



Add value.  
Inspire trust.

# Virtual Multiphase Flow Metering for Topside MPFMs

Sreejith Vidyadharan (TÜV SÜD)

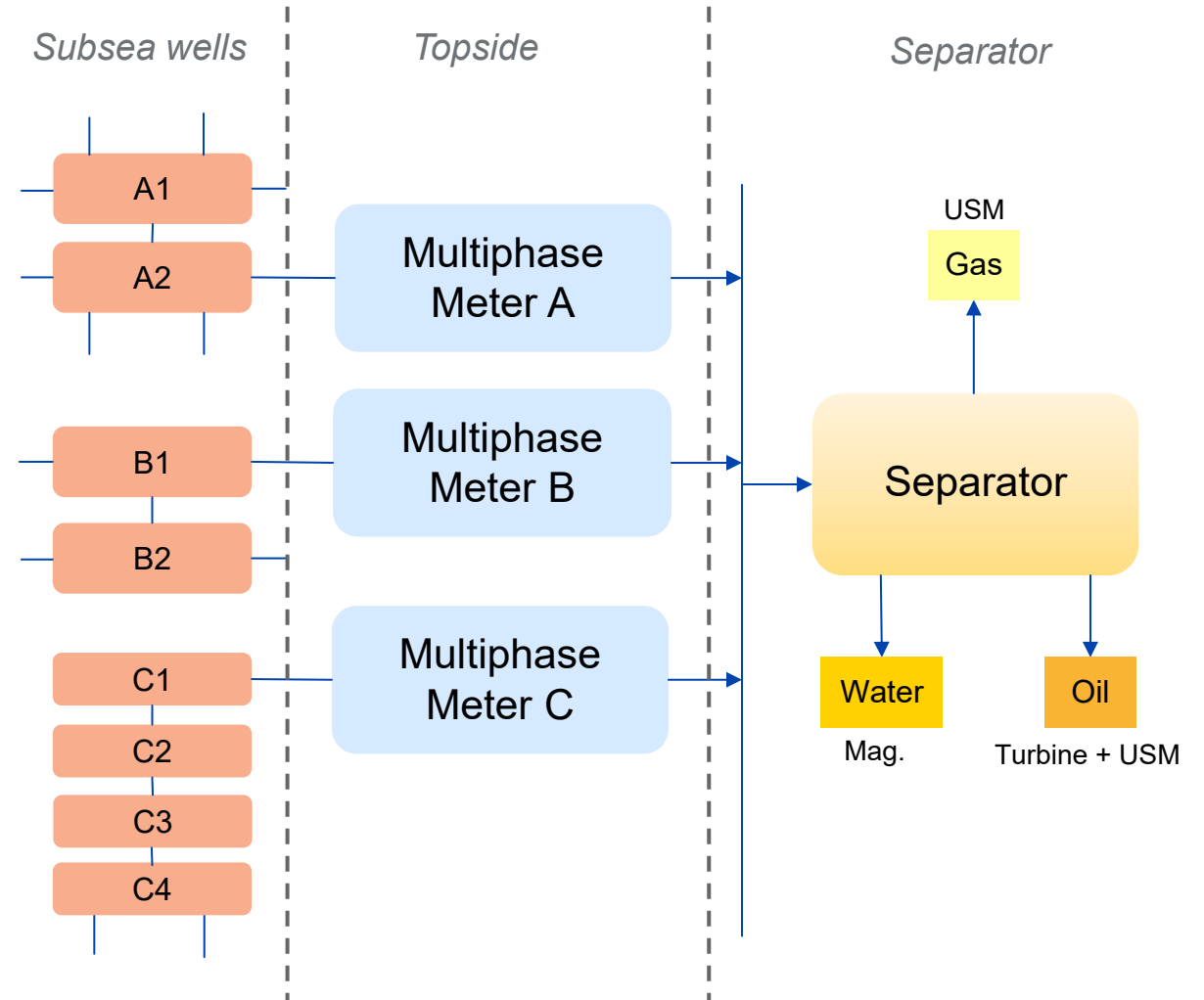
Sandy Black (TÜV SÜD), Konrad Kuczynski (TÜV SÜD), Børge Olafsen (AkerBP),  
Erlend Nilsen (AkerBP)

