wintershall

Shaping the future.

Maria to Kristin allocation from project to operation, a real life experience

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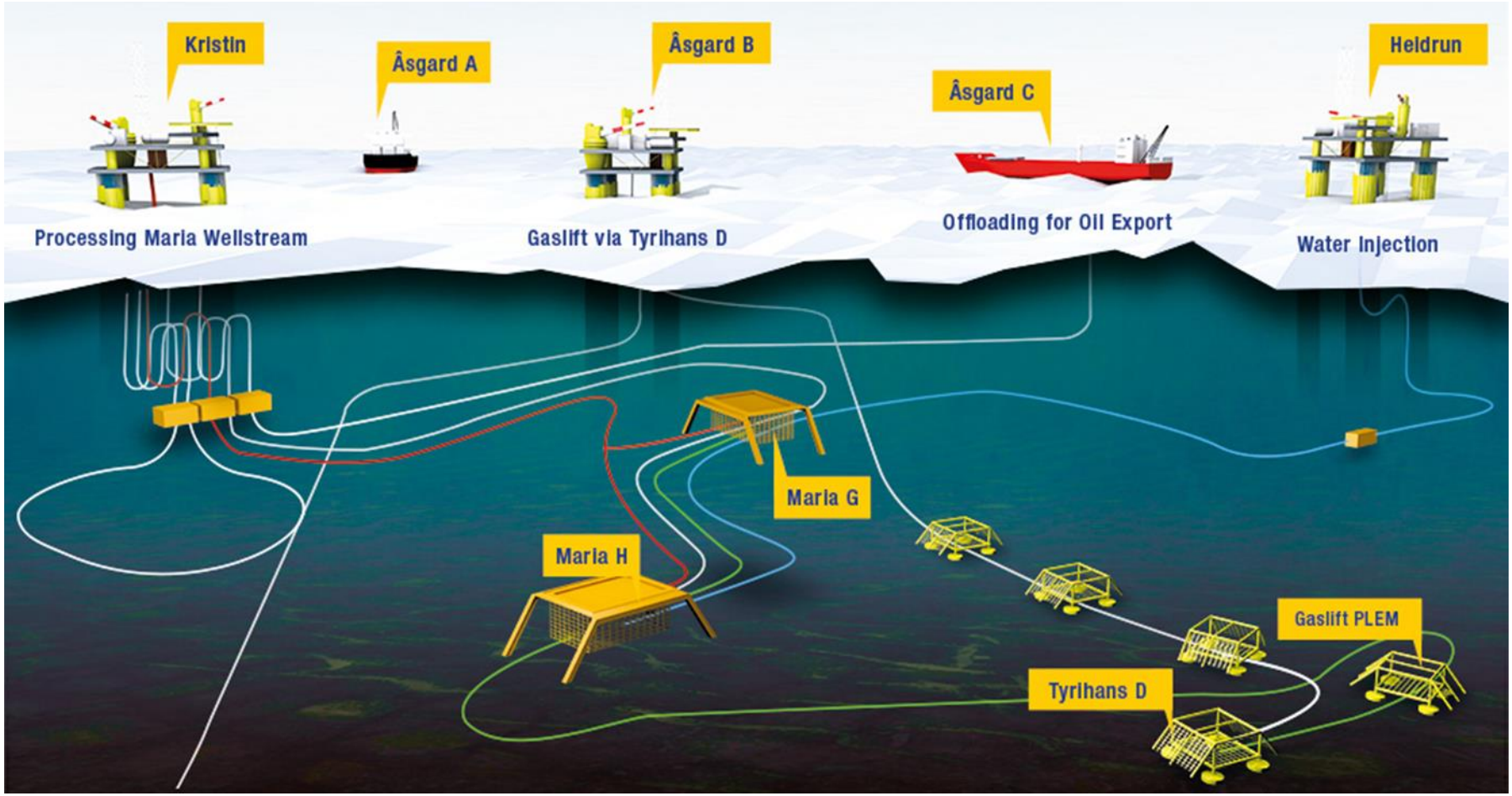
Anita Johnsen, Wintershall

