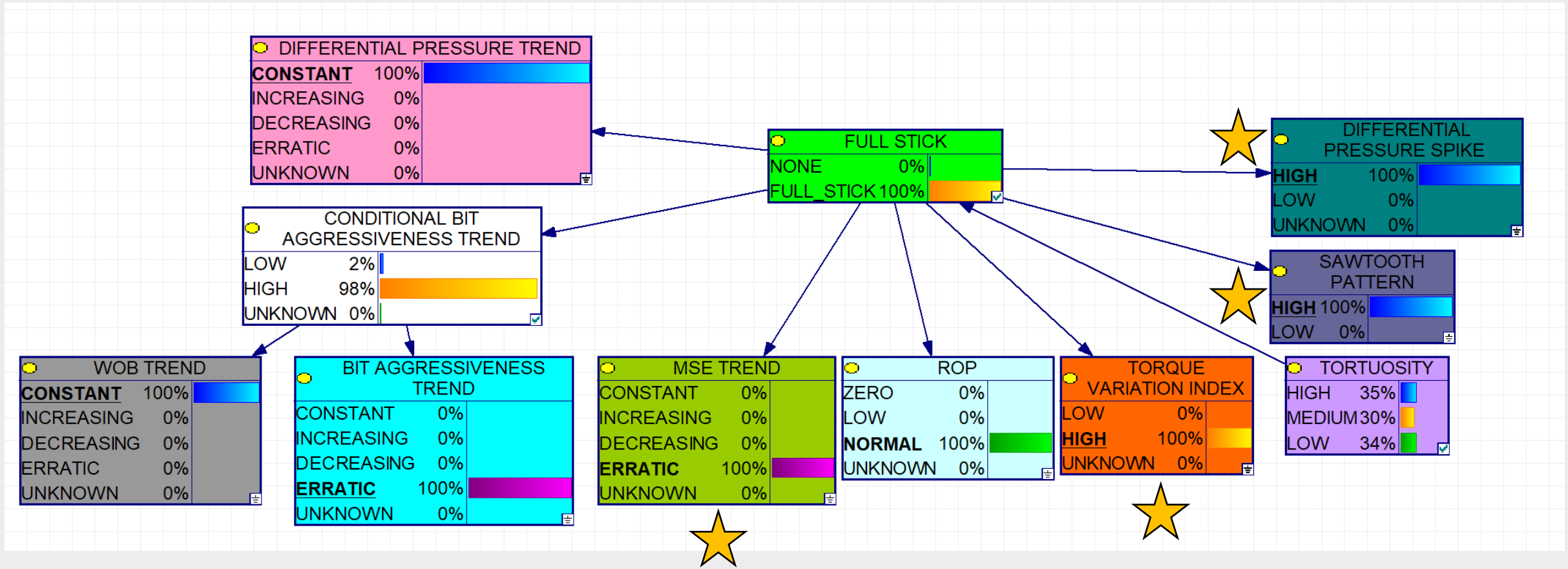