# Problem Definition

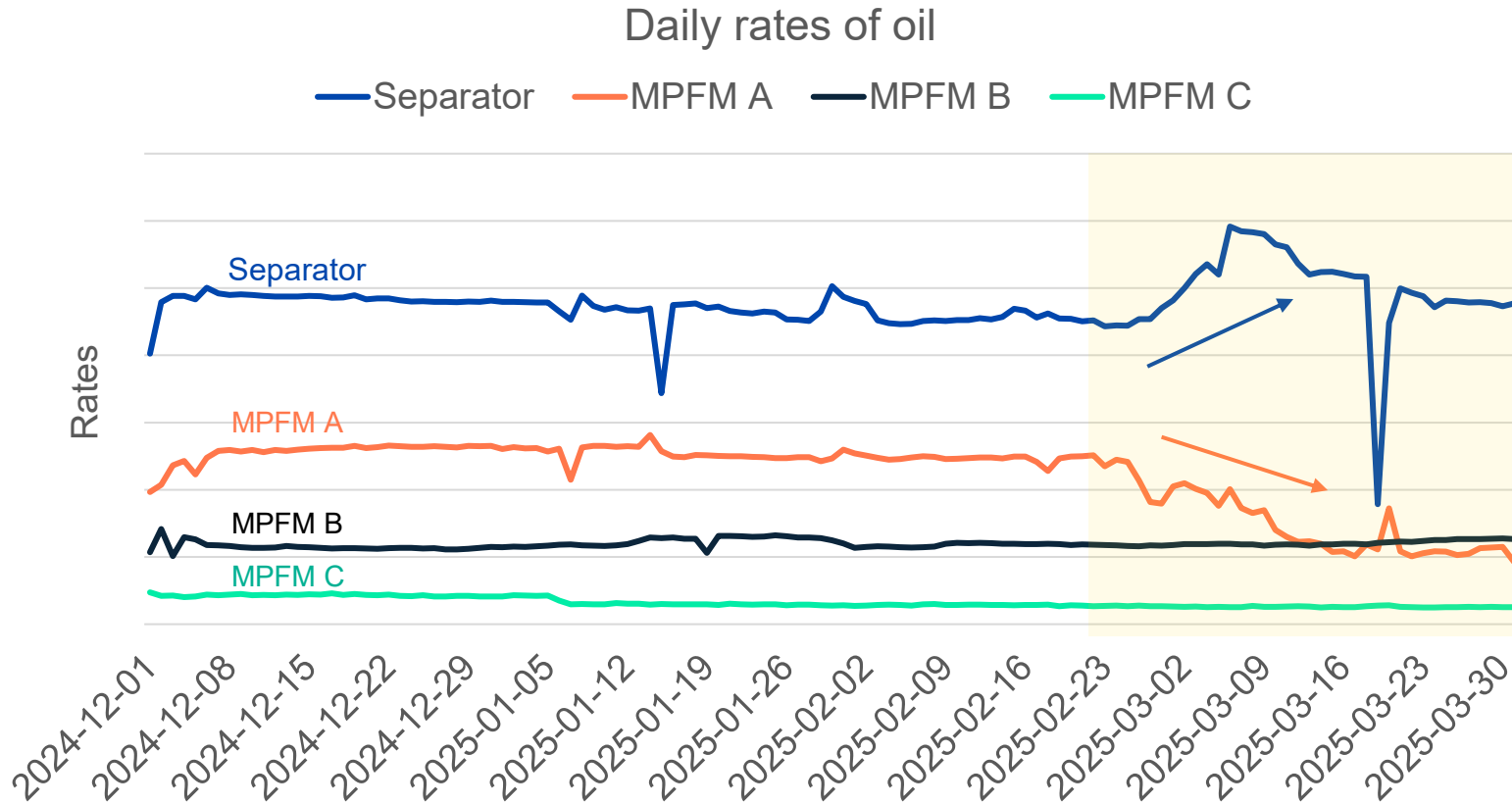
- Modern multiphase measurement systems are inherently complex, necessitating significant time and effort for effective monitoring and maintenance.
- As fields mature and expand, different partners may be present on different flowlines which makes daily allocation measurement by **MPFMs crucial**.
- Manually monitoring these fields becomes highly intricate, time consuming and therefore there is an increased risk of undetected measurement errors.
- A **virtual flow metering technology** has been developed by TÜV SÜD, in collaboration with the Norwegian oil and gas company, AkerBP, to assist the monitoring and troubleshooting of their topside MPFMs and is the topic of today's presentation.

# Problem Definition

- AkerBP has 3 separate flowlines (streams) connected to an inline separator.
- Each flowline carried multiphase flow (oil, gas and water) from multiple wells.
- Each flowline has a topside MPFM installed before the separator.
- Manually monitoring these fields is time-consuming and need further tools to monitor the flow rates.



# Example: daily oil rates oddity



= Valve positions constant, no other operator changes...