Arne Morten Dahl, Equinor

Agenda

- The Maria field
- Agreements
- Metering
- Allocation
- Value adjustment
- Lessons learnt

Overview Maria



Concept

- December 2017
  - Poor reading from topside MPFM
  - Validation planned to January 2018
  - PVT data from design basis used as starting point
  - Maria MPFM measurements will be corrected once validation and PVT lab analysis are completed
    - Subsequently reallocation will be perfomed

- Calibration / tuning on topside meters January 16th
  - Results used in prelim allocation from December 2017 until April 2018

- Calibration done in February not valid

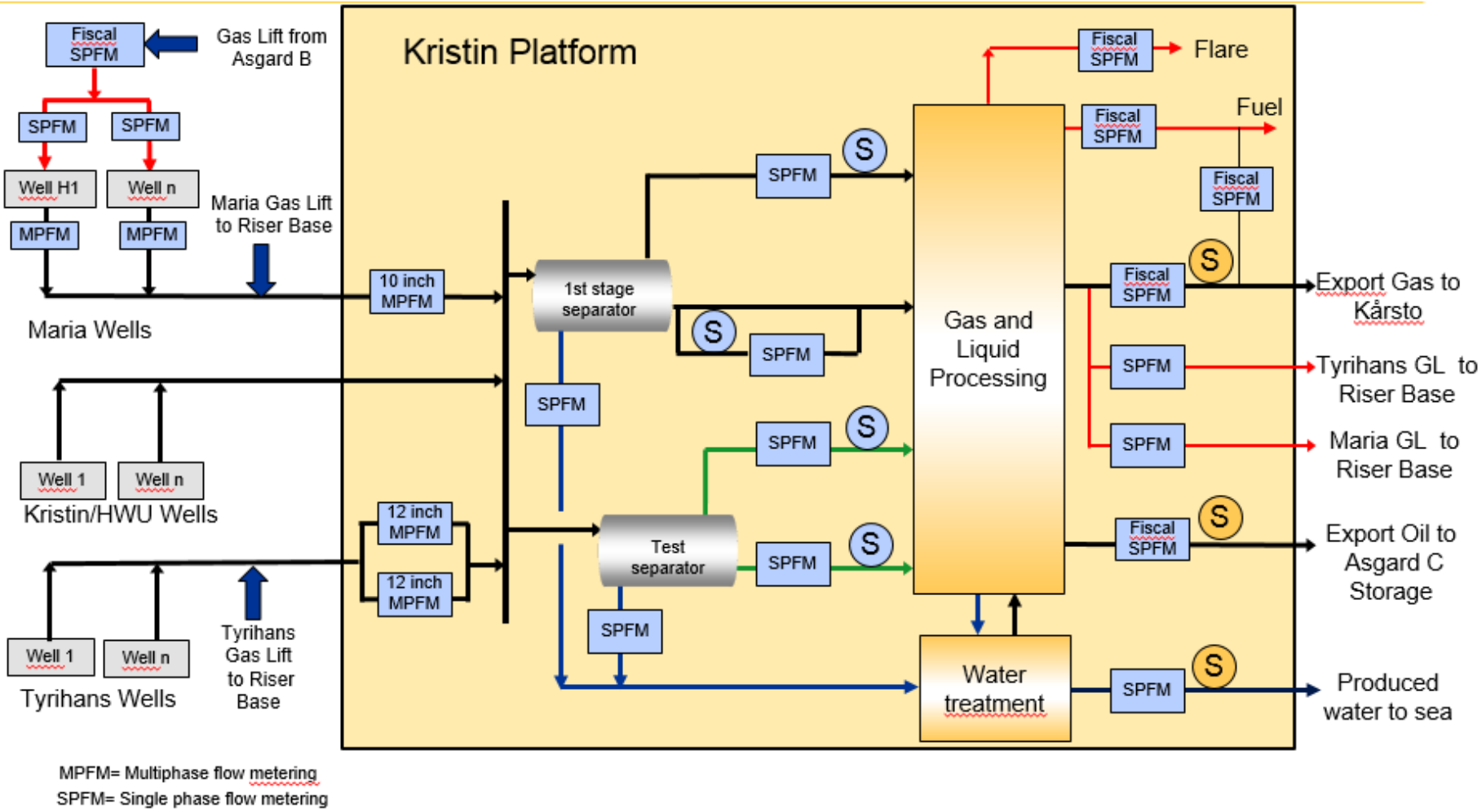
- Verification / tuning in March and April not performed
  - Waiting for H-2
  - Asfaltene cleaning
  - Gas lift started in April

