

```
print(f"X Expert validation dashboard failed: {e}")
import traceback
traceback.print_exc()
```

### 👤 DRILLING EXPERT VALIDATION DASHBOARD

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🎯 Preparing expert validation dashboard...

### 📊 DRILLING EXPERT VALIDATION DASHBOARD

Dataset: TAQA Drilling Operations

Features: 9 sensor channels

Sequence Length: 15 time steps

Units: Real drilling measurements (not normalized)

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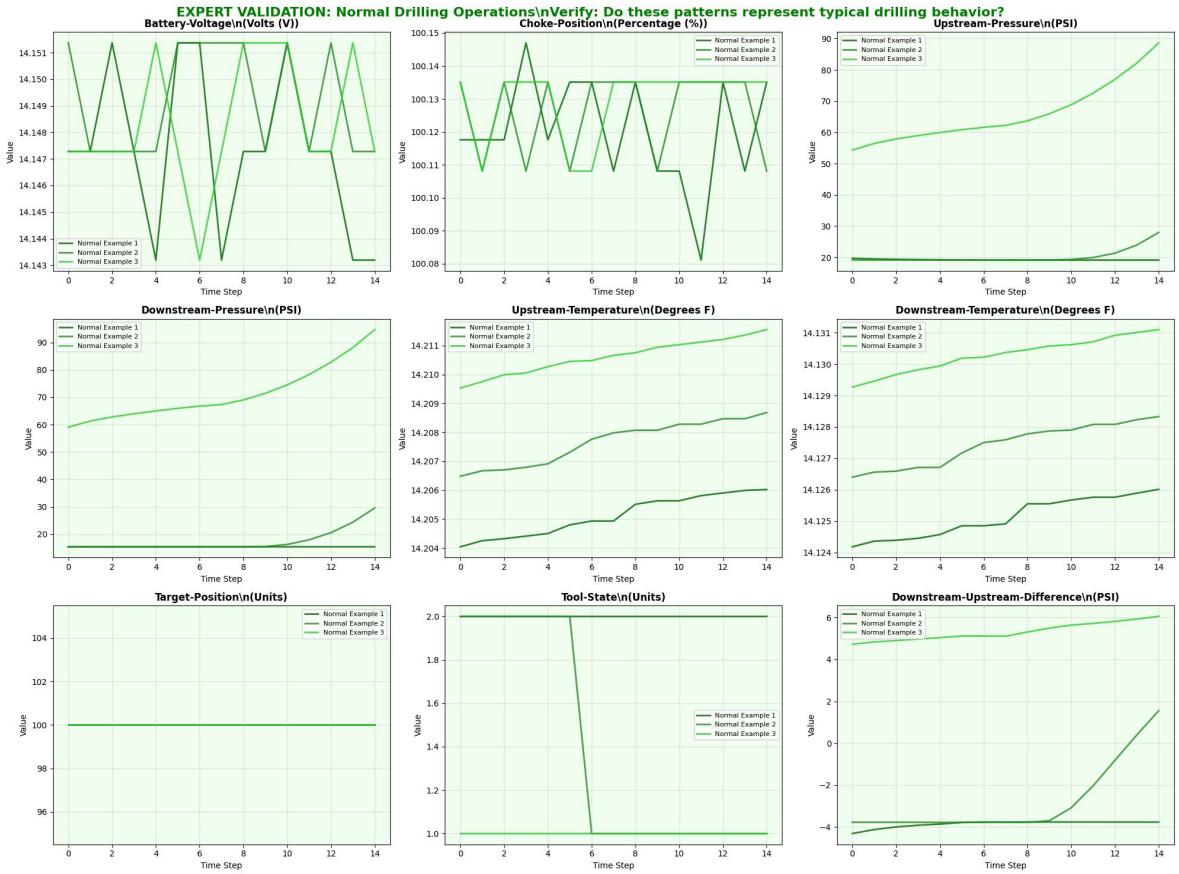
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#### ✓ SECTION 1: NORMAL DRILLING BEHAVIOR VALIDATION

Purpose: Verify that baseline operations look realistic to drilling experts

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\n📋 NORMAL BEHAVIOR VALIDATION CHECKLIST:
1. ✓ Do these sensor readings look like typical drilling operations?
2. ✓ Are all values within expected operational ranges?
3. ✓ Do sensor correlations make physical sense?
4. ✓ Are temporal patterns realistic for drilling sequences?
5. ✓ Would you expect the LSTM to learn these as 'normal'?

\n🔍 NORMAL BEHAVIOR SUMMARY:
    Normal Example 1: Typical drilling operation - all sensors within normal range
    Normal Example 2: Typical drilling operation - all sensors within normal range
    Normal Example 3: Typical drilling operation - all sensors within normal range

\n✅ Normal behavior validation complete - proceeding to anomaly validation...
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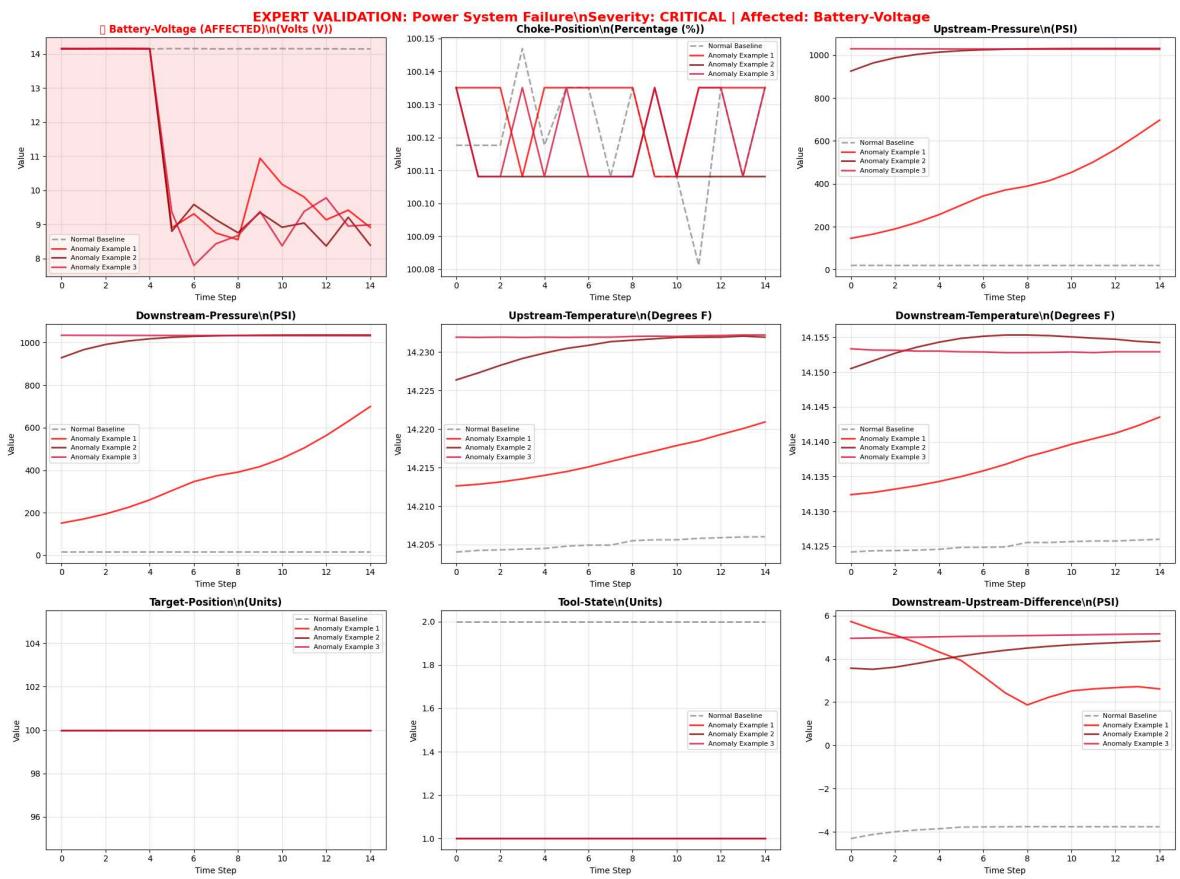
⚠️ SECTION 2: ANOMALY BEHAVIOR VALIDATION
Purpose: Verify synthetic anomalies match real drilling failure modes
LSTM Targets: sensor_spike, sensor_drift, sensor_failure, correlation_break,
              temporal_inversion, multi_sensor_failure, oscillation
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🔍 ANOMALY TYPE: POWER SYSTEM FAILURE
Severity: CRITICAL | Physics: Battery voltage should be 12-14V, failure drops to
          8-10V
Affected Sensor: Battery-Voltage
LSTM Target: sensor_failure (tests LSTM's ability to detect sensor_failure)
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/ttmp/ipykernel_1179/3657439822.py:138: UserWarning: Glyph 127919 (\N{DIRECT HIT})
missing from font(s) DejaVu Sans.
