: Influential Features I

| Node	Feature Description	Node State Breakdown	State Conducive to Belief
Delta Flow	Flow Out-Flow In	**ZERO:** Close to zero delta flow **POSITIVE:** Positive delta flow **NEGATIVE:** Negative delta flow	Zero
Flow Out Trend	Flow out trend over short time window	**CONSTANT:** Constant flow out **INCREASING:** Increasing flow out **DECREASING:** Decreasing flow out	Constant
Hydraulic Coefficient Flow In	Flow in hydraulic coefficient trend over a long time window where: $$h_{flow-in} = \frac{P}{Q_{in}^2}$$	**CONSTANT:** Constant flow in hydraulic coefficient **INCREASING:** Increasing flow in hydraulic coefficient **DECREASING:** Decreasing flow in hydraulic coefficient	Decreasing
Hydraulic Coefficient Flow Out	Flow out hydraulic coefficient trend over a long time window where: $$h_{flow-out} = \frac{P}{Q_{out}^2}$$	**CONSTANT:** Constant flow out hydraulic coefficient **INCREASING:** Increasing flow out hydraulic coefficient **DECREASING:** Increasing flow out hydraulic coefficient	Constant
Pit Volume Trend	Behavior of the pit volume curve over a short time window	**CONSTANT:** Constant pit volume **INCREASING LINEAR:** Pit volume increasing linearly **INCREASING CONCAVE UP:** Pit volume increasing concave up **INCREASING CONCAVE DOWN:** Pit volume increasing concave down **DECREASING LINEAR:** Pit volume decreasing linearly **DECREASING CONCAVE UP:** Pit volume decreasing concave up **DECREASING CONCAVE DOWN:** Pit volume decreasing concave down	Constant

Pump Failure: Influential Features II

Node	Feature Description	Node State Breakdown	State Conducive to Belief
Rig Activity	Current rig state	**DRILLING:** Rig state drilling rotary or drilling slide **TRIPPING OUT:** Rig state tripping out **TRIPPING IN:** Rig state tripping in **CONNECTION:** Rig state connection drilling, connection trip in, or connection trip out **CONDITION CIRC MUD:** Rig state condition circulate mud **BREAKING CIRC:** Rig state breaking circulation **PRESSURE TEST:** Rig state pressure test **STATIC:** Rig state static	Drilling, condition circ mud
Pump Pressure Trend	Pump pressure trend over a short time window	**CONSTANT:** Constant pump pressure **INCREASING:** Increasing pump pressure **DECREASING:** Decreasing pump pressure **ERRATIC:** Erratic pump pressure	Decreasing
Pump Pressure vs Model	Raw pump pressure with respect to modeled pump pressure $P-P_{model}$	**NORMAL:** Pump pressure close to modeled pump pressure **LOW:** Pump pressure much lower than modeled pump pressure **HIGH:** Pump pressure much higher than modeled pump pressure	Low
SPM Trend	SPM trend over short time window	**CONSTANT:** Constant SPM **INCREASING:** Increasing SPM **DECREASING:** Decreasing SPM **ERRATIC:** Erratic SPM	Constant
SPM Value	Raw SPM	**NONZERO:** Nonzero SPM **ZERO:** Zero SPM	Nonzero
WOB Trend	WOB trend over short time window	**CONSTANT:** Constant WOB **INCREASING:** Increasing WOB **DECREASING:** Decreasing WOB **ERRATIC:** Erratic WOB	Constant

Washout and Pump Failure Beliefs – Use during Operations

- Washout and pump failure signatures are the same except for flow out hydraulic coefficient

  - Washout: decreasing flow out hyd. coefficient

  - Pump failure: constant flow out hyd. coefficient

- If flow out is unavailable or not calibrated properly, distinguishing between the two dysfunctions is even more impractical

- For this reason, the **sum of washout and pump failure beliefs are monitored** instead of each one individually

- If the sum of these beliefs reaches the event threshold, a washout/pump failure event is established

- From that point, the operator can verify which of the two dysfunctions is truly occurring

Pump Failure: Example
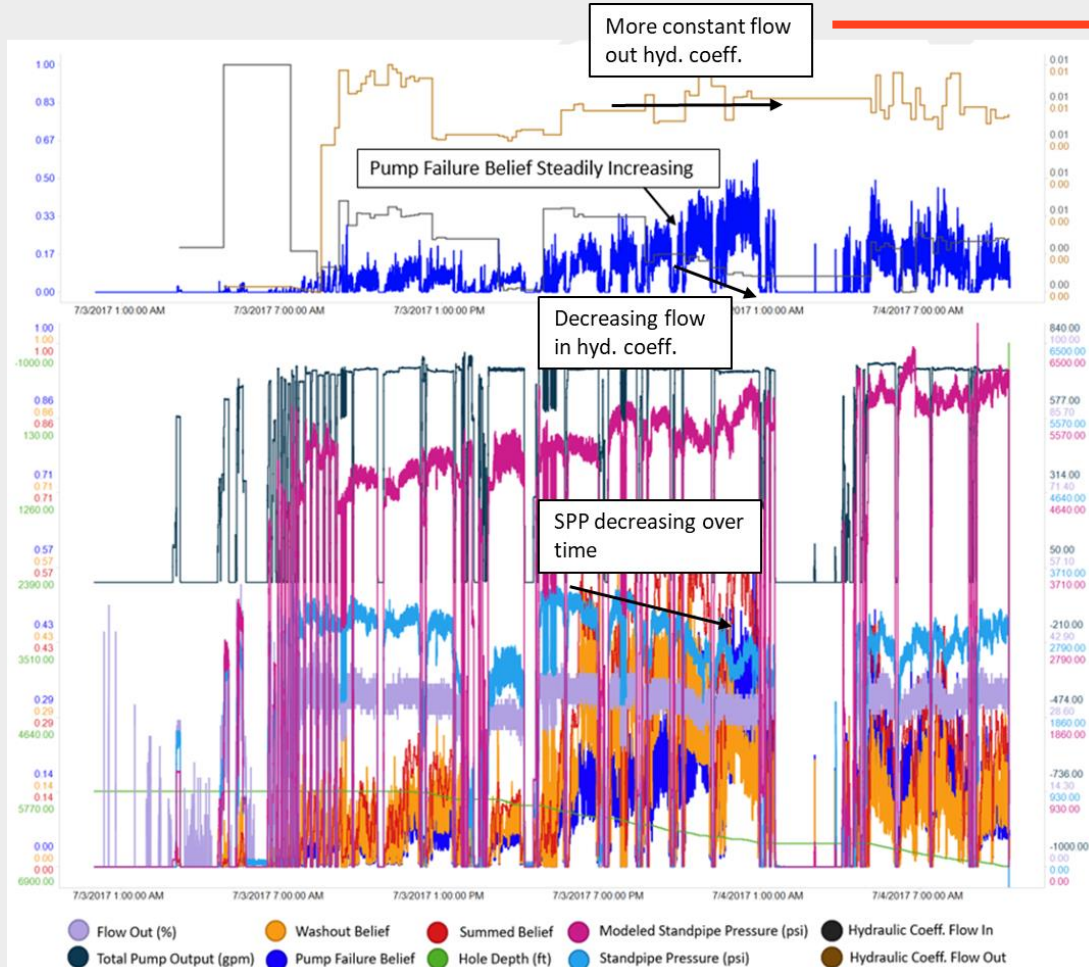
Check out paper SPE-189700-MS for more information

You can also email *info@intellicess.com* for a copy of the paper

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