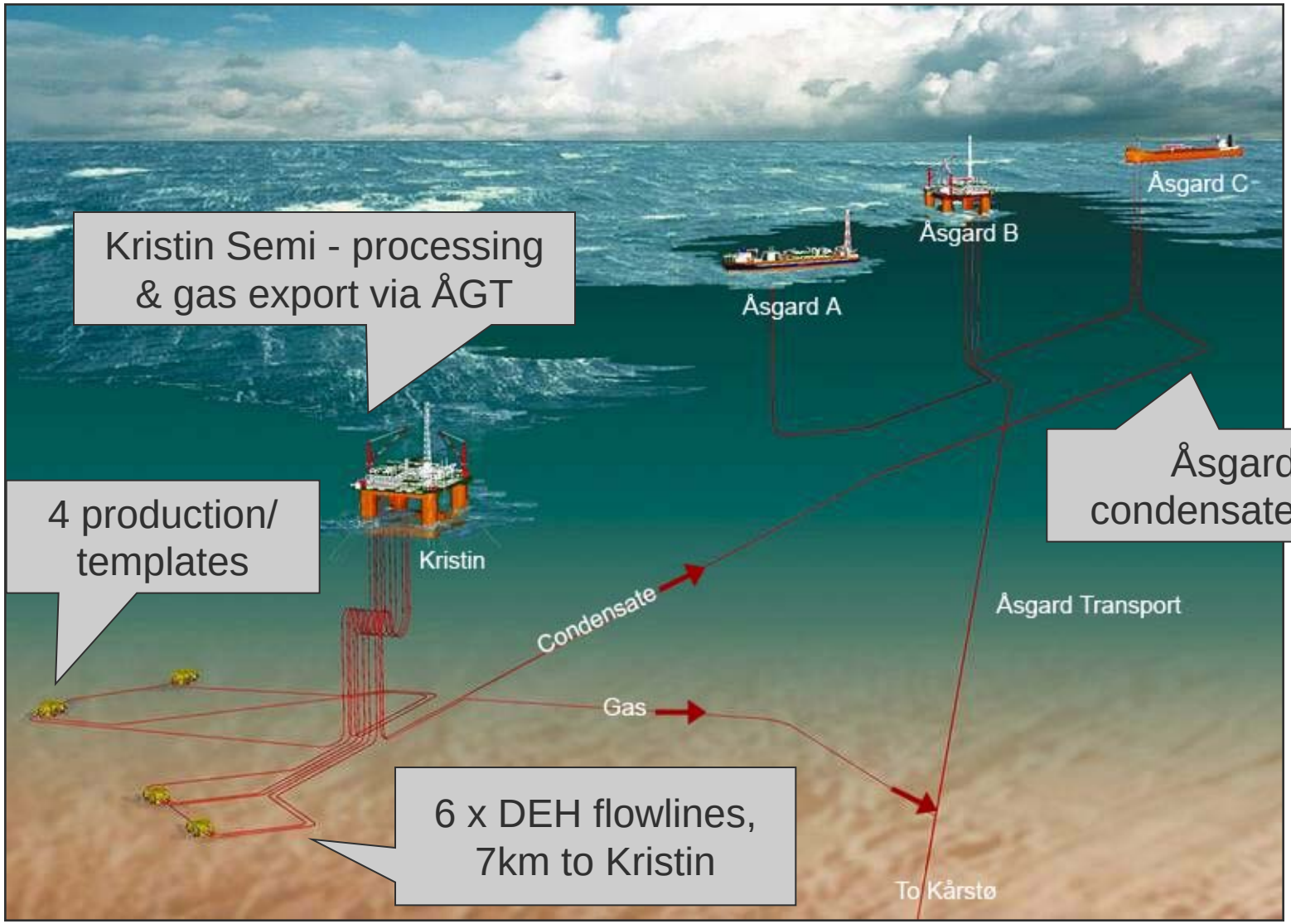
Multiphase metering for allocation between Kristin og Tyrihans

Arne Morten Dahl (Statoil, DPN OMN KH PTC KRI)