    plt.tight_layout()
/home/ashwinvel2000/TAQA/.venv/lib/python3.12/site-packages/IPython/core/pylabtoo
ls.py:170: UserWarning: Glyph 127919 (\N{DIRECT HIT}) missing from font(s) DejaVu
Sans.
    fig.canvas.print_figure(bytes_io, **kw)

```

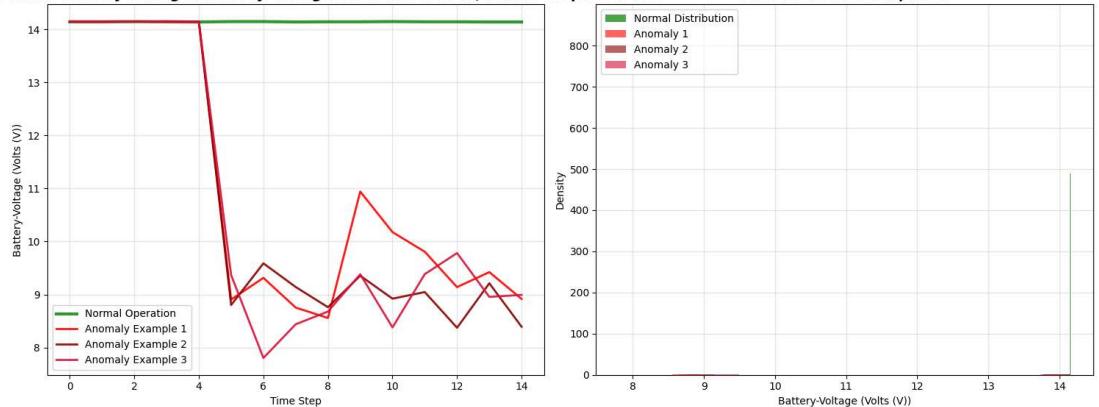


#### EXPERT VALIDATION CHECKLIST:

1. ✓ Does the Battery-Voltage anomaly look realistic?
2. ✓ Are the values within expected drilling ranges?
3. ✓ Does the pattern match real power system failure scenarios?
4. ✓ Are other sensors responding appropriately?
5. ✓ Would this trigger alerts in real drilling operations?

DETAILED VIEW: Battery-Voltage | Battery voltage should be 12-14V, failure drops to 8-10V

Value Distribution Comparison



#### DRILLING CONTEXT:

Description: Battery voltage drops below operational threshold

Physics: Battery voltage should be 12-14V, failure drops to 8-10V

Severity: CRITICAL

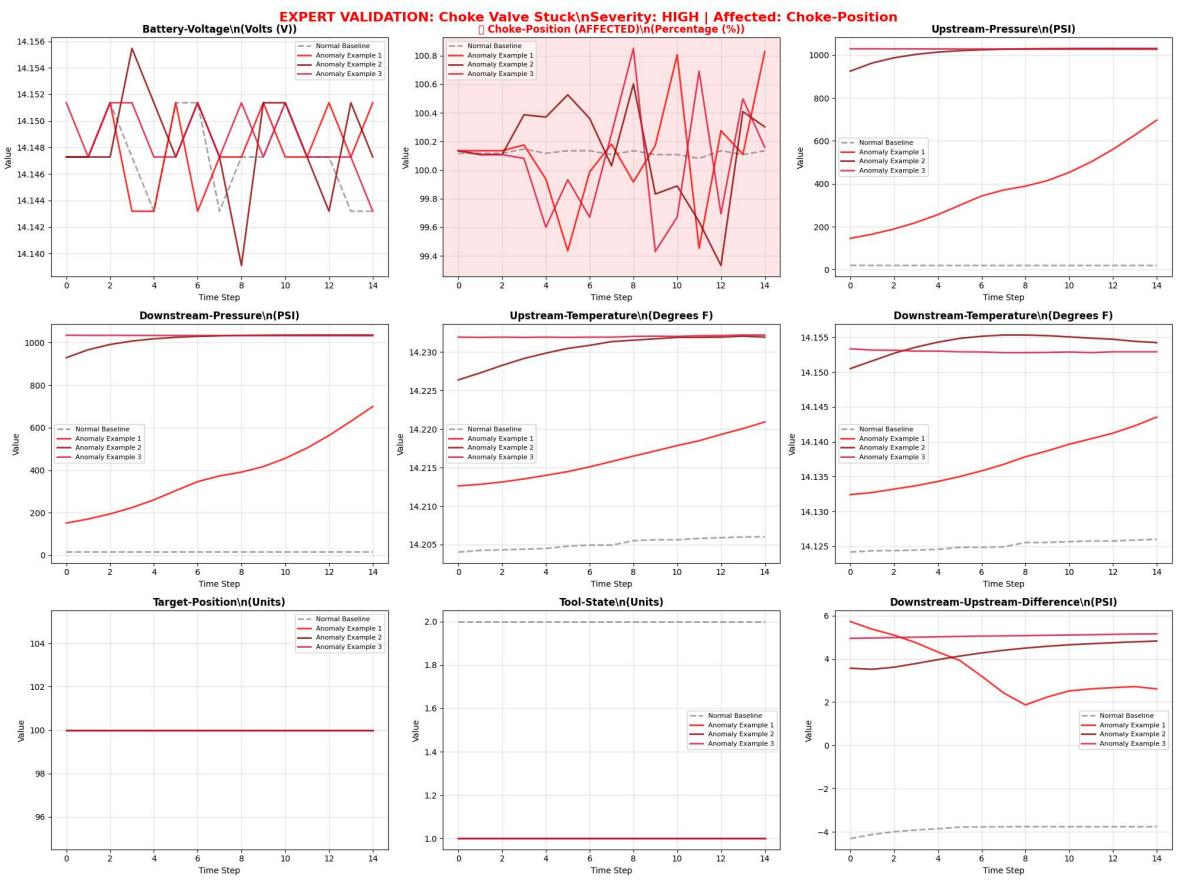
Expected Response: This anomaly should IMMEDIATELY trigger alerts

#### ANOMALY TYPE: CHOKE VALVE STUCK

Severity: HIGH | Physics: Choke should vary 0-100%, stuck shows flat line

Affected Sensor: Choke-Position

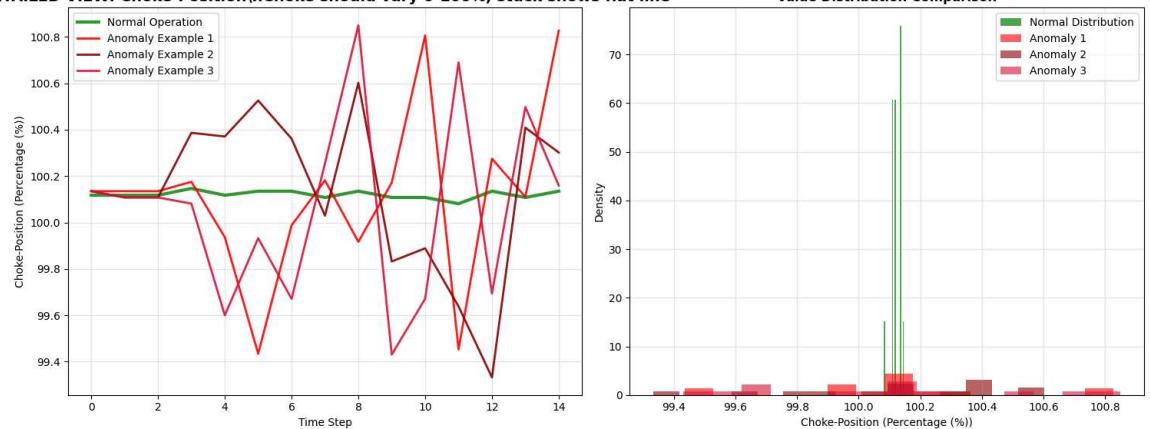