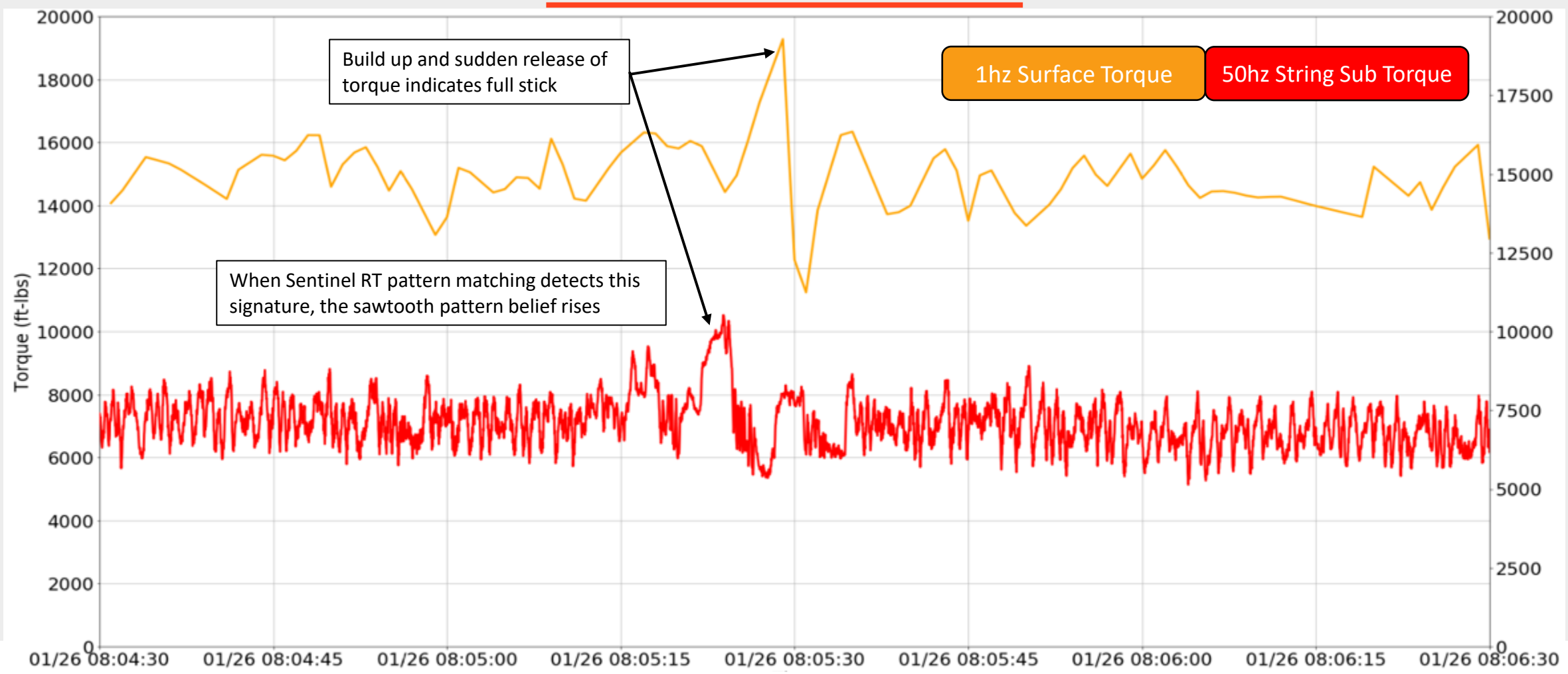
Full Stick Detection