Outline

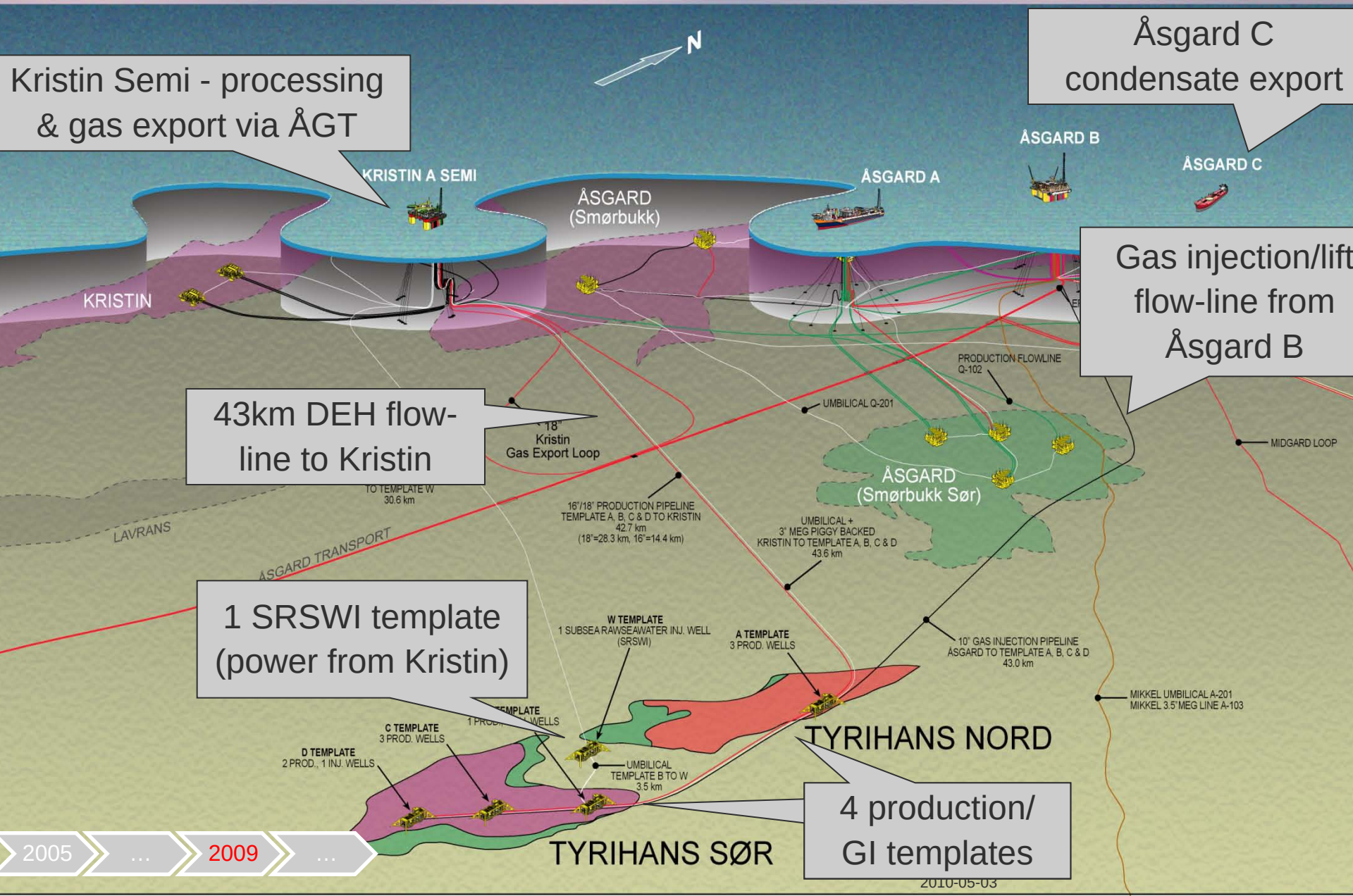
- MPFM for field allocation, introduced by tie-in of Tyrihans to Kristin
- Original metering philosophy and allocation principle
- Events and challenges
- Remedial actions and changes
- Status metering and allocation
- Future challenges technologies / opportunities