- Verification / tuning on topside meters May 2nd
  - Results will be used in allocation for May 2018 and forward until new verification

Agreements

- Allocation appendix Maria-HWU (Kristin) for product allocation
  - Allocation of gas, liquid, fuel and flare
- Allocation appendix Maria-Åsgard B for gas lift
  - Agreement for fuel allocation for injection compressor
- Allocation appendix Maria-Heidrun for water injection
  - Agreement for tariff purposes
- Allocation appendix Maria-Tyrihans for use of Tyrihans pipeline
  - Tyrihans owner of pipeline from topside to connection Maria pipeline

Metering



MPFM= Multiphase flow metering
SPFM= Single phase flow metering

Metering concept

- Multiphase metering on Maria
  - One 10 inch meter installed in flowline topside Kristin platform
  - Each producing well installed with subsea multiphase meter in FCM
    - Topside meter as primary meter and subsea as secondary meters
- Validation against test separator
  - Test separator installed with flow metering on all 3 phases from separator
  - Water metering
    - Recertified flow meter
  - Upgraded gas metering from v-cone to USM
    - Single ultrasonic flow meter
    - New gas density cabinet
  - Condensate metering
    - Recertified ultrasonic flow meter
    - New fast loop sampling cabinet (incl. density and water cut)

Operational experience after startup

- Ultrasonic flow metering on oil outlet
  - Experienced drop out of signals from USM at both from 1. stage separator and test separator.
    - Flashing of gas in the oil
    - At 1st stage separator the oil reference meter are changed from ultrasonic meter to a turbine meter
      - No loss of signal from this meter but there are still the same situation related to flashing of gas
- Drop out may be related to slugging

Operational experience after startup

- Gas density cabinets
  - Same type of cabinets at test separator and 1st stage separator
  - Cabinets have a cold and a hot part
  - Electronics installed in cold part and tubing for gas in hot part to avoid condensing of gas
  - Issue with temperature reading results in manual sampling for determination of density
- Condensate density cabinets
  - Instability in temperature readings
  - Due to design/configuration
  - Resulting in unstable density reading

