

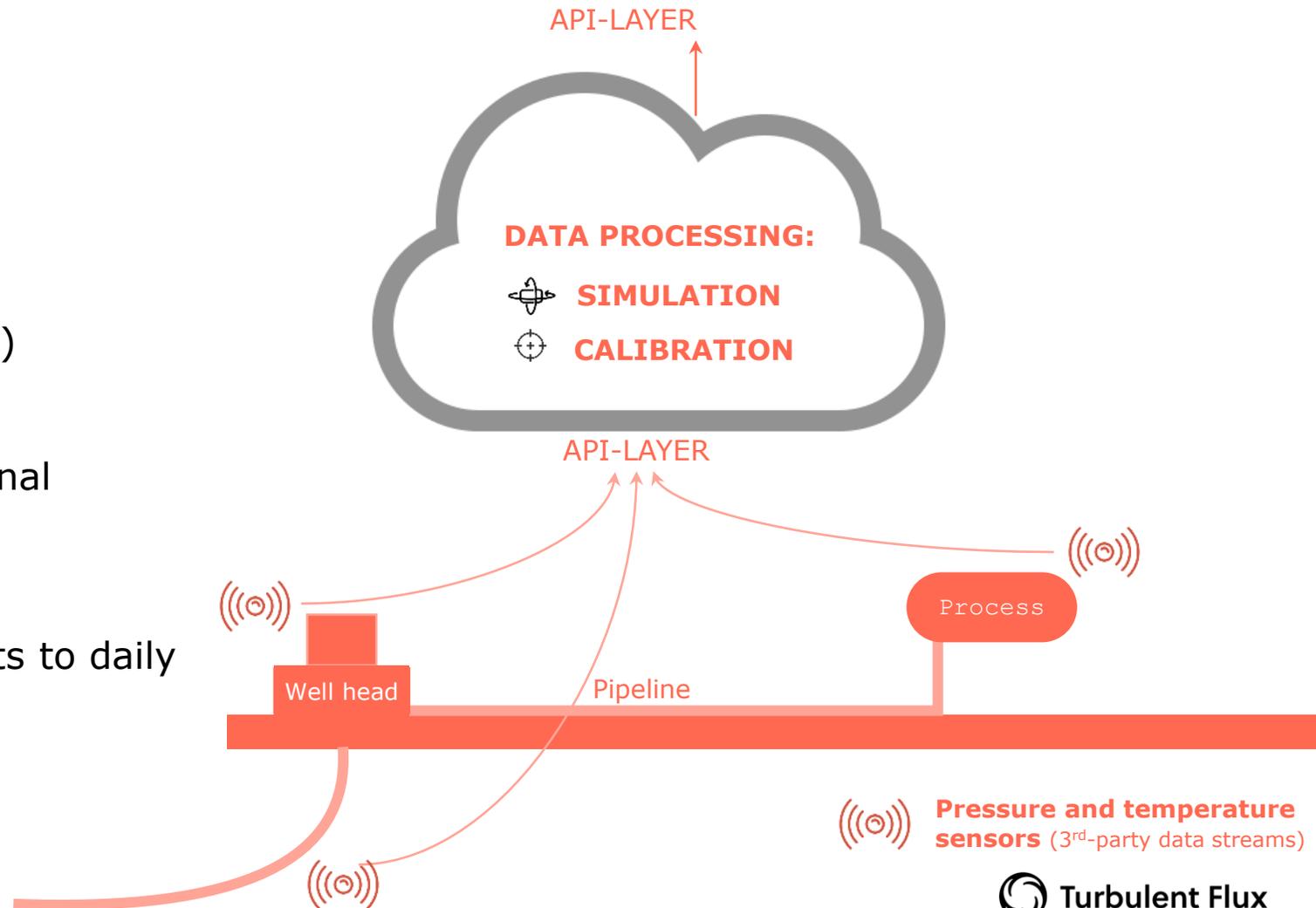


Turbulent Flux

An introduction

Embracing technology in the digital age

- Cloud-native software
- Utilizes data from existing sensors
- Hybrid model (physics and analytics)
- Integrates with proprietary operational systems through API-layer
- Provides real-time actionable insights to daily operations