Kristin subsea infrastructure

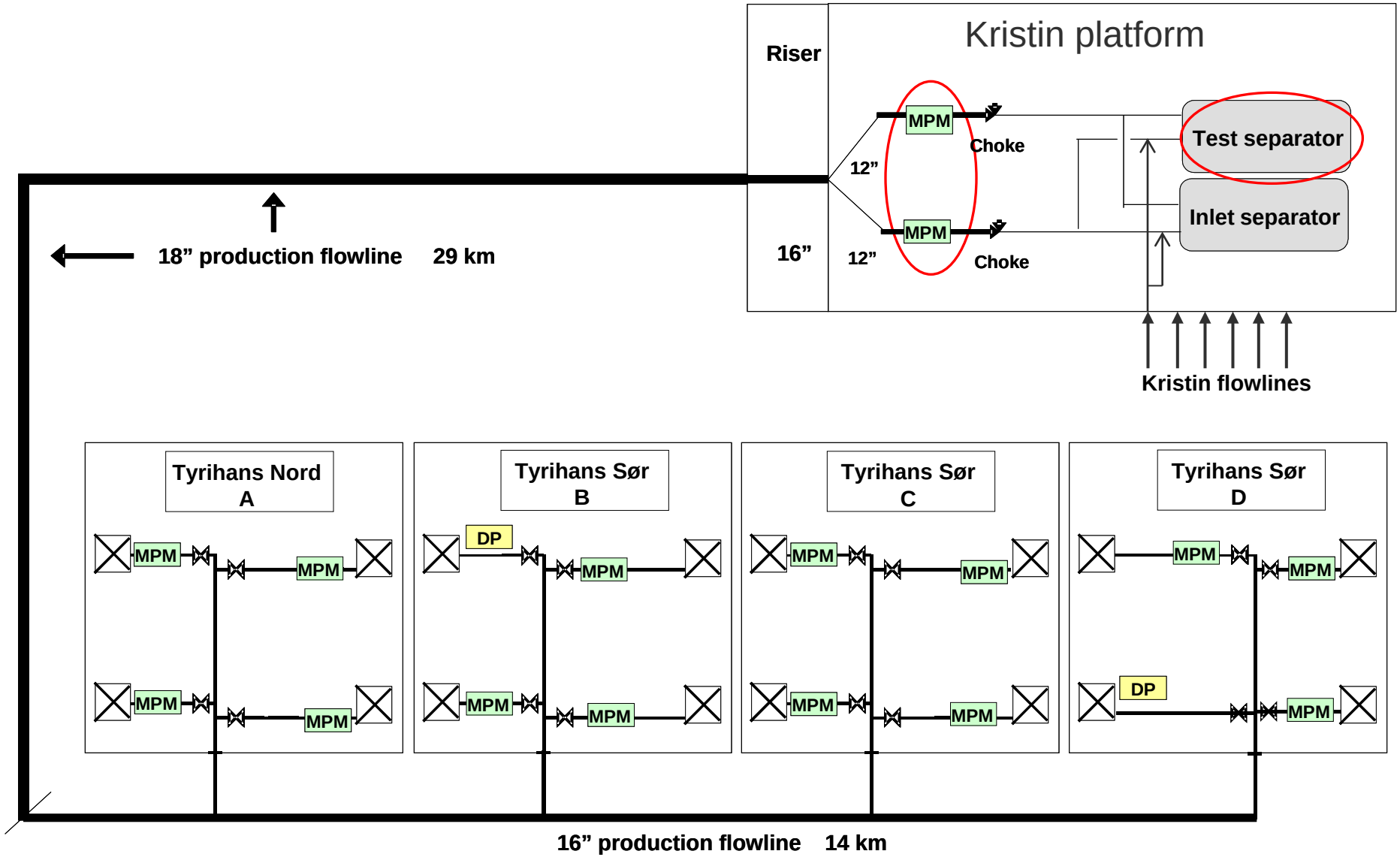


Statoil

Tyrihans subsea infrastructure



2005 … 2009 …

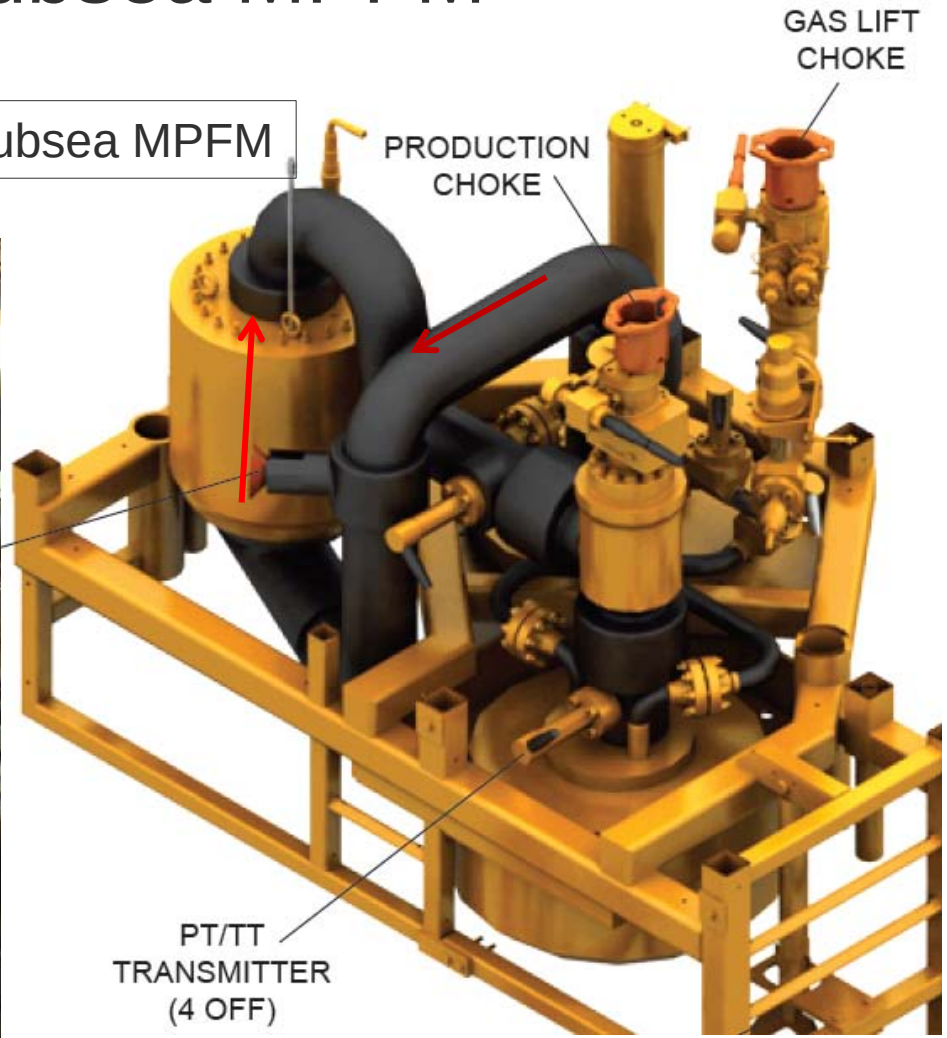

Riser
Kristin platform
MPM
Choke
12”
MPM
Choke
12”
16”
Test separator
Inlet separator
18” production flowline 29 km
Kristin flowlines
Tyrihans Nord
A
Tyrihans Sør
B
Tyrihans Sør
C
Tyrihans Sør
D
DP
DP
16” production flowline 14 km

Statoil

Tyrihans Topside and Subsea MPFM

Topside MPFMs

Subsea MPFM



Main purposes of oil and gas allocation

- Fiscal allocation
  - Ownership allocation, distribution of the income
    - Oil and condensate mass
    - Gas energy
- Production Management
  - Detailed production monitoring and optimization
    - Allocated production and injection volumes for individual wells
- Reservoir Management
  - Reservoir simulation model history matching
    - Allocated production and injection volumes for individual wells

Main purposes of oil and gas allocation

- Ownership allocation, distribution of the income
  - Oil and condensate mass
  - Gas energy
- Detailed production monitoring and optimization
  - Allocated production and injection volumes for individual wells
- Reservoir simulation model history matching
  - Allocated production and injection volumes for individual wells

Original Allocation principle: Kristin as balance field (Kristin by difference – KBD)