LSTM Target: sensor\_failure (tests LSTM's ability to detect sensor\_failure)



#### \n📝 EXPERT VALIDATION CHECKLIST:

1. ✓ Does the Choke-Position anomaly look realistic?
2. ✓ Are the values within expected drilling ranges?
3. ✓ Does the pattern match real choke valve stuck scenarios?
4. ✓ Are other sensors responding appropriately?
5. ✓ Would this trigger alerts in real drilling operations?

#### DETAILED VIEW: Choke-Position\nChoke should vary 0-100%, stuck shows flat line



#### \n🛠 DRILLING CONTEXT:

Description: Choke position becomes unresponsive/stuck

Physics: Choke should vary 0-100%, stuck shows flat line

Severity: HIGH

Expected Response: This anomaly should PROMPTLY trigger alerts

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#### 🔍 ANOMALY TYPE: PRESSURE SURGE/KICK

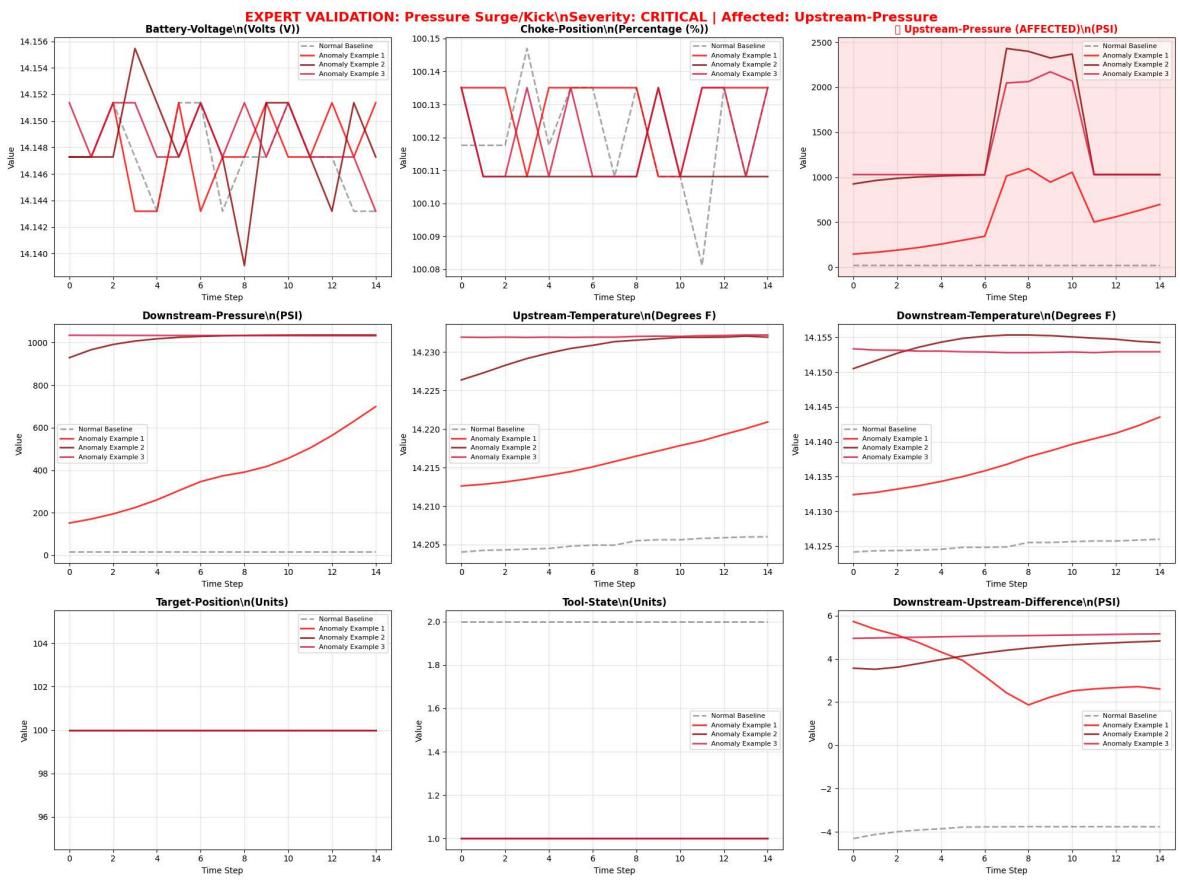
Severity: CRITICAL | Physics: Normal 100-1000 psi, surge can reach 2000+ psi

Affected Sensor: Upstream-Pressure

LSTM Target: sensor\_spike (tests LSTM's ability to detect sensor\_spike)

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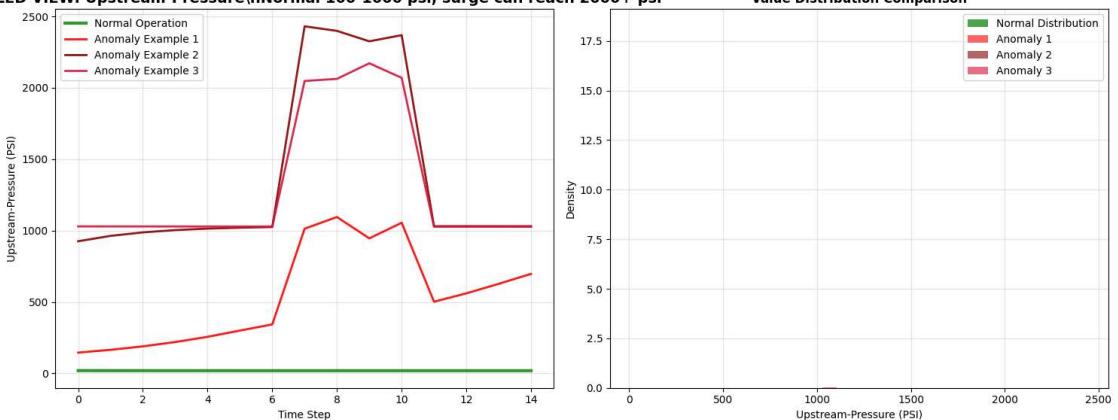
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#### \n📝 EXPERT VALIDATION CHECKLIST:

1. ✓ Does the Upstream-Pressure anomaly look realistic?