FLUX Applications – A paradigm shift in production monitoring

- Rapid market uptake both onshore and offshore
- International client base with solutions deployed on three continents

WELLS

VIRTUAL
FLOW METER

WELL START-
UP ADVISER

NEW APPLICATIONS
IN DEVELOPMENT

PIPELINES

PIPELINE
MONITORING

STABILITY
ADVISER

WAX DEPOSITION
MONITOR

COOLDOWN
ADVISER

NEW APPLICATIONS
IN DEVELOPMENT

FLUX Foundation
(hybrid technology)

Supporting Aker BP since 2018

MAY 2019

Turbulent Flux & Cognite Delivered Virtual Flowmeter to Address Aker BP's Chalk Influx Challenges in Valhall Wells



EXPECTED ANNUAL SAVINGS: 5-10 MNOK

IMPACT

Increased insights into the fluid flow help the petroleum engineers and field operators to plan and make correct decisions. The impact is higher production and fewer mistakes. Real-time information about fluid flow enables better and faster decision-making.

The Turbulent Flux transient VFM solution is running on Aker BP's Valhall field on the Norwegian Continental Shelf.

"Well G9 Virtual Flow Meter will aid diagnosing well performance, including start-ups and events caused by water breakthrough and/or chalk influx."

-- Dmitry Shchekotov, Senior Petroleum Engineer, AkerBP

Wells

FLUX VFM

Basis for Production Optimization

Virtual Flow Metering:

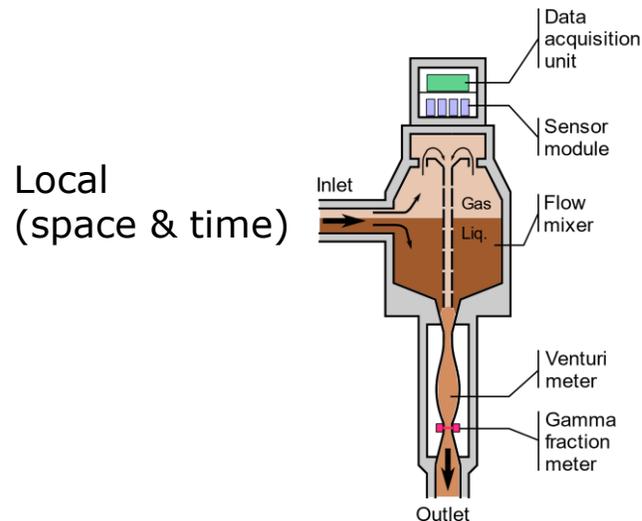
- 24/7 insights into flow rates, pressures, temperatures, etc. anywhere in a well
- Self-calibration – always accurate flow rate predictions (on par with well-calibrated MPFM)
- Software solution using existing sensor infrastructure
- Very cost effective, subscription-based (OPEX)
- Fast to deploy – real-time insights available within weeks