$$Kristin_{oil,gas} = Kristin_{total} - Tyrihans_{oil,gas}$$

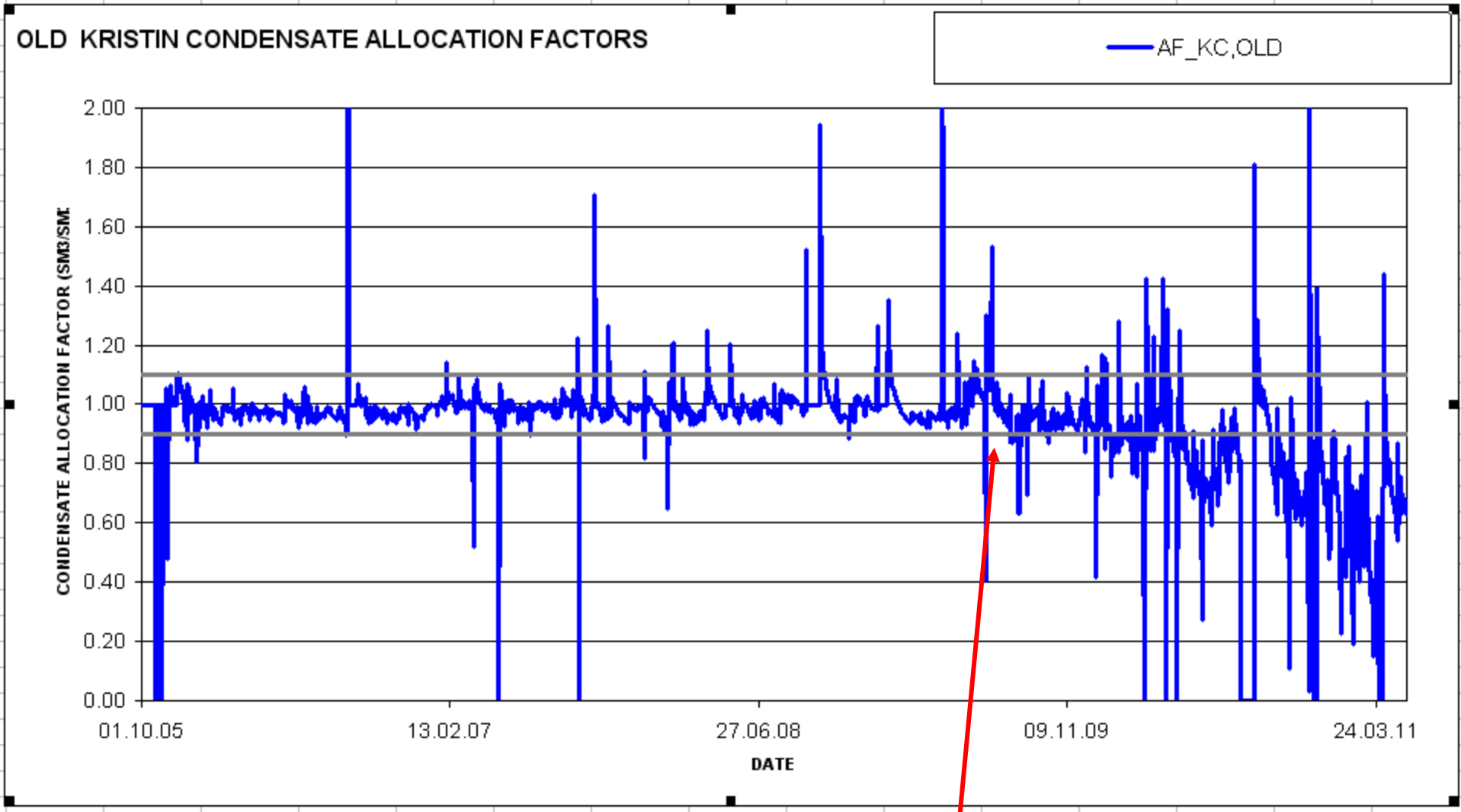
Well tests

Multiphase meters topside (2 off) ~80% of total production

Accuracy and performance?

Multiphase meters subsea (backup)

Accuracy and performance?