2. ✓ Are the values within expected drilling ranges?
3. ✓ Does the pattern match real pressure surge/kick scenarios?
4. ✓ Are other sensors responding appropriately?
5. ✓ Would this trigger alerts in real drilling operations?

DETAILED VIEW: Upstream-Pressure\nNormal 100-1000 psi, surge can reach 2000+ psi



#### \n🔧 DRILLING CONTEXT:

Description: Sudden upstream pressure increase indicating formation fluid influx

Physics: Normal 100-1000 psi, surge can reach 2000+ psi

Severity: CRITICAL

Expected Response: This anomaly should IMMEDIATELY trigger alerts

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#### 🔍 ANOMALY TYPE: CIRCULATION LOSS

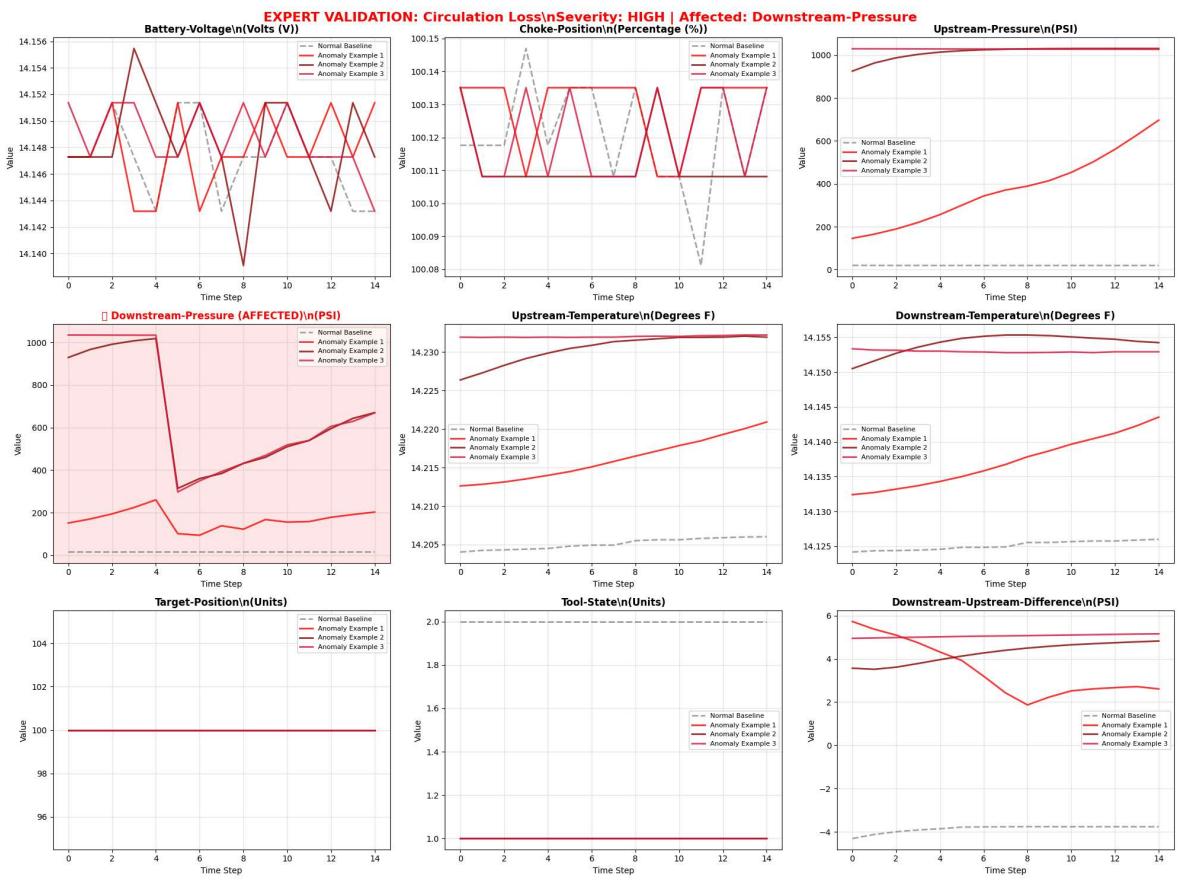
Severity: HIGH | Physics: Pressure drops indicate fluid loss to formation

Affected Sensor: Downstream-Pressure

LSTM Target: sensor\_drift (tests LSTM's ability to detect sensor\_drift)

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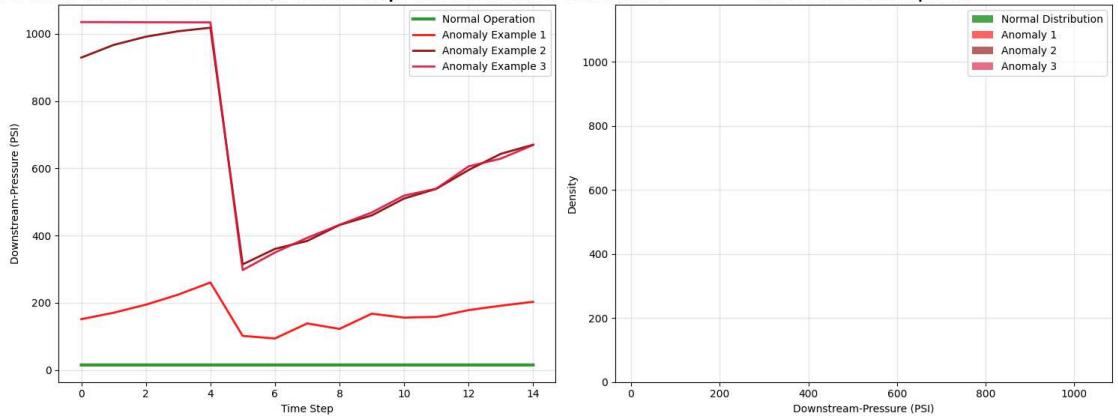
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#### EXPERT VALIDATION CHECKLIST:

- ✓ Does the Downstream-Pressure anomaly look realistic?