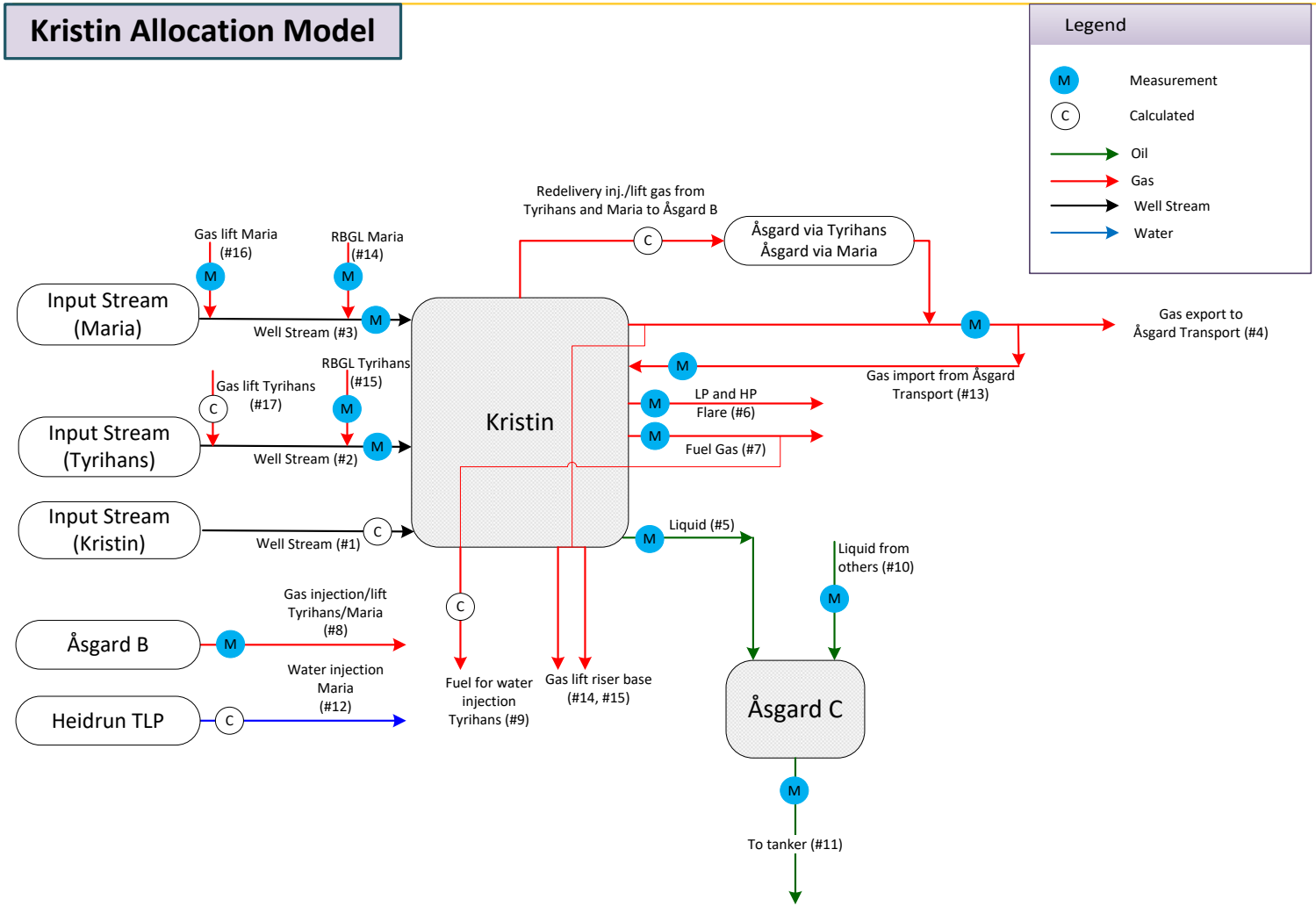
- Independent evaluation of density cabinets gas and condensate
  - Several points that should be modified

Allocation and value adjustment

- Development of allocation method and value adjustment
- Starting point
  - Metering and sampling modifications at Kristin SEMI platform
  - Allocation principles from preliminary allocation appendix
  - RNB production forecasts for Kristin and Tyrihans
  - Design Basis for Maria production
  - Existing Åsgard Area crude oil value adjustment system

Allocation model

Kristin Allocation Model



Development of allocation method

- Updated Kristin process model implemented in Unisim
  - Basis profiles for existing fields with known well stream composition and PVT data
  - Maria profiles from preliminary prognosis and available PVT data
- Production over Kristin facilities
  - All 3 fields with different products and difference in GOR
  - Commingling effects must be expected

Cases simulated for evaluation of allocation

Case	*Field*	*Routing/Allocation*
1	**Kristin/HWU - Stand alone**	1st Stage Separator
2	**Tyrihans - Stand alone**	1st Stage Separator
3	**Maria - Stand alone**	1st Stage Separator
4 A	**All in**	Kristin/HWU to Test Separator, Tyrihans + Maria to 1st Stage Separator
5	**Kristin/HWU + Tyrihans**	Kristin/HWU to Test Separator, Tyrihans to 1st Stage Separator
6 C	**All in**	Kristin/HWU + Tyrihans to 1st Stage Separator, Maria to Test Separator