Allocation factor = Allocated volume/theoretical volume

Tyrihans start-up

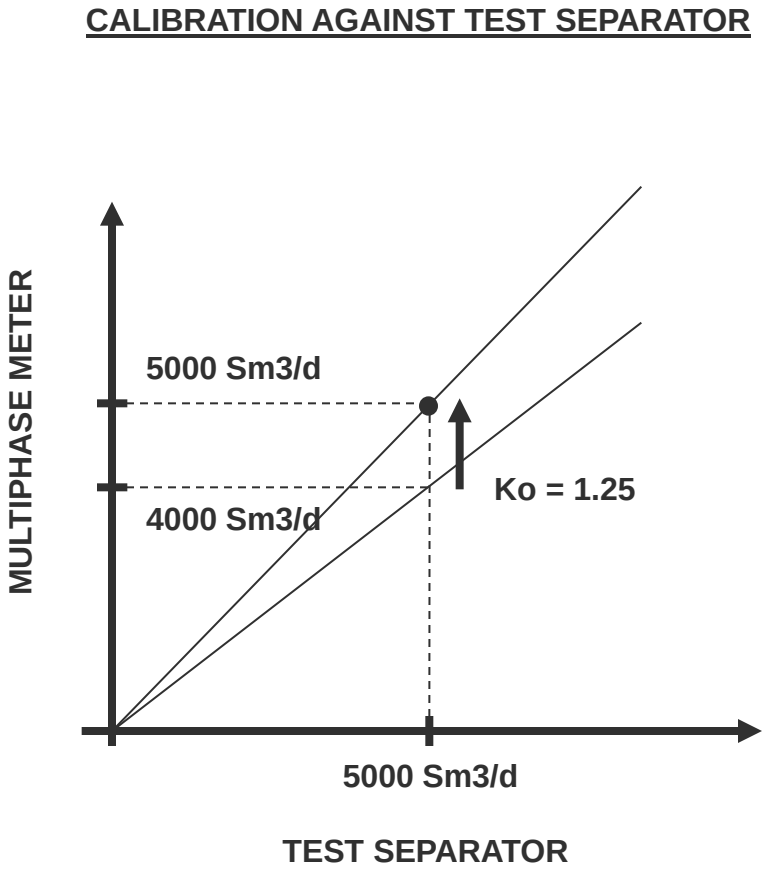
Troubleshooting Allocation System

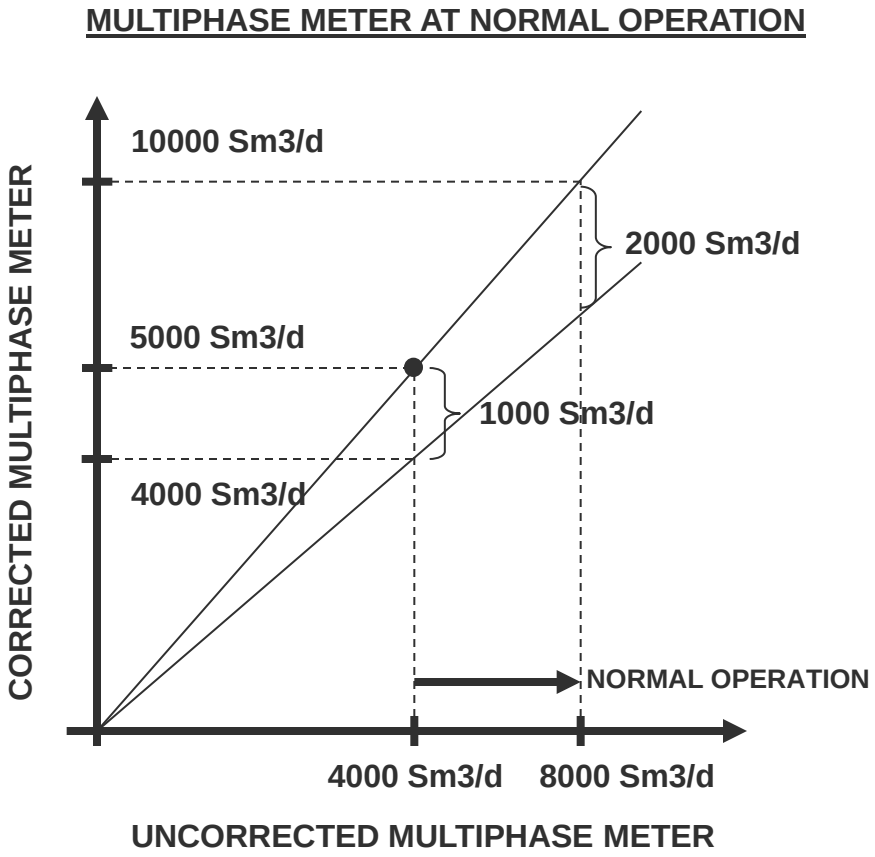
The original field allocation system does not reproduce the results from field tests.

Main issues seem to be:

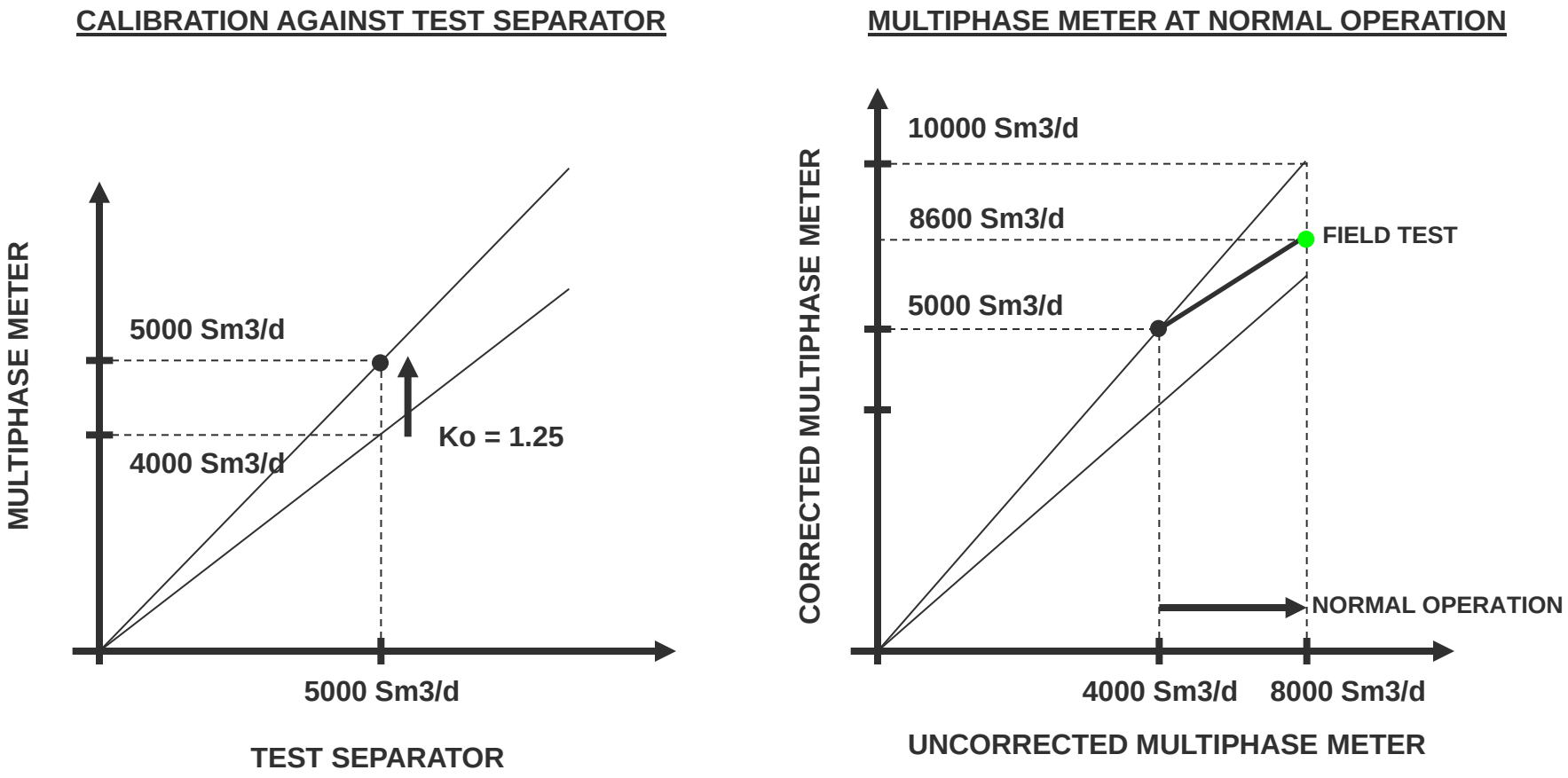
- Test separator readings high compared to export rates
- Topside MPFM mass correction is not linear as a function of rate under calibration
- Unable to calibrate topside MPMs against the test separator at normal operational conditions
- Problem with gas measurements at high rates
- Allocation principle with Kristin as balance field