- ✓ Are the values within expected drilling ranges?
- ✓ Does the pattern match real circulation loss scenarios?
- ✓ Are other sensors responding appropriately?
- ✓ Would this trigger alerts in real drilling operations?

DETAILED VIEW: Downstream-Pressure | Pressure drops indicate fluid loss to formation



#### DRILLING CONTEXT:

Description: Downstream pressure drops indicating lost circulation

Physics: Pressure drops indicate fluid loss to formation

Severity: HIGH

Expected Response: This anomaly should PROMPTLY trigger alerts

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#### ANOMALY TYPE: THERMAL SYSTEM MALFUNCTION

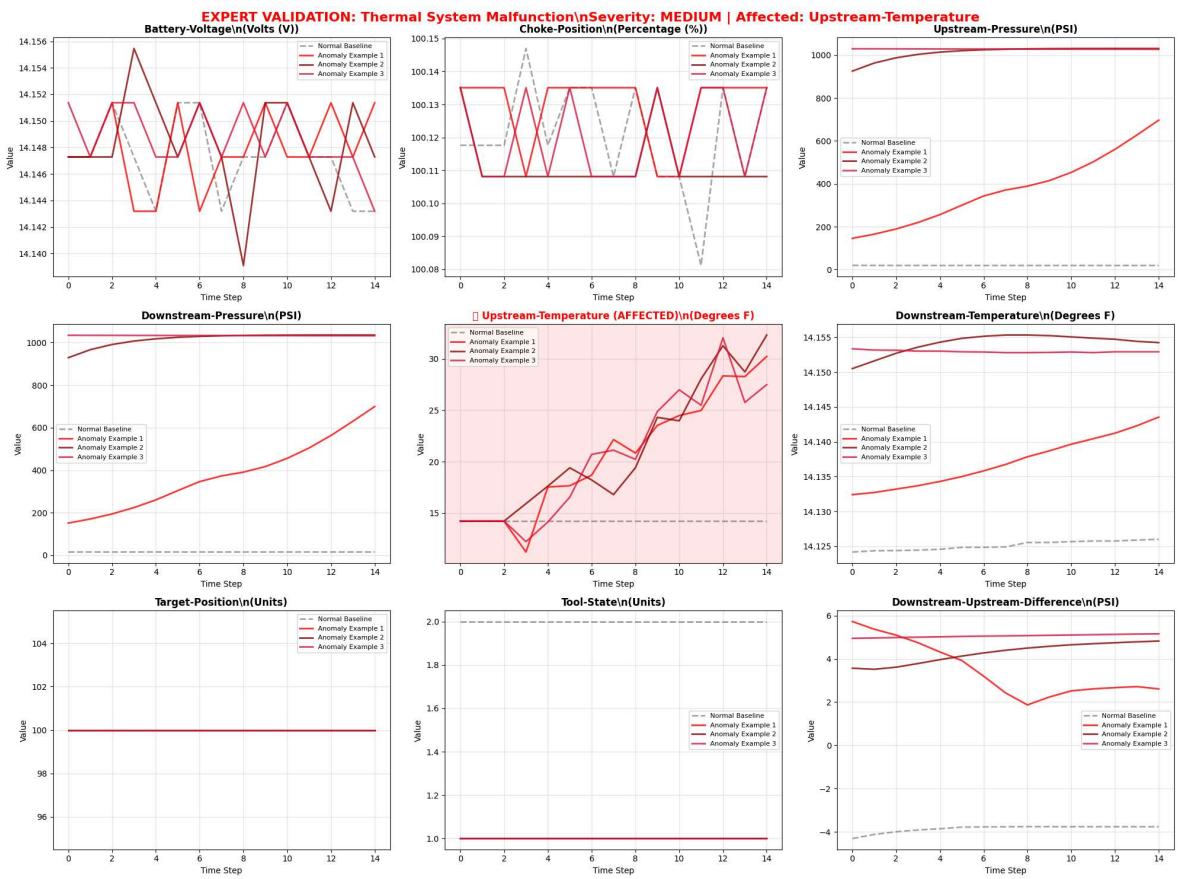
Severity: MEDIUM | Physics: Up/downstream temps should correlate, drift indicates sensor issues

Affected Sensor: Upstream-Temperature

LSTM Target: sensor\_drift (tests LSTM's ability to detect sensor\_drift)

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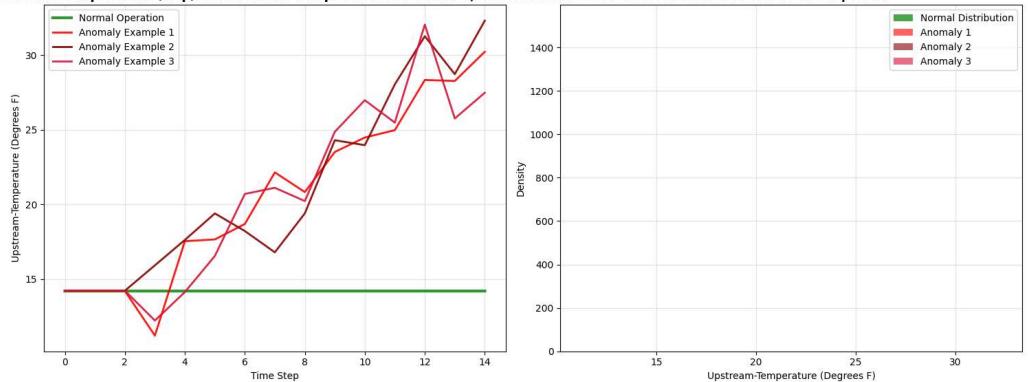
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#### 📝 EXPERT VALIDATION CHECKLIST:

- ✓ Does the Upstream-Temperature anomaly look realistic?
- ✓ Are the values within expected drilling ranges?
- ✓ Does the pattern match real thermal system malfunction scenarios?
- ✓ Are other sensors responding appropriately?
- ✓ Would this trigger alerts in real drilling operations?