↑ Separator total rate

↓ Multiphase flow meter rate A

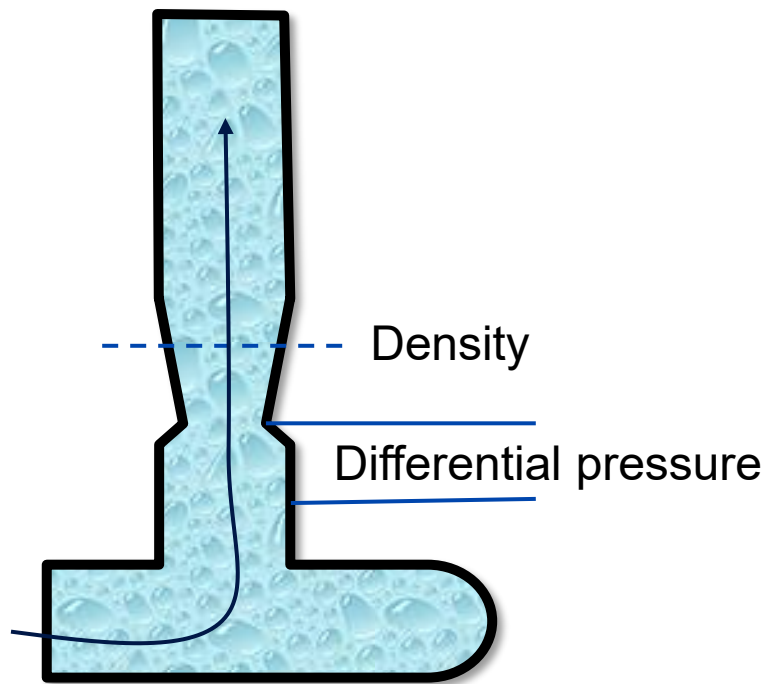
= Multiphase flow meter rate B

= Multiphase flow meter rate C

**What is going on?**

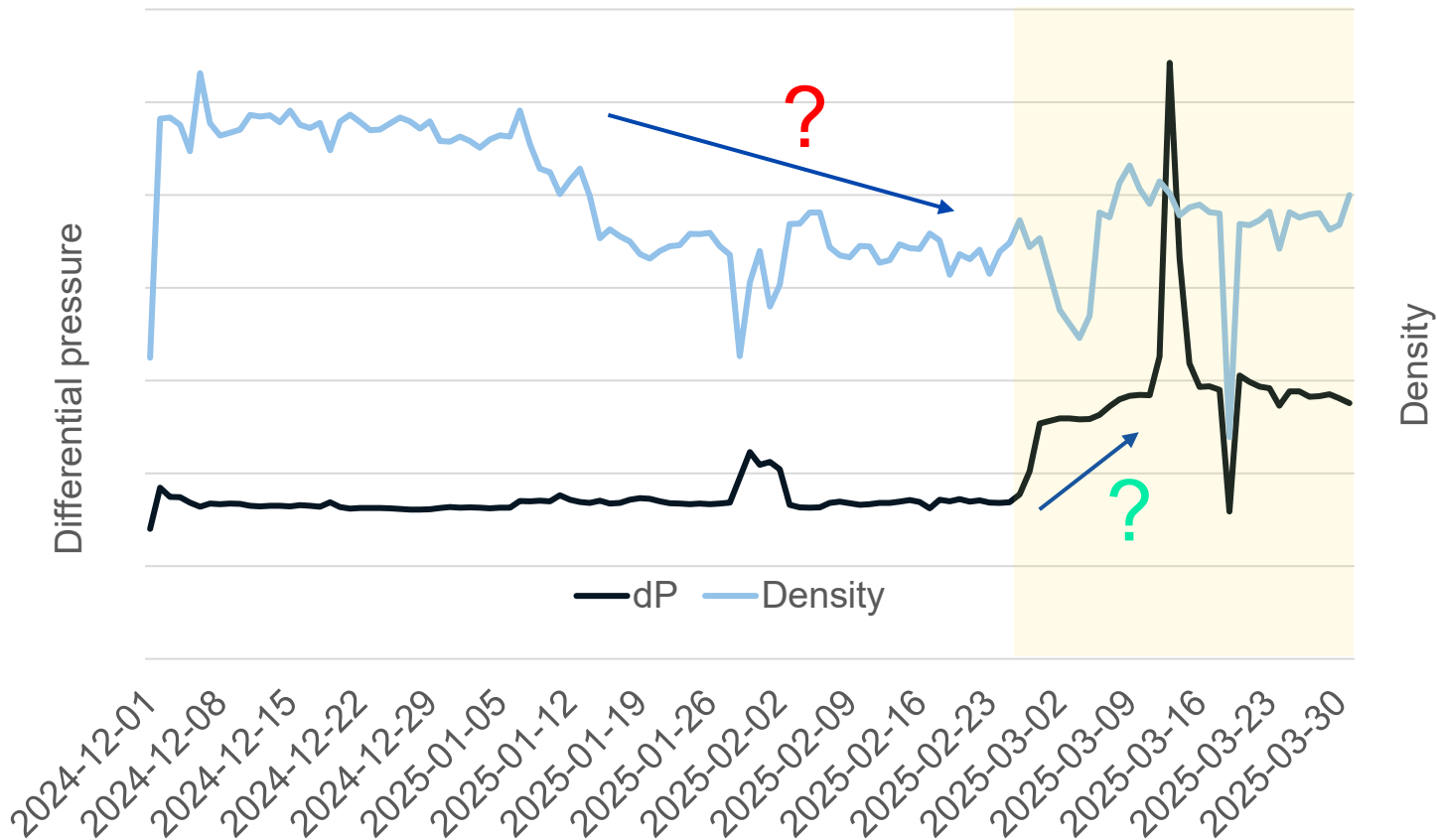
**This appears to happen  
~ 25<sup>th</sup> February**

# Example: multiphase flow meter A



Flow is approximately:  $Q = C_v \cdot \frac{\sqrt{\Delta P}}{\rho}$

Differential pressure and density from multiphase meter



**Same question: what is going on?**

# Virtual Flow Metering

## What is a virtual flow meter?



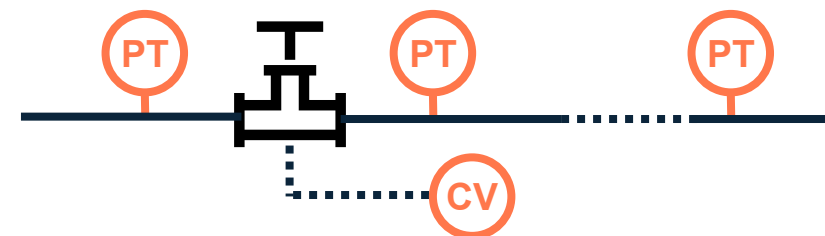
A model which allows the estimation of multiphase / multicomponent flow rates in real-time



The model is trained by physics based and / or data science models



Uses **existing** instrumentation and equipment



# Virtual Flow Metering

## PT Historical datasets

### Field data (per flowline)

- Minimum requirement
- Pressures
  - Temperatures
  - Choke valve positions
  - Separator data
  - Other (e.g. MPFM sensor data)

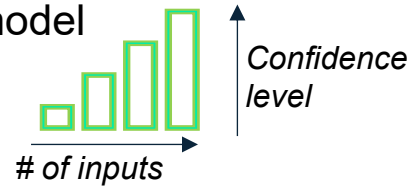
### Facility information

- Piping information
- PVT information
- CV curves

## Training

### Physics based models

- ⇨ Sachdeva model
- ⇨ Al-Safran
- ⇨ Hydro model
- ...