Multi phase flow meter calibration principle

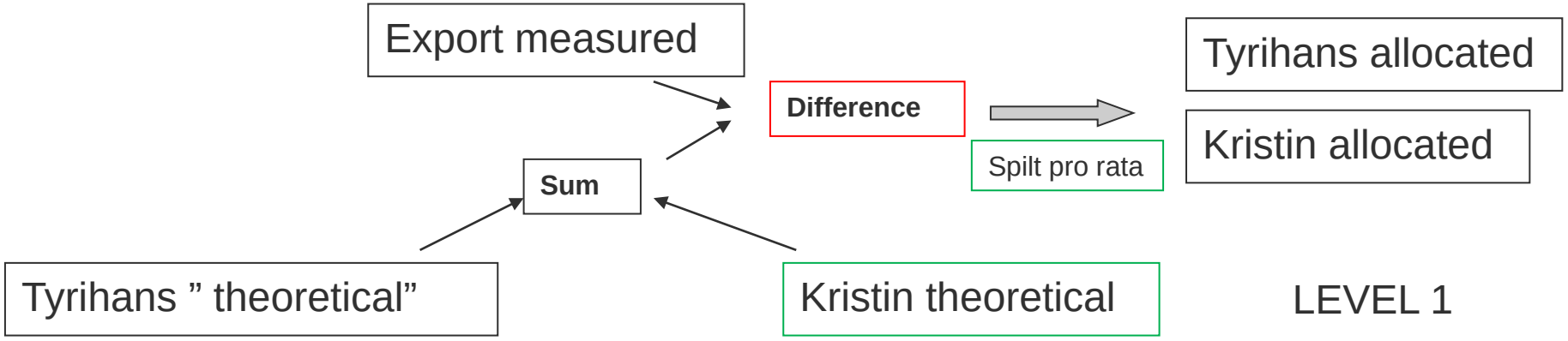




Multi phase flow meter calibration principle



New allocation principle: Subsea HC mass & ProRata split



Allocation input and sources

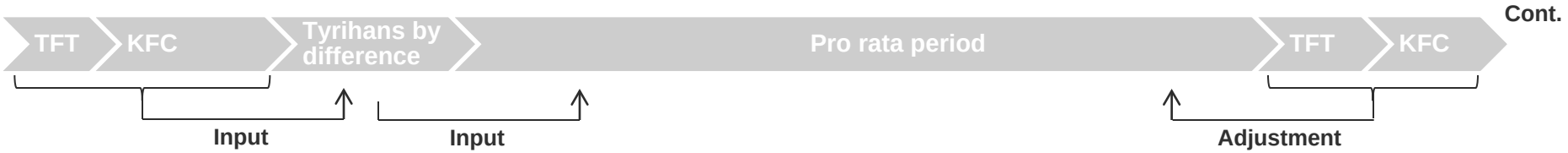
- TYH HC mass
  - TYH total mass (Subsea MPFM and Performance Curves)
  - TYH total water mass fraction (Test separator)
- PVT
  - TYH total HC composition (GOR) (KFC – flowline separator tests)
  - TYH total HC molecular weight pr component (Recombined PVT-samples)
  - Tyrihans gas molecular weight (ISO 6976)
  - Oil recovery factors (ORF) (Hysys)
  - Tyrihans oil density (Hysys)
  - Kristin condensate density (Hysys)
- Well rate estimates
  - Kristin theoretical condensate volume (Performance Curves, KFC – flowline separator tests)
  - Tyrihans theoretical oil volume (Subsea MPFM and Performance Curves)
- Fiscal metering
  - Total export oil and condensate (Fiscal export meters)
  - Total export gas (Fiscal export meters)

Allocation quality control

- Kristin Flowline Campaign (KFC) – Tyrihans by Difference (TBD)
- Allocation factors
- Pro-rata allocation vs TBD result
- Topside MPFM “calibration” (based on TBD)
- Topside MPFM trend
- Subsea MPFM and PC
- PVT-samples
- Single field tests

TFT = Tyrihans Flowline Tests
KFC = Kristin Flowline Campaign

Allocation workflow



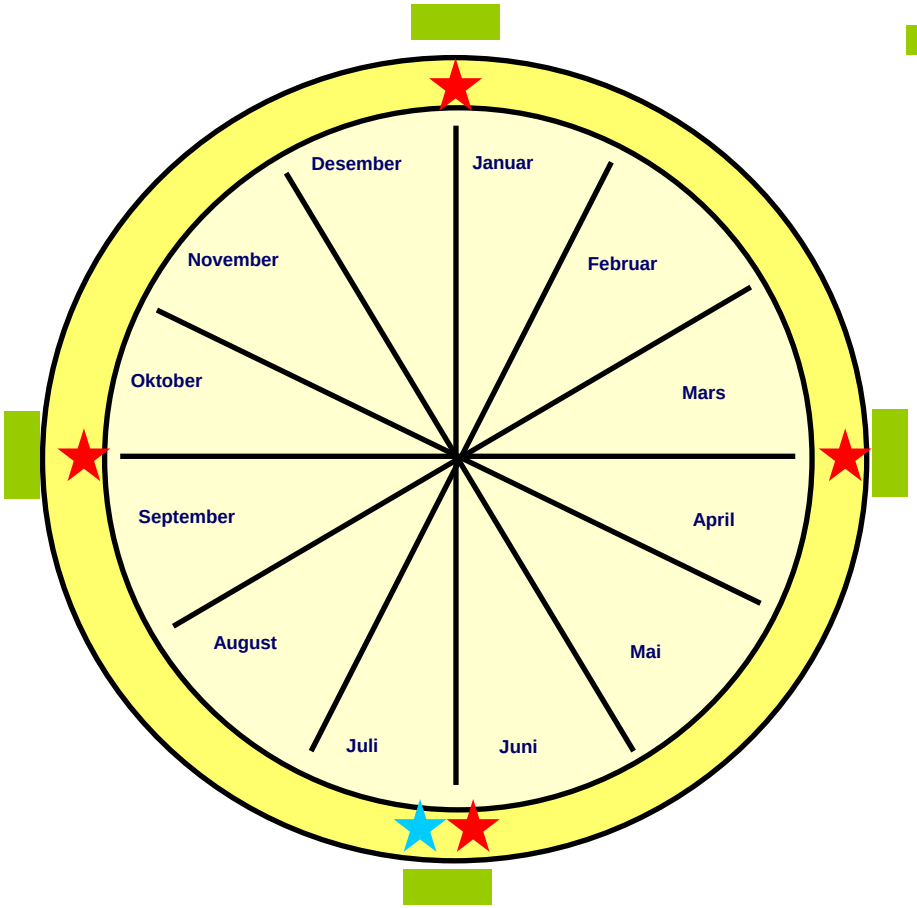
- «Tyrihans by difference» (one production day)
  - Kristin production based on KFC
  - Tyrihans production based on total production and KFC/TFT
  - Tyrihans GOR and WCT determined