**DETAILED VIEW: Upstream-Temperature** Up/downstream temps should correlate, drift indicates sensor issues



#### 🔧 DRILLING CONTEXT:

Description: Temperature readings become uncorrelated or drift

Physics: Up/downstream temps should correlate, drift indicates sensor issues

Severity: MEDIUM

Expected Response: This anomaly should PROMPTLY trigger alerts

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#### 🔍 ANOMALY TYPE: SENSOR CORRELATION BREAK

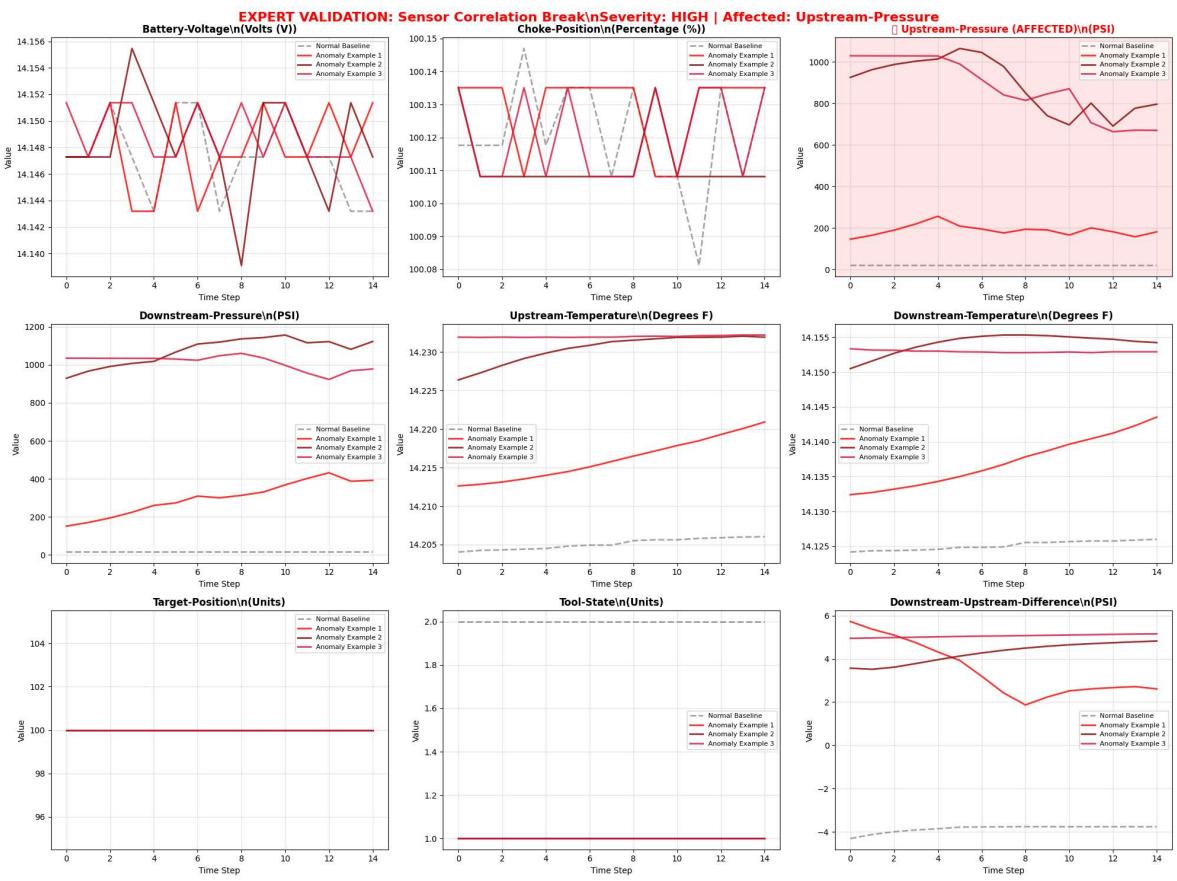
Severity: HIGH | Physics: Up/downstream pressures should correlate, break indicates system failure

Affected Sensor: Upstream-Pressure

LSTM Target: correlation\_break (tests LSTM's ability to detect correlation\_break)

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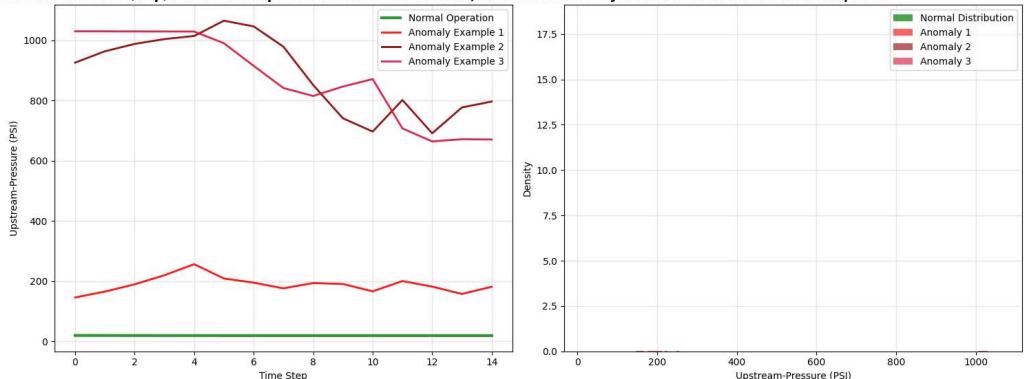
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#### \n📝 EXPERT VALIDATION CHECKLIST:

- ✓ Does the Upstream-Pressure anomaly look realistic?
- ✓ Are the values within expected drilling ranges?
- ✓ Does the pattern match real sensor correlation break scenarios?
- ✓ Are other sensors responding appropriately?
- ✓ Would this trigger alerts in real drilling operations?

**DETAILED VIEW: Upstream-Pressure\nUp/downstream pressures should correlate, break indicates system failure**



#### \n🛠 DRILLING CONTEXT:

Description: Upstream/downstream pressure correlation breakdown

Physics: Up/downstream pressures should correlate, break indicates system failure

Severity: HIGH

Expected Response: This anomaly should PROMPTLY trigger alerts

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#### 🔍 ANOMALY TYPE: TEMPORAL PATTERN INVERSION