### Data science models

- ⇨ Grid search of machine learning methods and their hyperparameters
- ⇨ Find optimal solution
- ...

Model selection

## Virtual flow meter

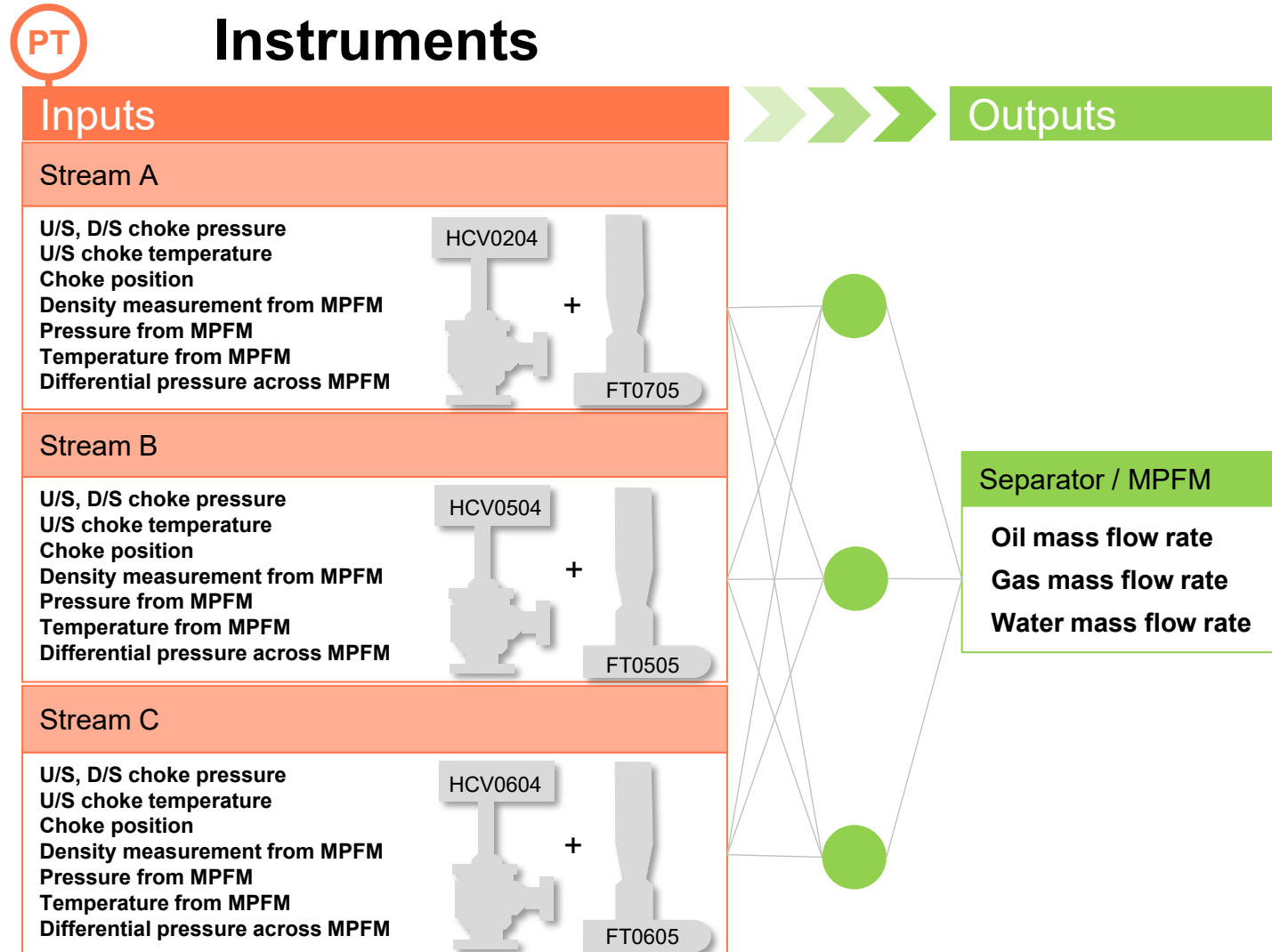
VFM

- ✓ Appropriate model selected
- ✓ Deployed to cloud
- ✓ Flow rate output\*
  - ✓ Oil
  - ✓ Gas
  - ✓ Water

\* Confidence on flow rates highly dependent on quality of inputs available

# Historical datasets

- For creating VFM models for each stream, we used historical data accessed from the AkerBP cloud using the shared tags.
- Selected the appropriate inputs which included sensor measurements from the topside MPFM and choke valve readings:
  - Upstream / downstream pressures
  - Choke positions
  - Upstream / downstream temperatures
  - Density output (MPFM)
  - Differential pressure (MPFM)
  - Temperature / Pressure (MPFM)