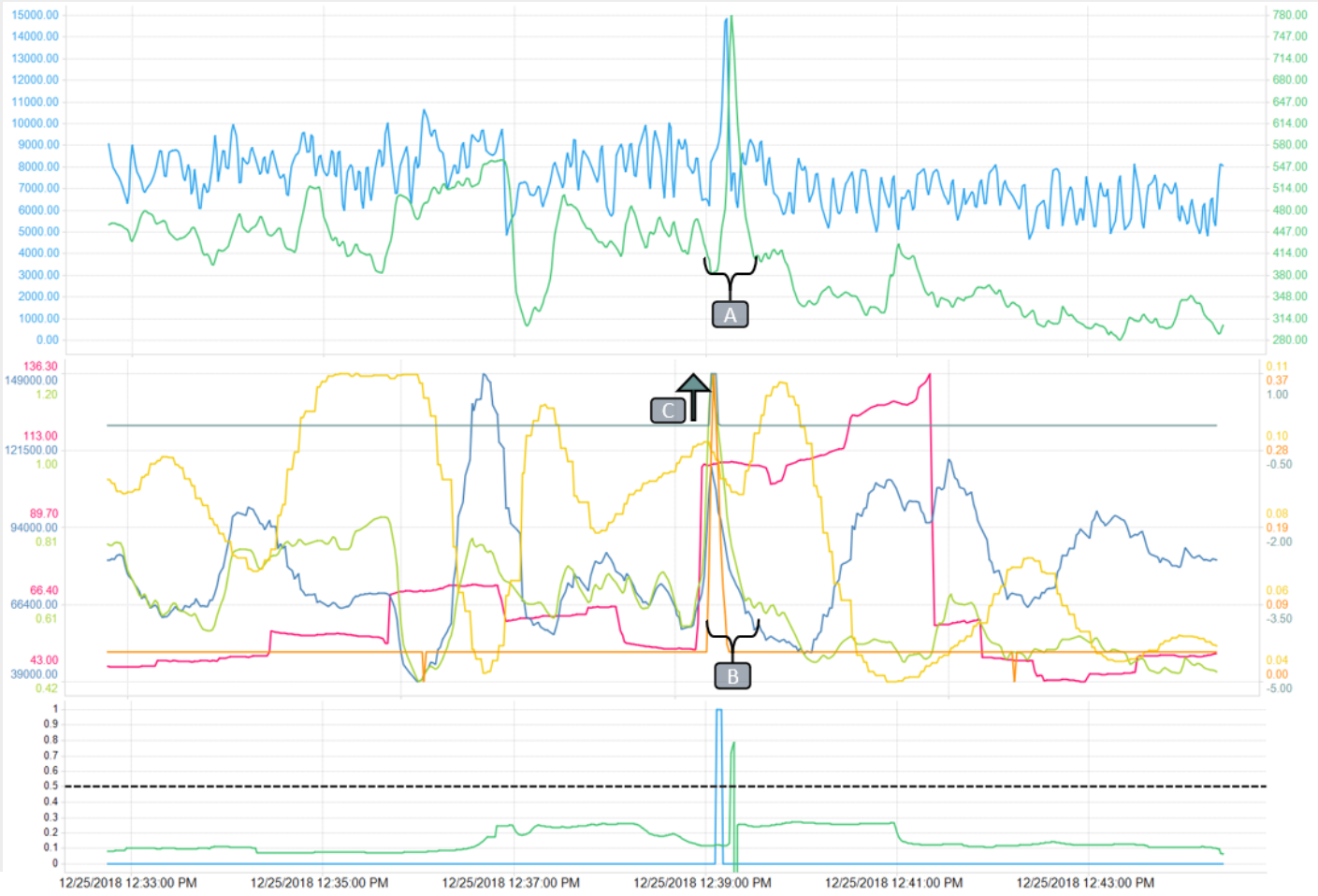
Influential Features

Node	Feature Description	Node State Breakdown	State Conducive to Belief
Conditional Bit Aggressiveness Trend	Surface bit aggressiveness erratic given constant WOB, where: $$Surface\ Bit\ Aggressiveness = \frac{12 * T}{WOB * d}$$	**LOW:** Bit aggressiveness not erratic given constant WOB **HIGH:** Bit aggressiveness erratic given constant WOB	High
Differential Pressure Spike	Likelihood that a differential pressure spike occurred recently	**HIGH:** Likely that differential pressure spike occurred **LOW:** Unlikely that differential pressure spike occurred	High
Differential Pressure Trend	Differential pressure trend over short time window	**CONSTANT:** Constant differential pressure **INCREASING:** Increasing differential pressure **DECREASING:** Decreasing differential pressure **ERRATIC:** Erratic differential pressure	Constant
ROP	Real-time .5ft cut foot ROP with respect to configurable expected ROP values	**ZERO:** Zero ROP **LOW:** ROP low compared to expected value **NORMAL:** ROP meets or exceeds expected value	Normal
MSE Trend	Surface MSE trend over short time window where: $$MSE_{surface} = \frac{4 * WOB}{\pi * (d)^2} + \frac{480 * RPM * T}{(d)^2 * ROP}$$	**CONSTANT:** Constant MSE **INCREASING:** Increasing MSE **DECREASING:** Decreasing MSE **ERRATIC:** Erratic MSE	Increasing, Erratic
Sawtooth Pattern	See next slide for details	**HIGH:** Sawtooth pattern present **LOW:** Sawtooth pattern absent	High
Torque Variation Index	Erraticity of torque: $$Torque\ Variation\ Index = \frac{Torque_{max} - Torque_{min}}{Torque_{avg}} \times 100$$	**LOW:** Non-erratic torque **HIGH:** Erratic torque	High

Rotary Full Stick : Sawtooth Pattern



Rotary Full Stick : Example



Differential Pressure

Torque

A Spike in both the differential pressure and the torque. Torque ramps up and then drops rapidly.

Torque Variation Index

Downhole MSE

Downhole Bit Aggressiveness

Depth of Cut

Differential Pressure Spike Belief

Sawtooth Pattern Belief

B The torque variation index, MSE, bit aggressiveness, and differential pressure spike belief all sharply rise during the full stick event.

C Sawtooth torque signal is detected.

Full Stick Belief

Full Stick Event

From Downhole Data