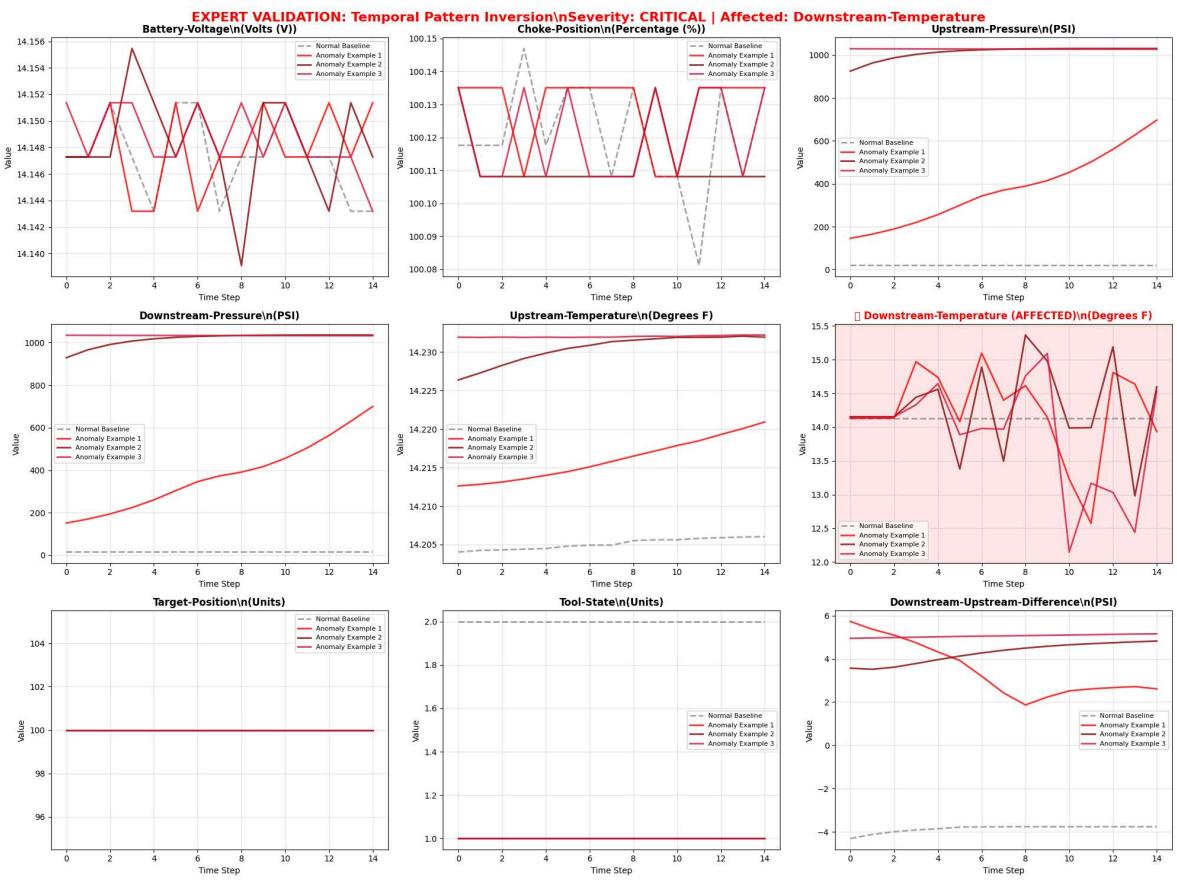
Severity: CRITICAL | Physics: Temperature patterns reversed - physically impossible sequence

Affected Sensor: Downstream-Temperature

LSTM Target: temporal\_inversion (tests LSTM's ability to detect temporal\_inversion)

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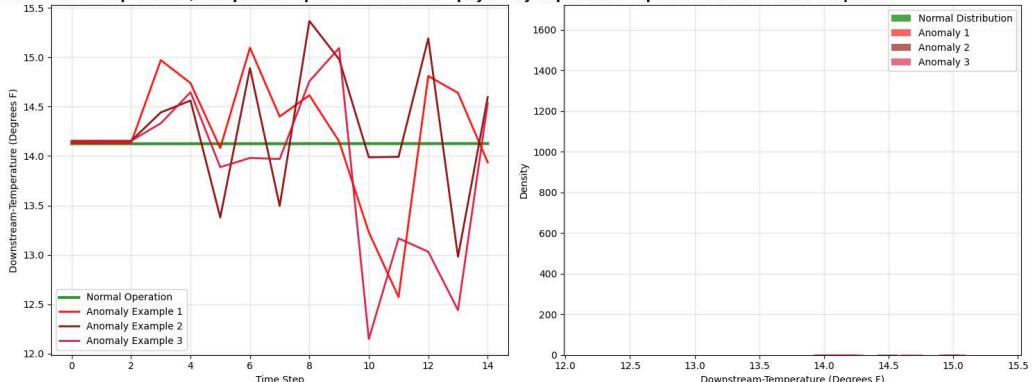
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#### \n📝 EXPERT VALIDATION CHECKLIST:

1. ✓ Does the Downstream-Temperature anomaly look realistic?
2. ✓ Are the values within expected drilling ranges?
3. ✓ Does the pattern match real temporal pattern inversion scenarios?
4. ✓ Are other sensors responding appropriately?
5. ✓ Would this trigger alerts in real drilling operations?

**DETAILED VIEW: Downstream-Temperature\nTemperature patterns reversed - physically impossible sequence**



#### \n🔧 DRILLING CONTEXT:

Description: Temperature trend reversal (impossible physics)

Physics: Temperature patterns reversed - physically impossible sequence

Severity: CRITICAL

Expected Response: This anomaly should IMMEDIATELY trigger alerts

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**🔍 ANOMALY TYPE: CASCADING SYSTEM FAILURE**

Severity: CRITICAL | Physics: Power failure causes cascading sensor malfunctions

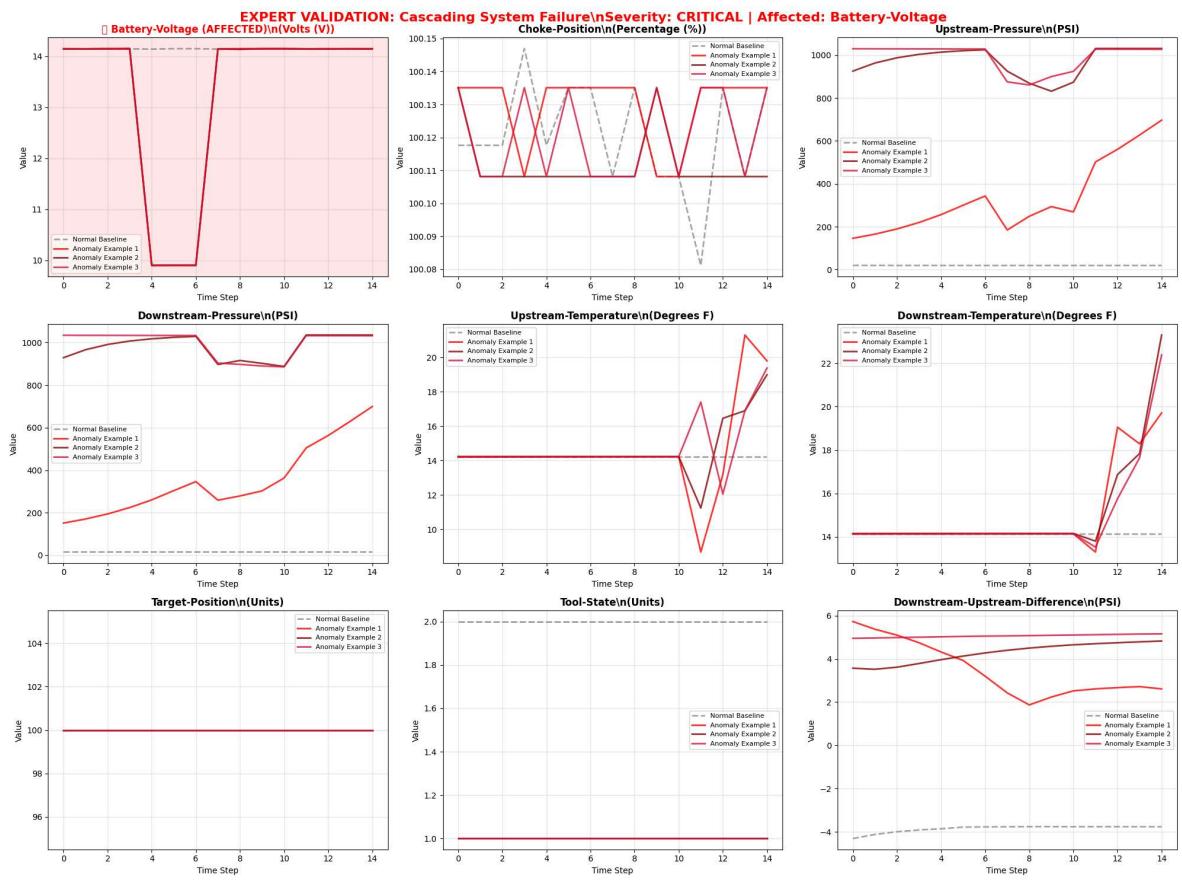
Affected Sensor: Battery-Voltage

LSTM Target: multi\_sensor\_failure (tests LSTM's ability to detect multi\_sensor\_failure)

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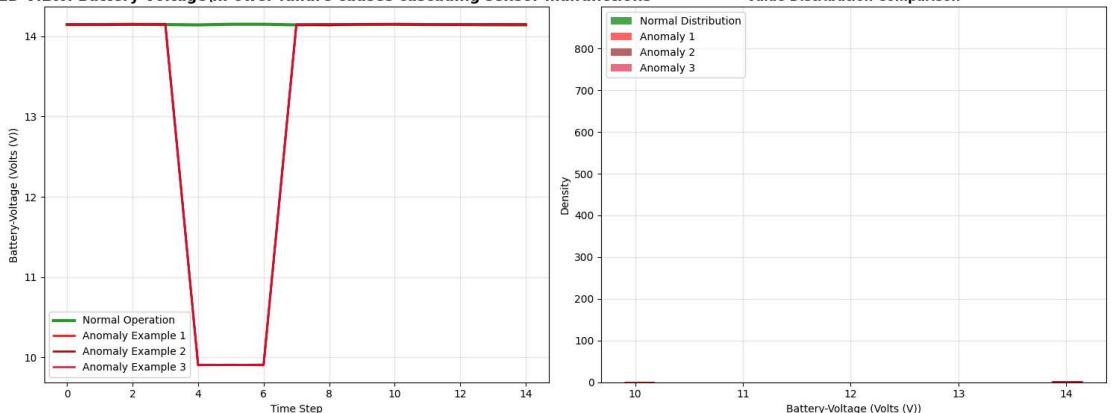
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#### EXPERT VALIDATION CHECKLIST:

- ✓ Does the Battery-Voltage anomaly look realistic?