- «Pro rata period» (normally 14+ days)
  - Based on latest «Tyrihans by difference»
  - Pro-rata principle to compensate for Tyrihans GOR/WCT development and Kristin depletion effects (not captured by performance curves)
  - Tyrihans GOR (total HC composition) adjusted if necessary (observed trends)

- After next TFT and KFC;
  - Previous «pro rata period» adjusted with new results

- Reallocation is performed when ORF is updated (quarterly)

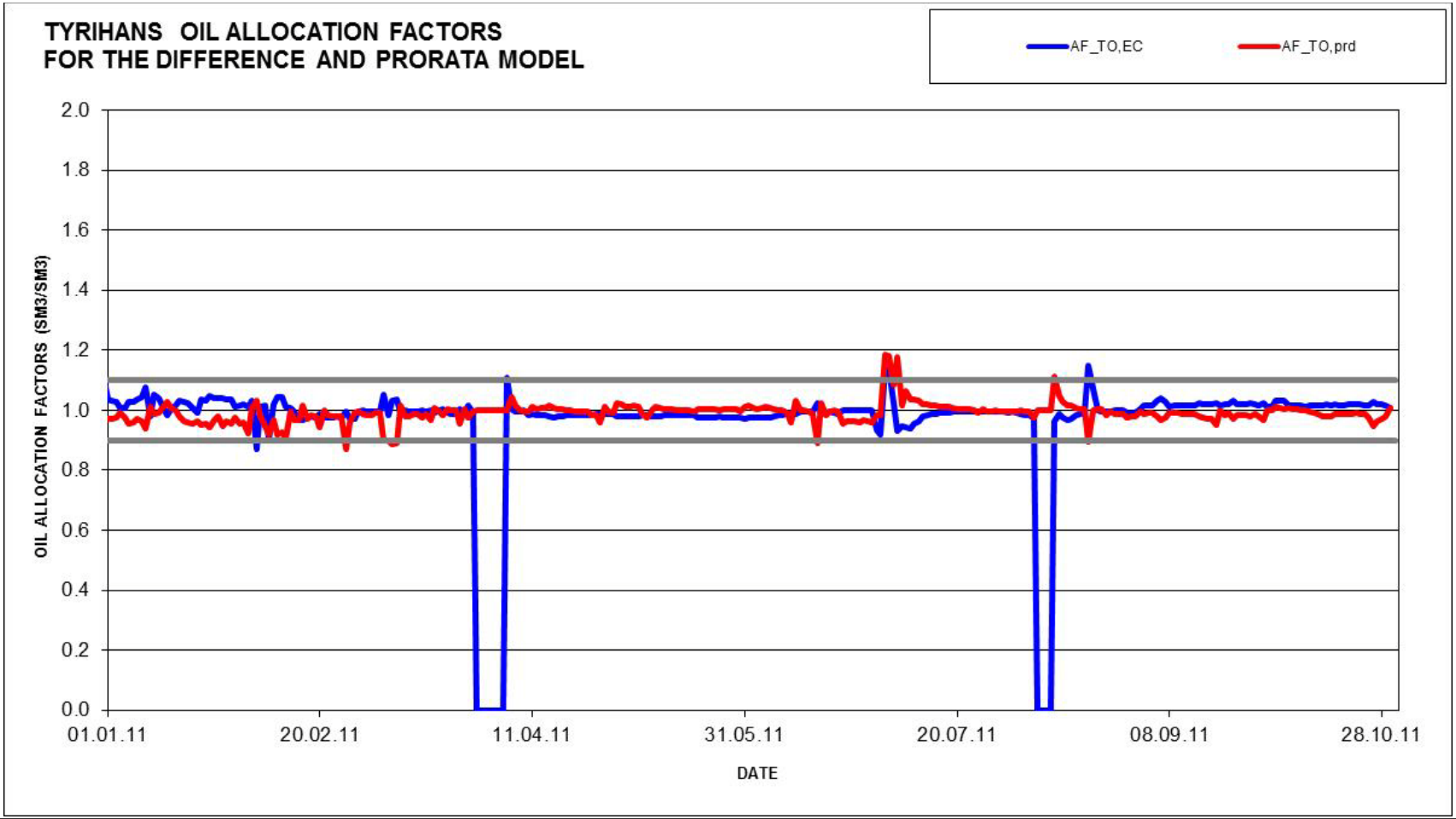
PVT sampling KRI/TYH
Basis for ORF-calculations and allocation



- Process simulations (ORF update)
- Sampling of TYH mixed well stream + condensate & export gas
  - every three months
  - + as necessary due to fluid changes (new wells)
- Annual sampling of KRI wells / flowlines

Statoil

Allokeringsfaktor 2011



Statoil

Summary:
Challenges in Kristin Tyrihans Allocation

- Tyrihans topside multiphase flow meters (MPFM) disqualified for allocation
  - Cannot be calibrated against test separator at normal operating conditions due to test separator rate limitation
  - Can be adjusted against result for Tyrihans from Kristin Flowline Campaign testing (KFC). Measurement drifting between adjustments.
- Tyrihans subsea multiphase flow meters malfunctioning
  - Only as few as two out of seven subsea MPFM in working order for a long time period (currently 5 of 9 working).
- Extensive use of well performance curves (PC) both on Kristin and Tyrihans.
- QC rely heavily on test separator performance.
- Single field tests that require shut-down of either Kristin or Tyrihans are costly and do not show the mixing effect of the two fields.