- Cases used in further evaluation of allocation methods

Agreed allocation principle

- Kristin to be allocated gas and liquid based on theoretical production
  - Well performance curves based on testing over test separator
- Tyrihans allocated gas and liquid based on metered hydrocarbon production from multiphase meters
  - Testing against 1. stage separator
  - 1. stage separator equipped with flow metering and sampling based on fiscal design
- Maria allocated gas and liquid based on metered hydrocarbon production from multiphase meters
  - Testing against test separator
  - Test equipped with flow metering and sampling based on fiscal design
- Commingling effects
    - Strong effects between Tyrihans and Maria
    - Some effects between Kristin and Tyrihans
  - Agreed between parties
    - Kristin liquid shall be held harmless

Agreed allocation principle

- Final agreed liquid
  - Condensate determined by ORF (oil recovery factor) per component where ORF per component determined by stand alone simulation
    - Stand alone means as if one field is the only producer over facility
      - Using topside conditions as if all fields were producing
  - Maria and Tyrihans fields to take share of difference in condensate production

- Final agreed gas
  - Produced gas from field as difference between produced hydrocarbons and allocated condensate deducted allocated gas lift
  - All fields to take share of difference in gas production
  - Final allocated produced gas to fields are prorated between fields based on allocated produced gas

Agreed allocation principle

- Fuel and Flare
  - Attributable fuel and flare per component allocated to the field responsible
  - Remaining total fuel and flare determined and prorated between fields
    - Remaining fuel and flare for liquid handling
      - Initially 20% of fuel and flare
      - Allocated pro rata based on allocated condensate production per component
    - Remaining fuel and flare for gas processing
      - Initially 80% of fuel and flare
      - Allocated pro rata based on allocated gas production per component

Agreed allocation principle

- Final allocated export gas
  - Allocated produced gas from fields deducted allocated fuel and flare to fields
- Commercial
  - Gas Lift to Maria field shall be redelivered to Åsgard B
  - Redelivery of fuel gas to Åsgard B due to Gas Lift to Maria
  - Deferral compensations for gas and condensate included in allocation procedure
    - For Maria includes deferral to Åsgard B, Kristin and Tyrihans
  - Redelivery and deferral compensation of gas performed in-kind on energy basis
    - Separate accounting system