# Training period and datasets

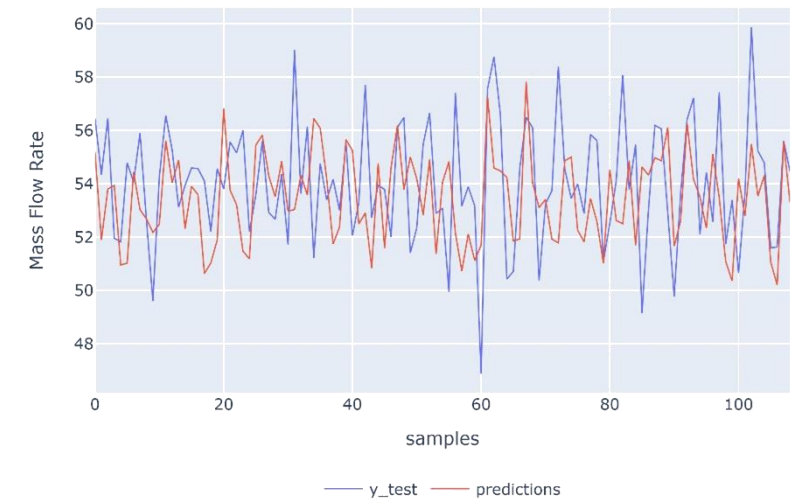
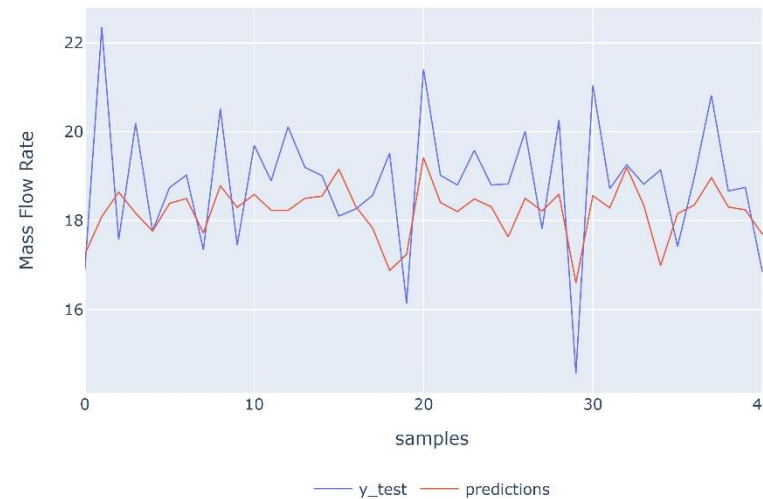
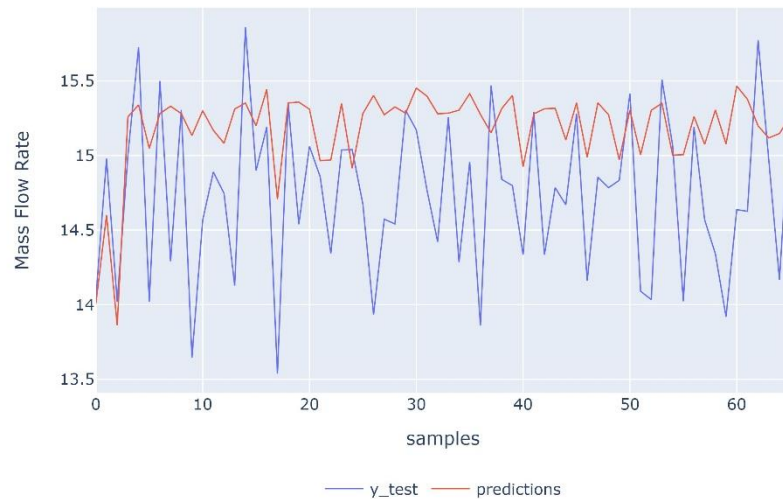
- AkerBP provided NEL with the time periods suitable for the dataset chosen for modelling individual streams.
- Single stream calibration data was available for period before Jan 2024.
- Stable / trusted periods were chosen from June 2024.
- Worked with AkerBP to determine trustworthy and reliable datasets.

Dataset	Target used for training
Single Stream Calibration data	Separator mass flow rates
Stable period data	MPFM mass flow rates