Physical vs. Virtual Flow Meters

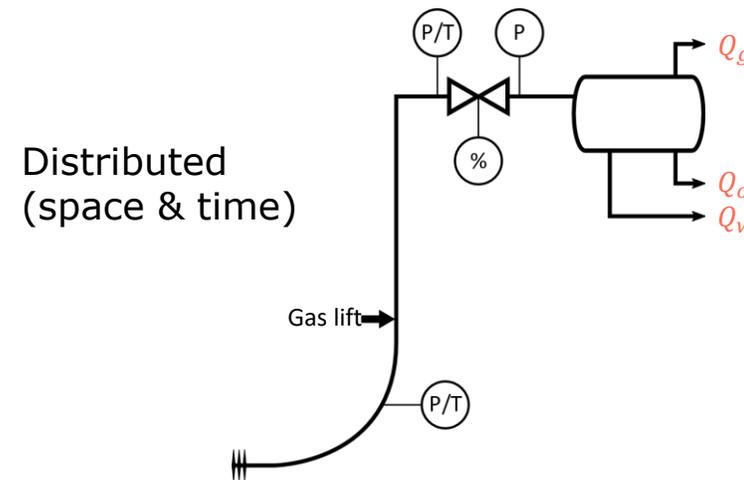
Multiphase Flow Meter

- Hardware & Software
 - CAPEX and OPEX intensive
- Uses pre-determined sensor measurements
- Requires PVT modeling
- Flow computer for given device geometry



Virtual Flow Meter

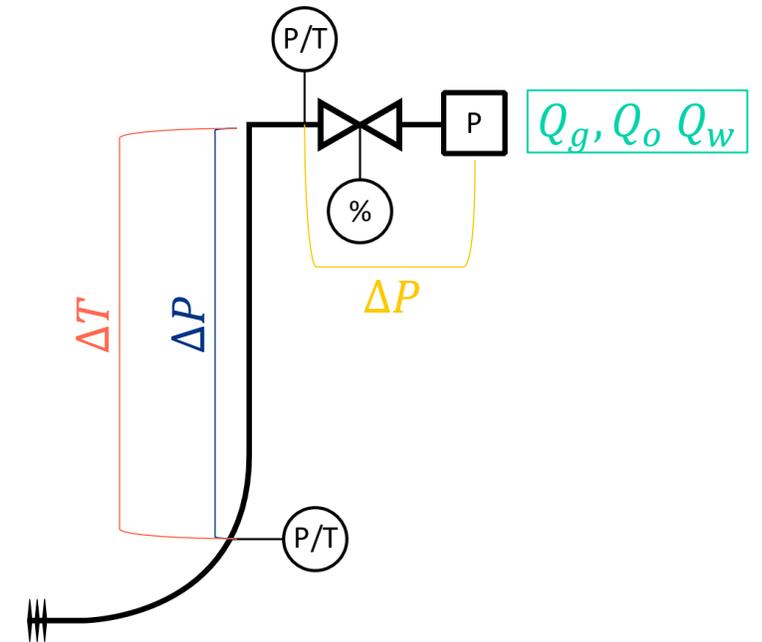
- Software only
 - OPEX
- Subscribes to available sensor measurements
- Requires PVT modeling
- **Flexible flow computer**



Virtual Flow Meter

Sensor data requirements

- Number of independent quantities determines number phase flow rates which can be estimated
 - Example (extreme simplification):
 - $\Delta P_{\text{well}} \rightarrow$ gas/liquid split
 - $\Delta T_{\text{well}} \rightarrow$ oil/water split
 - $\Delta P_{\text{choke}} \rightarrow$ flow rate
- Too few quantities or too small differences (e.g., fully open choke)
 - a) Use FLUX Analytics
 - b) Reduce number of phase flow rates (e.g., from gas/oil/water to gas/liquid)
 - c) Introduce additional assumptions

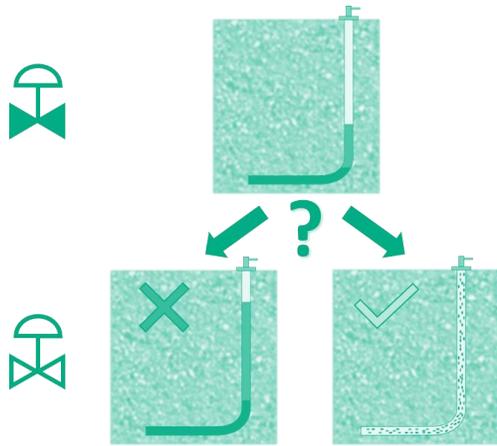


Example VFM configuration.

VFM configuration determined on case-by-case basis based on sensor availability.