Future challenges / concerns

- Replacing existing subsea MPFMs (present vendor)
  - Long delivery time, dependent on available choke modules
  - Reliability (will they fail again?)
- Low pressure production (LPP) period from 2014
  - Change in topside process conditions (PVT, ORF-factors, etc.)
  - Change of performance of subsea MPFM under LPP conditions?
- Possible additional 3rd party tie-ins
  - Change in metering philosophy?
  - Change in allocation procedure?
  - Change in topside process conditions (PVT, ORF-factors, etc.)

Future technologies / opportunities

- Install new subsea MPFMs (new vendor)
  - Long delivery time, need mechanical fitting
  - Increased subsea power requirement (limit max no. of MPFMs in operation per template)
- Connect to existing subsea MPFM by ROV for flow data logging possible?
  - Logging for a short period, move to next well and repeat logging
  - Revise well hydraulic models for allocation input
- Investigate subsea PVT sampling (Mirmorax)
  - Representative fluid sampling per well, input to PVT for MPFM calibration / allocation
  - Need mechanical modifications

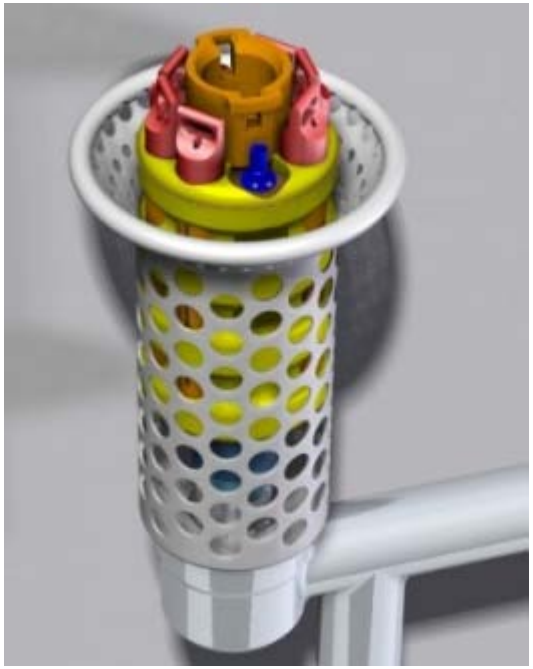


Figure: ©Mirmorax

Future technologies / opportunities

- Virtual metering
  - Replace direct measurements by indirect analysis and modelling
  - Replace MPFMs
  - «Model based allocation». Calculations based on online data model of the subsea system, updating based on sensor changes.

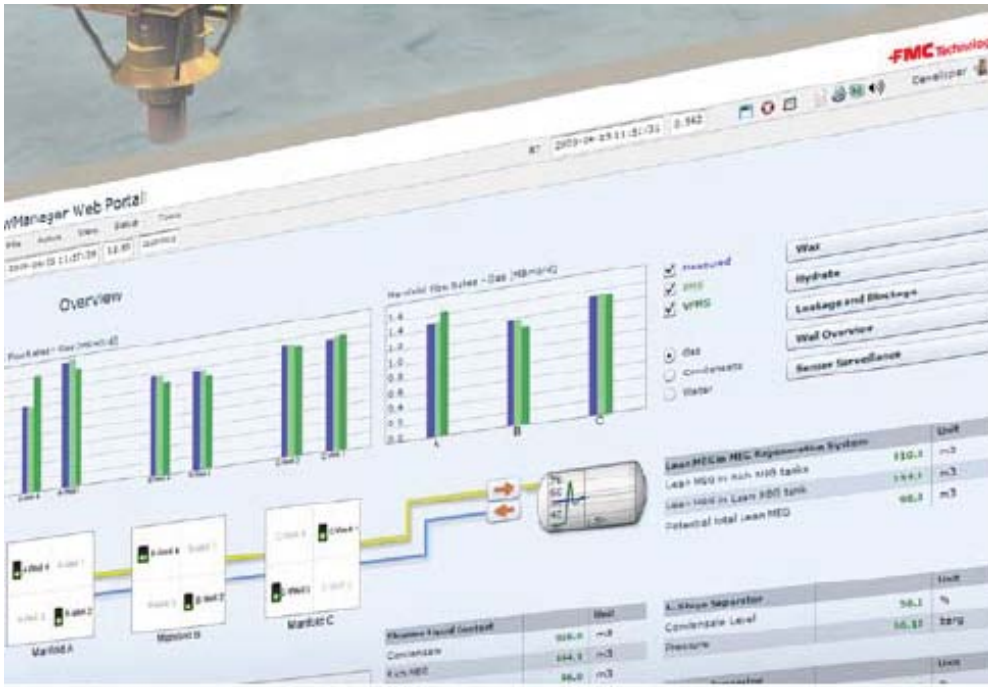


Figure: ©FMC

2005 … 2009 2010 2011 2012 2013 2014 …

Statoil

Future technologies / opportunities

- Multi-diciplinary integrated modelling
  - Integration of Reservoir simulation to Topside simulations for historical matching and future forecast of ORF.
  - Integrated possibility to calculate ORF based on
    - Lab sample measurements and
    - Historical production data
  - Both options compliant with the work processes and technical requirement for simulation for field allocation
    - Possibility for more frequent update of ORF calculations by utilizing input from reservoir simulations.
    - Possibility for less frequent update of ORF based on Lab sample measurements due to knowledge of future development..

There's never been a better time for good ideas

Takk til følgende for bidrag:

- Trygve Kløv
- Kurt Haugnæss
- Even Lillemo
- Yngve H. Belsvik
- Kolbjørn Kyllo

(alle Statoil)

Multiphase metering for allocation between Kristin og Tyrihans

Arne M. Dahl
Principal Engineer Prod Tech,
Kristin Petek
KH PTC KRI
amda@statoil.com
Tel: +4792660405