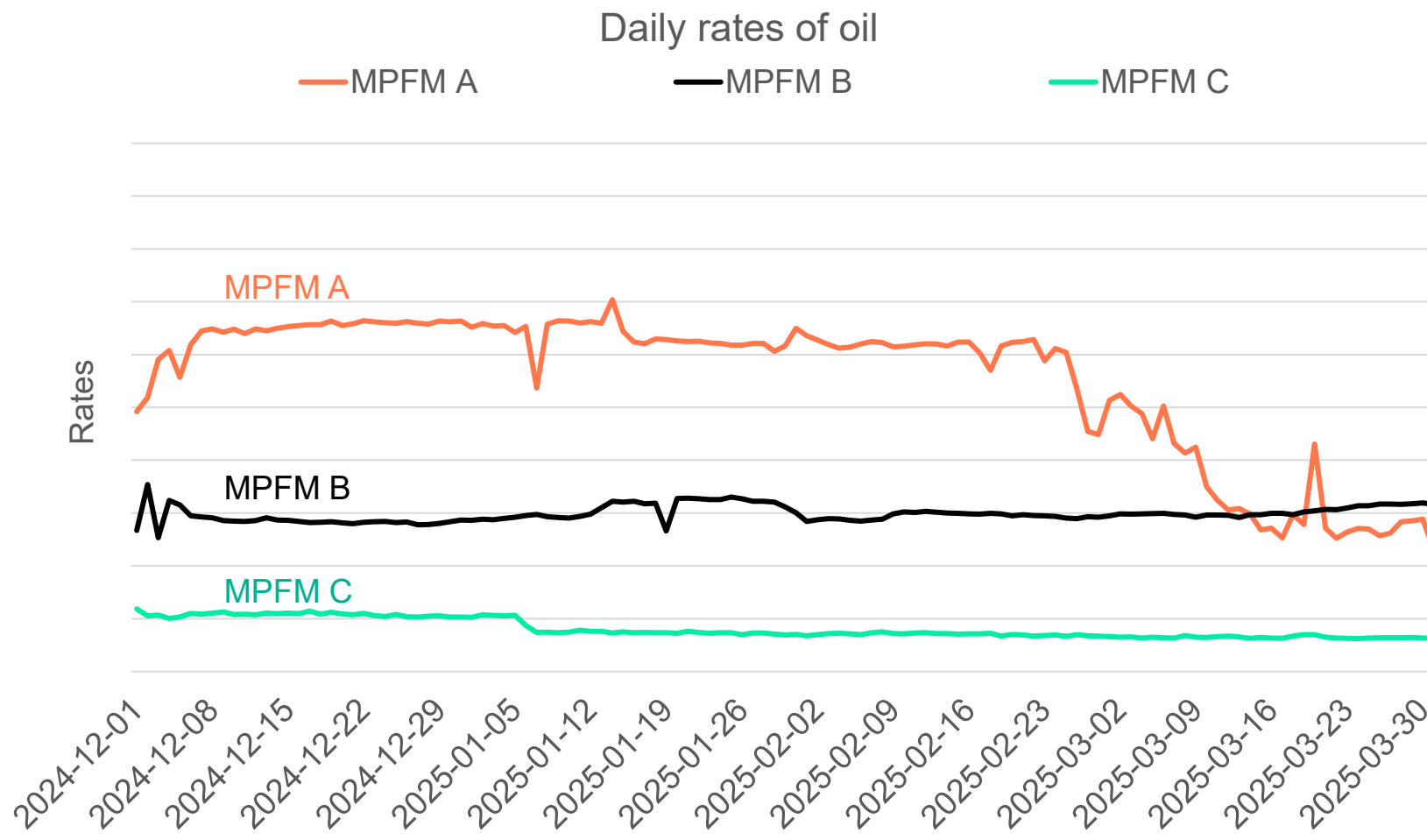
# Model training

- For the chosen datasets, 80% was allocated for training and 20% for testing.
- Tested different modelling approaches, and **machine learning was chosen** due to insufficient data and variability for deep learning and physics-based models.

## VFM Gas Mass Flow Rate Predictions (Test Data)



# Example: daily oil rates oddity



= Valve positions constant, no other operator changes...