Scenario Simulations

Well Start-up Adviser



Background

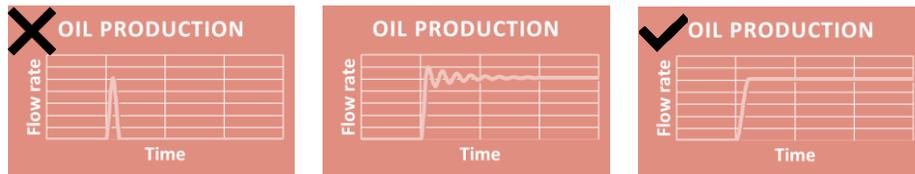
- Wrong start-up procedures may result in prolonged NPT, deferred production, and need for costly interventions

Objective

- Optimize well start-up

Value

- Optimal production faster
- Optimal use of resources, e.g. lift gas
- Reduce instabilities and ensure integrity



Technology

FLUX Foundation



FLUX Simulator

- Transient multiphase flow simulator
- Physics-based simulator
- From fast transients to steady state



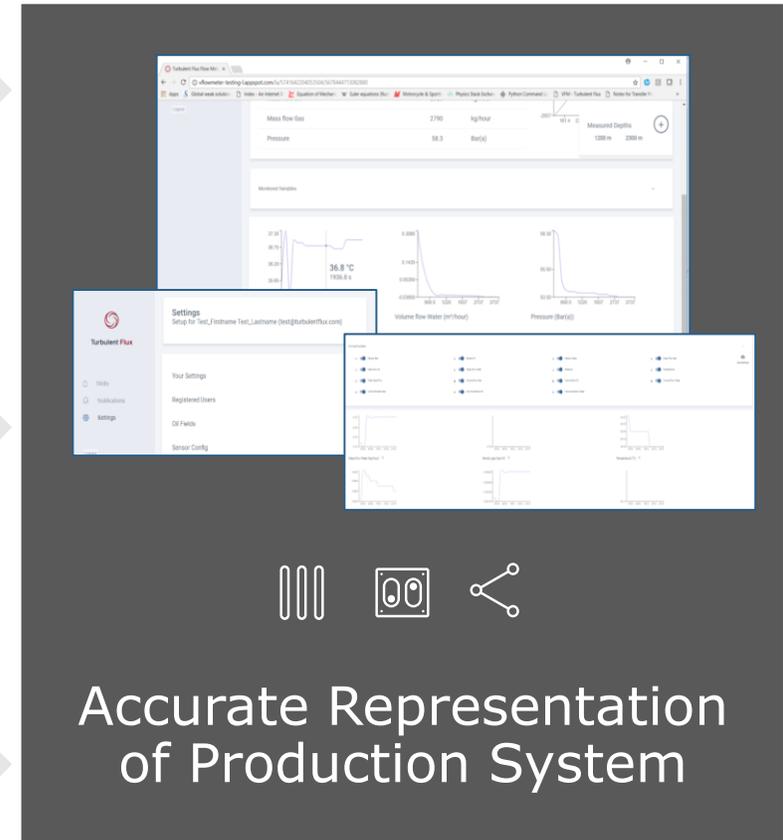
FLUX Optimizer

- Optimization module
- Auto-calibration using sensor data



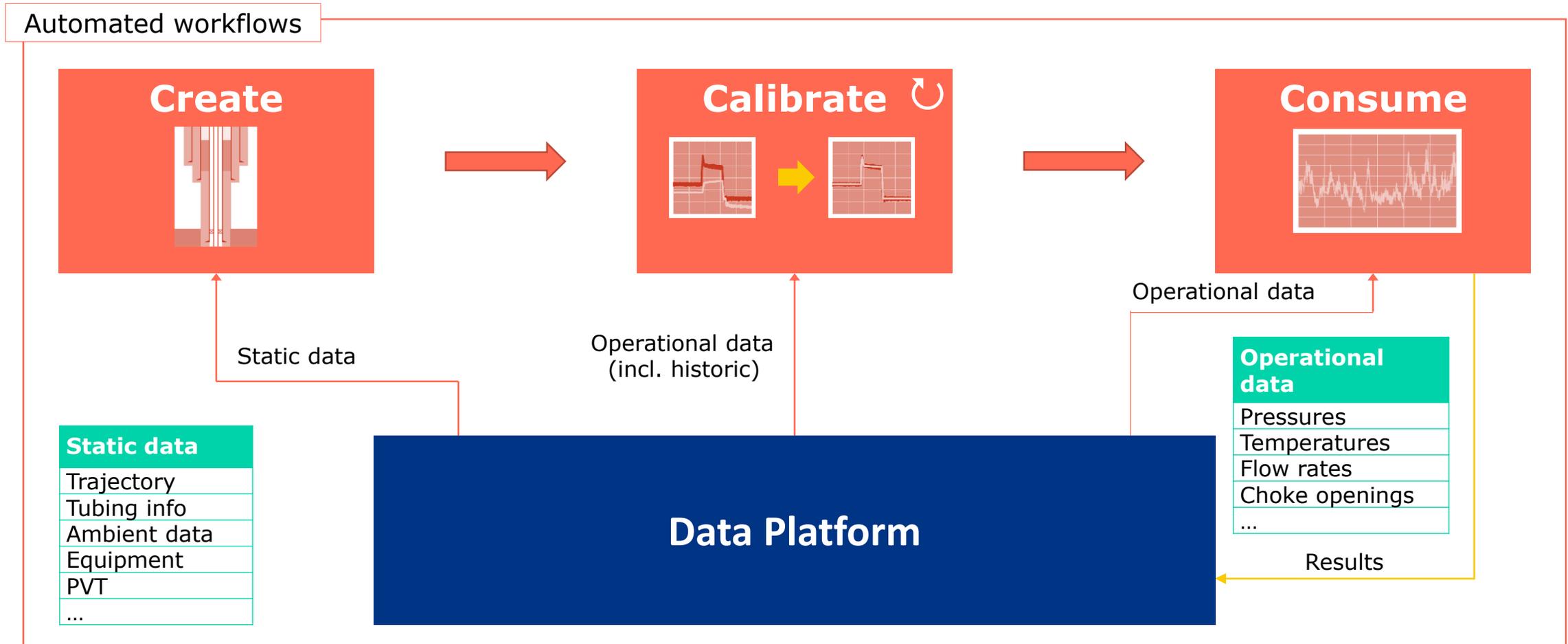
FLUX Analytics

- Domain knowledge in ML solutions
- Mine data for improved physics