- ✓ Are the values within expected drilling ranges?
- ✓ Does the pattern match real cascading system failure scenarios?
- ✓ Are other sensors responding appropriately?
- ✓ Would this trigger alerts in real drilling operations?

#### DETAILED VIEW: Battery-Voltage\nPower failure causes cascading sensor malfunctions



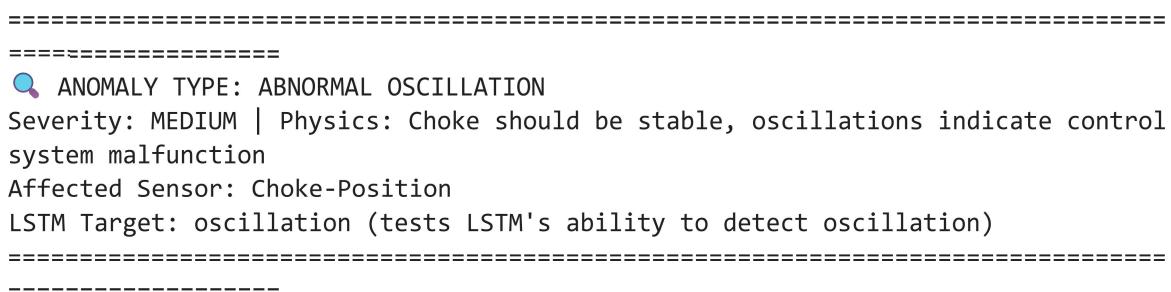
#### DRILLING CONTEXT:

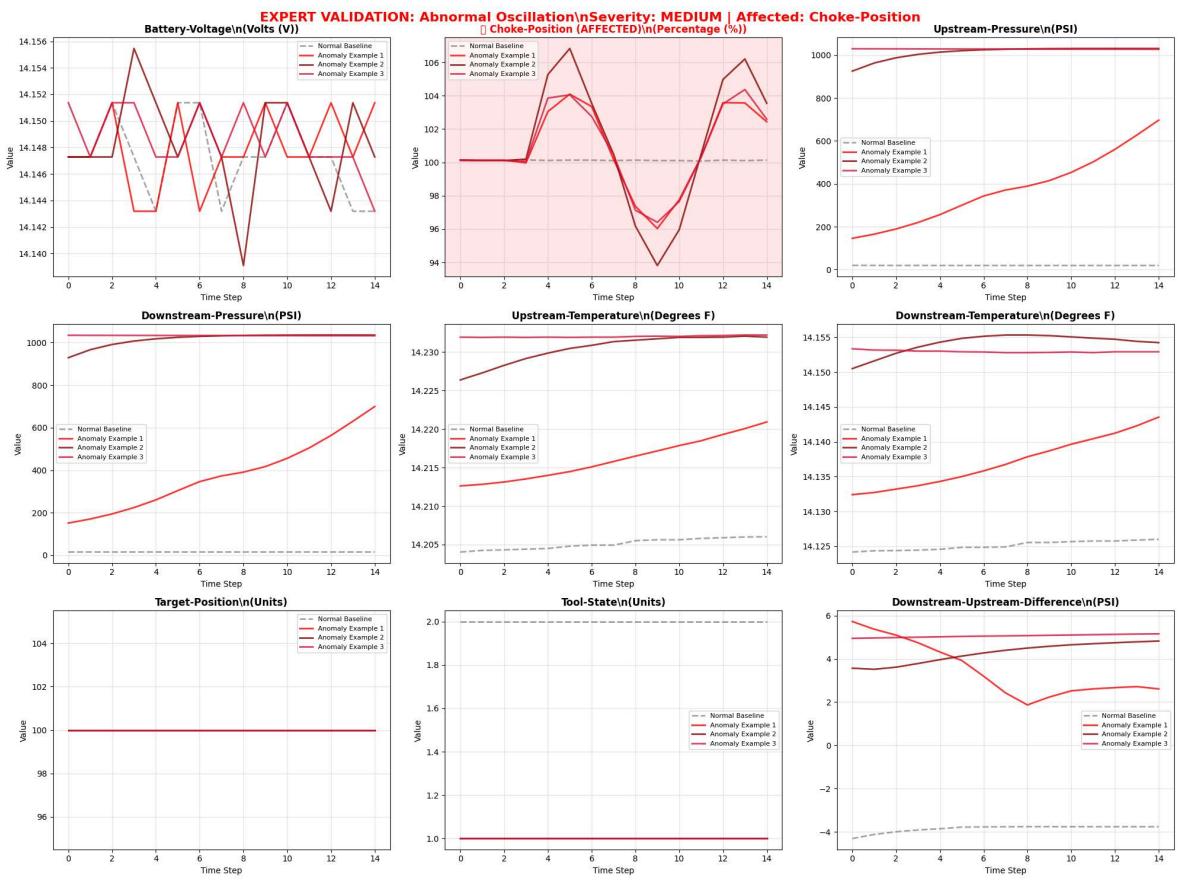
Description: Multiple sensors failing in sequence (propagating failure)

Physics: Power failure causes cascading sensor malfunctions

Severity: CRITICAL

Expected Response: This anomaly should IMMEDIATELY trigger alerts





#### \n📝 EXPERT VALIDATION CHECKLIST:

- ✓ Does the Choke-Position anomaly look realistic?
- ✓ Are the values within expected drilling ranges?
- ✓ Does the pattern match real abnormal oscillation scenarios?
- ✓ Are other sensors responding appropriately?
- ✓ Would this trigger alerts in real drilling operations?

**DETAILED VIEW: Choke-Position\nChoke should be stable, oscillations indicate control system malfunction** Value Distribution Comparison