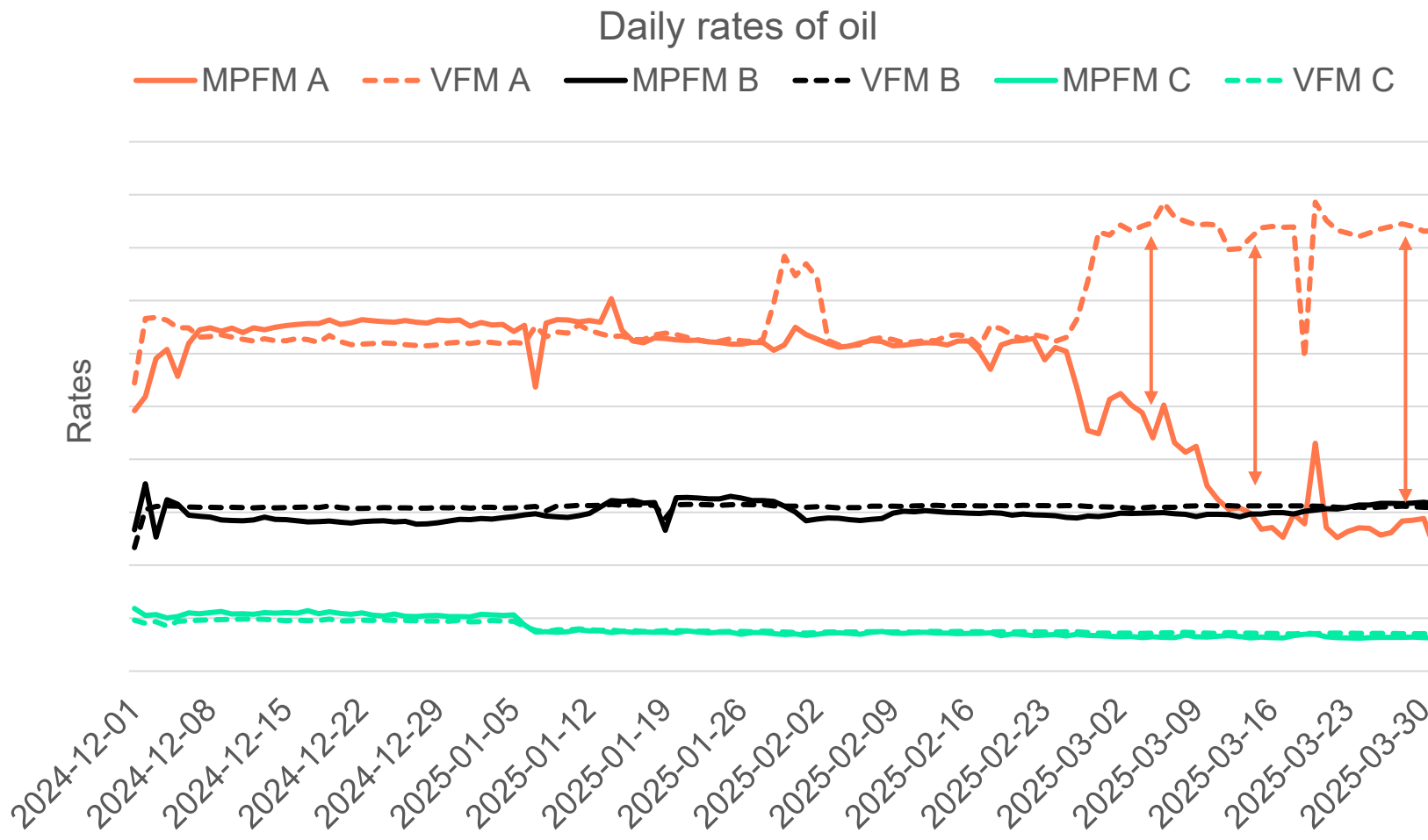


Multiphase flow meter rate A

= Multiphase flow meter rate B

= Multiphase flow meter rate C

# Example: daily oil rates oddity



Virtual meter created for each **three** streams

### Stream A :

- Large differences after 25<sup>th</sup> February!

### Stream B:

- Agreement within 10 %

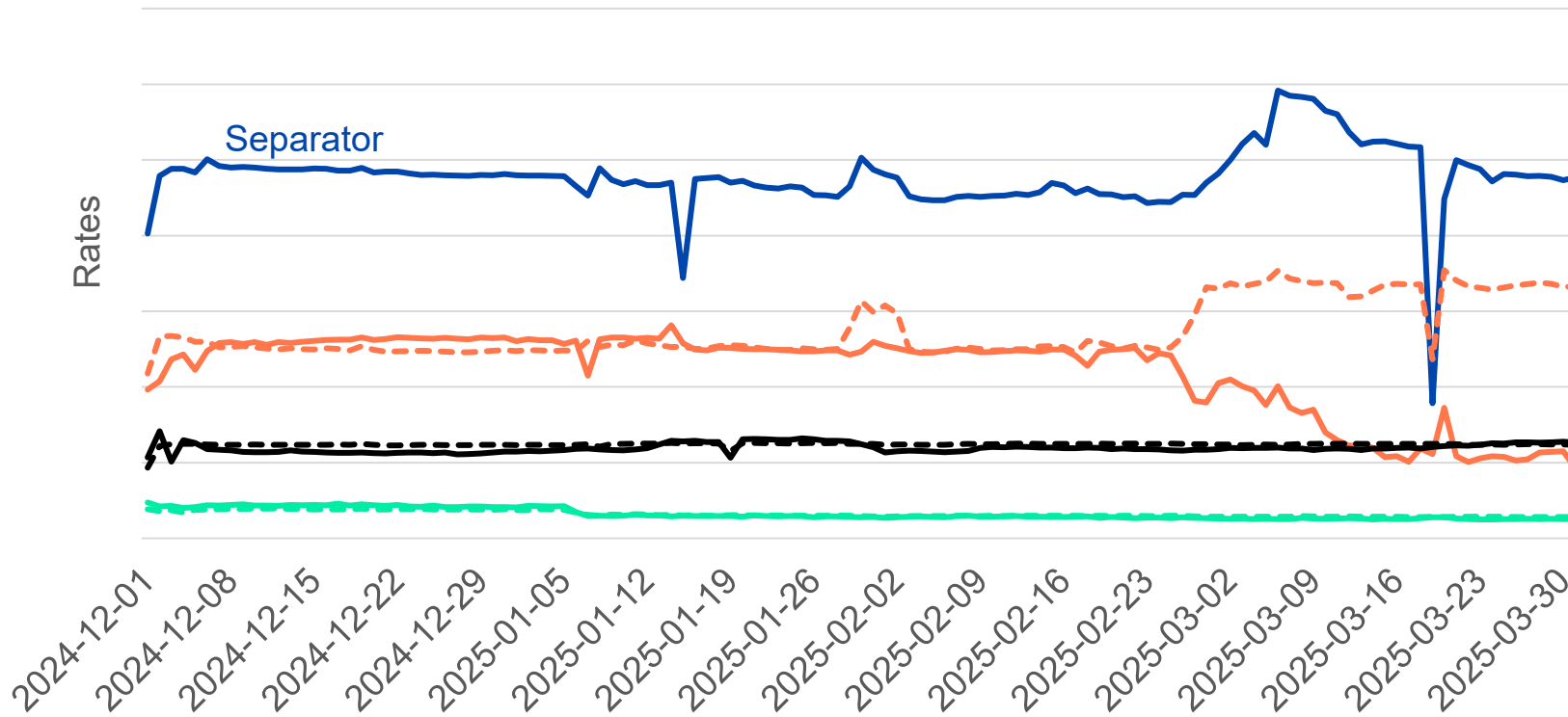
### Stream C:

- Agreement within 10 %

# Example: daily oil rates oddity

Daily rates of oil

— Separator     
 — MPFM A     
 - - - VFM A     
 — MPFM B  
- - - VFM B     
 — MPFM C     
 - - - VFM C