Plan for development of allocation method

Maria tie-in agreement - Development of Appendix C

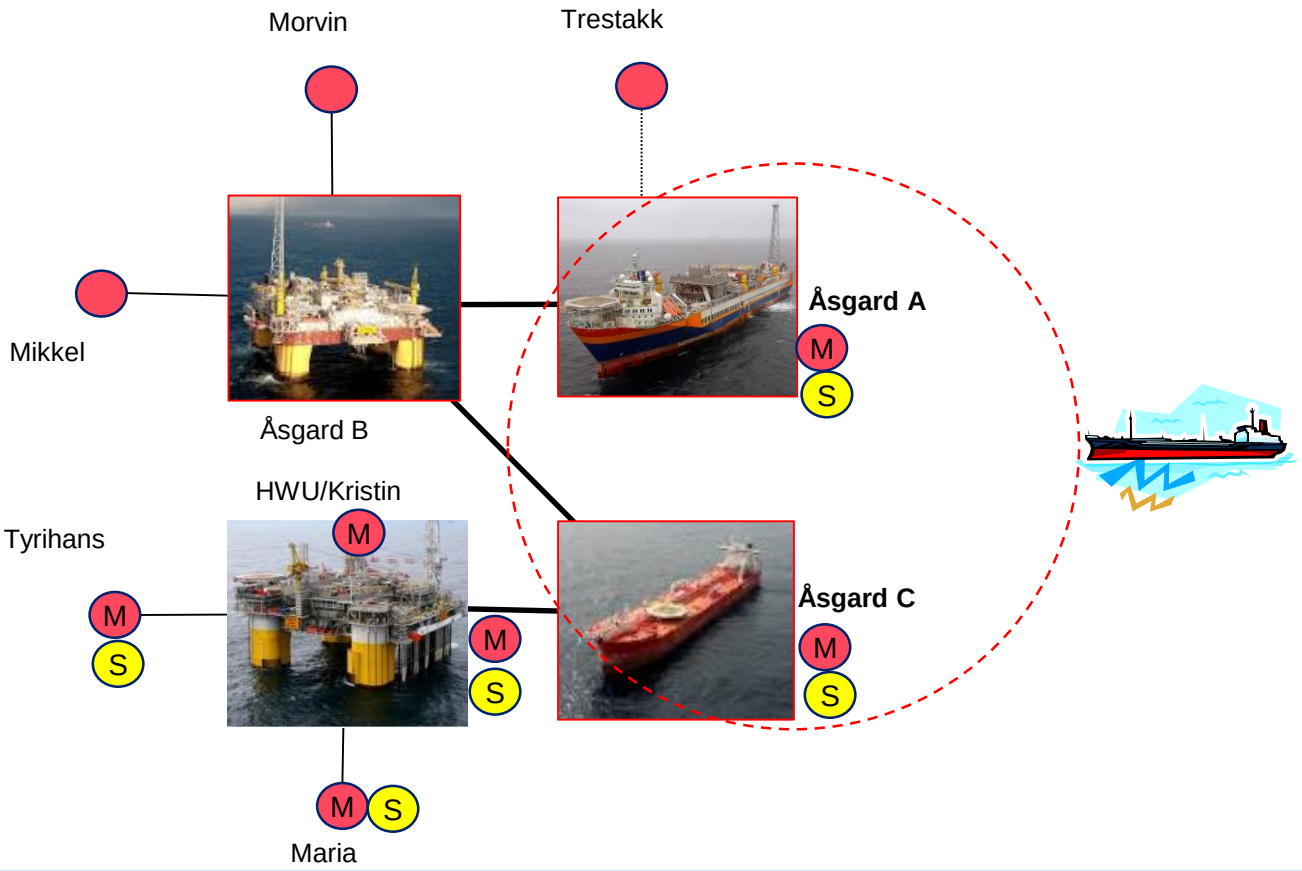
Year	2016									2017							
Month	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A
Process simulations																	
Establish simulation model																	
Simulation work																	
Internal review	★																
Status meeting WINO		★															
		11.05															
Allocation modelling work																	
Develop allocation principle																	
Presenting allocation model to stakeholders			★★★														
Acceptance process																	
Energy Components model development																	
Defining all data input and algorithms																	
Programming and development of test program for verification of EC calculations																	
Final testing of EC and development of shipment and allocation																	
Appendix C development																	
Draft appendix C																	
Final appendix C																	
Appendix C partner review																	
Appendix finalized and signed														★			

Agreed allocation principle

- Plan for development indicated first draft from operator for allocation agreement 1 year before planned start-up 1st of May 2018
  - First draft ready as planned
- Official expected startup date moved from 1st of May 2018 to 1st December 2017
- Several meetings between Operator and Kristin/Maria owners before final agreements signed short before start up in December 2017

Agreed allocation principle

- Fields contribution to Åsgard Blend



Crude Oil Value adjustment

- Åsgard Blend
  - The need for value adjustment occurs when oil streams with different qualities are mixed together in one blend – Åsgard Blend
  - Sampling, determination of quality and use of Platts prices used to calculate the product value of the different streams and Åsgard Blend
  - If the contributing stream leads to an increase or decrease compared to the Åsgard Blend an adjustment of volume entitlement is done
  - Maria value adjustment implemented in the existing Åsgard Area value adjustment system

Lessons learnt

- Close collaboration in entire value chain important
  - Project organization – Commercial – Stakeholders – Operations, etc.
- Complexity in agreements
  - Considerable commercial aspects to be included in allocation and reporting
  - Delayed process for agreeing on final allocation appendix, completing the detailed document is work intensive
  - Understanding of how the agreements content impact daily operation, and how to act accordingly
- Overview of sampling and analysis needs important for preparations and planning in operations
- Close follow-up of implementation of the agreed allocation procedure in operational phase important