Accurate Representation
of Production System

User Value from Sensor Data Leveraging a Data Platform

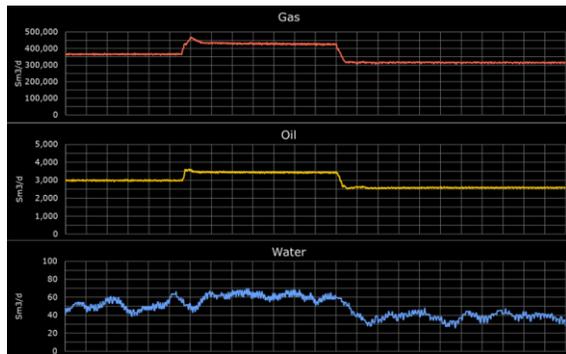


Real-time time insights and beyond

Operating modes

Real-time

- Up-to-date flow information based on live sensor data



Scenario

- Look-ahead
 - Predict the future if operations remain unchanged
- What-if
 - Investigate the impact of different operational procedures (forward-looking as well as retrospective)



FLUX Applications

Key takeaways

- **Open**
 - Rich API facilitates 3rd-party integration
 - Connects to any data platform
- **Scalable**
 - Fast to deploy in high volumes
 - Easy to adapt solution to ever changing needs
- **Cost effective**
 - Subscription model
- **Accurate flow insights – always**
 - Automated self-calibration