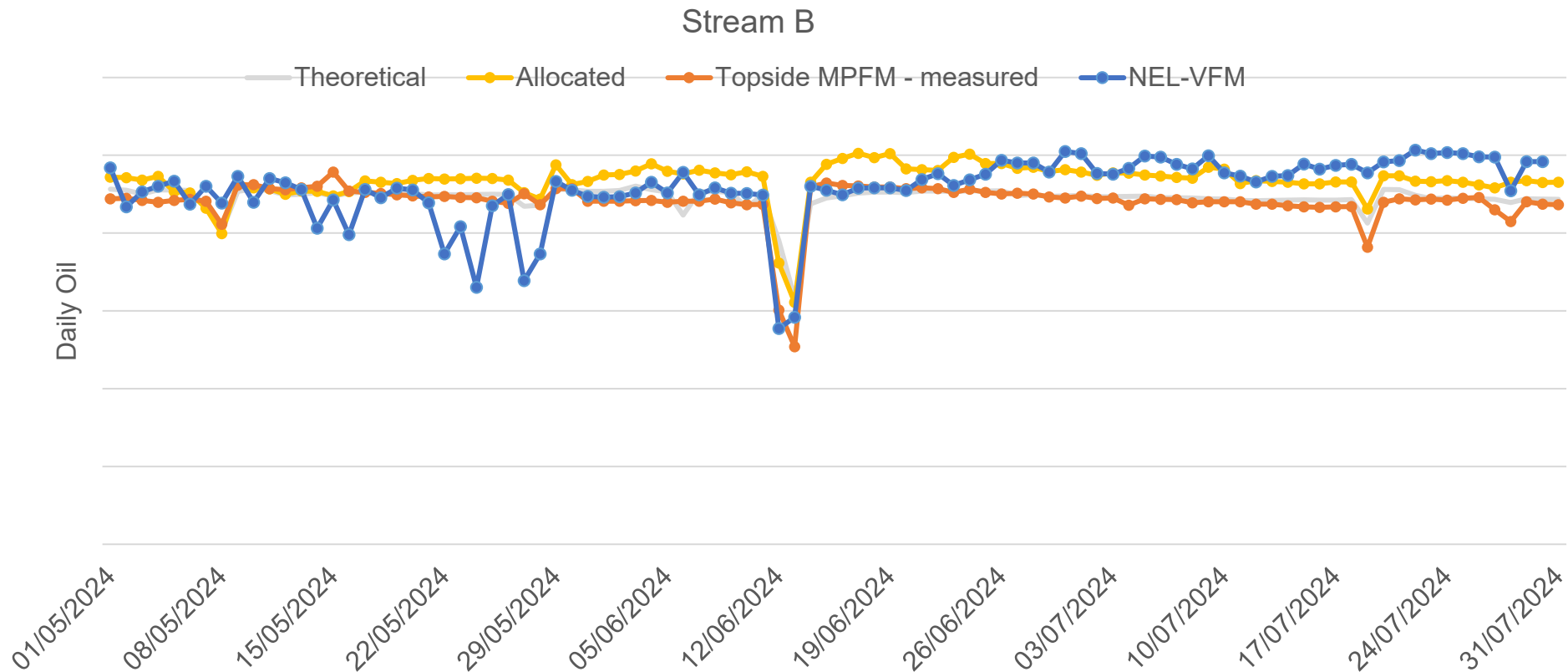


Increase in **Separator** flow rate correlated with increased production in **Stream A**, consistent with **VFM A**

- ↑ Separator total rate
- ↓ Multiphase flow meter rate A
- = Multiphase flow meter rate B
- = Multiphase flow meter rate C

# VFM predictions – Single Stream Calibration data

- Oil predictions for Stream B are displayed below using monthly data for a three-month period
- For Stream B, when evaluated over a period from January-June 2024, VFM oil predictions were within 5% of the allocated rates.



# Deployment

## AkerBP measurement data



*Cognite API*

- Stream A IDs
- Stream B IDs
- Stream C IDs

## Virtual Flow Meter

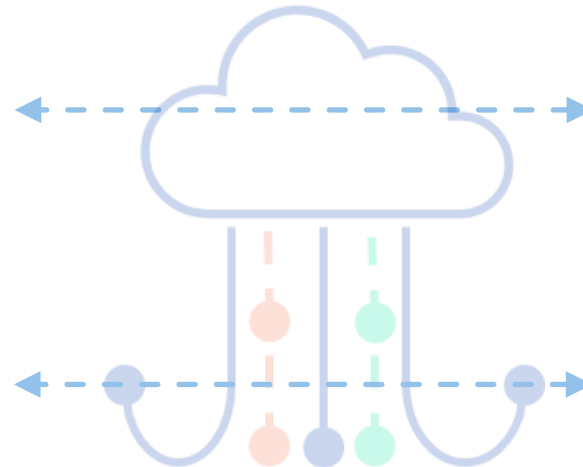


*Access via TÜV SÜD NEL's Azure cloud*

- Stream A VFM
- Stream B VFM
- Stream C VFM

Output of

- Oil mass flow rate
- Gas mass flow rate
- Water mass flow rate



## API Data flow



- Receive data collected from **AkerBP Cognite**
- Json input data sent via API to **NEL Azure**
- Data processed and flow rate results generated
- Results returned via API, relevant tags updated

# Summary and way forward

- AkerBP is now increasing the complexity of their asset by adding multiple new MPFMs on other flowlines going into another inlet separator.
- Currently, there is a notable absence of tools designed to ensure accuracy and quality of these systems. As different partners have a share on different flowlines, reliable daily allocation using the **MPFMs is crucial**.
- A virtual measurement system using machine learning models and existing instrumentation available in the cloud on **three streams** has been developed by TÜV SÜD to assist AkerBP in monitoring and troubleshooting topside MPFMs with the aim to reduce undetected measurement errors.
- The presentation shows the development of these streams and highlights an example of the importance of virtual tools to help early intervention and enhance the quality of multiphase flow measurements.
- VFM solution present a promising path towards more efficient, reliable and cost-effective production optimisation in the oil and gas industry.

# Contact Information:

Sreejith Vidyadharan

[Sreejith.Vidyadharan@tuvsud.com](mailto:Sreejith.Vidyadharan@tuvsud.com)