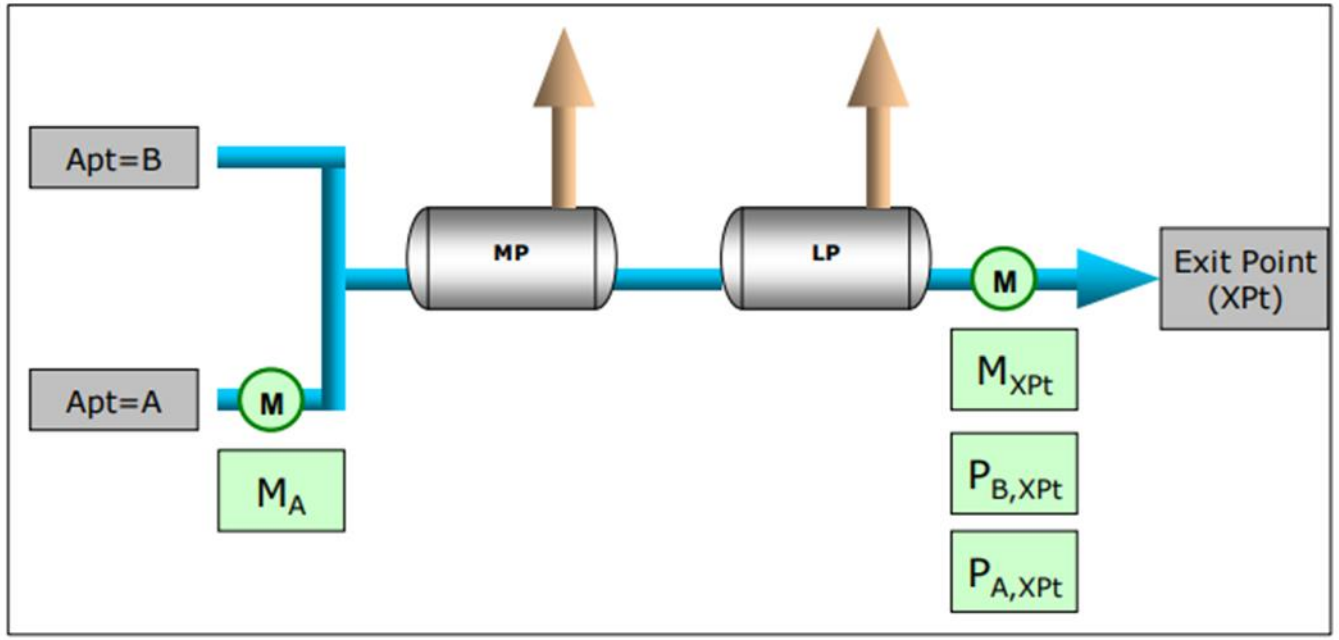
UNCERTAINTY BASED ALLOCATION – OPERATOR EXPERIENCE

June, 2022

Simplified Example



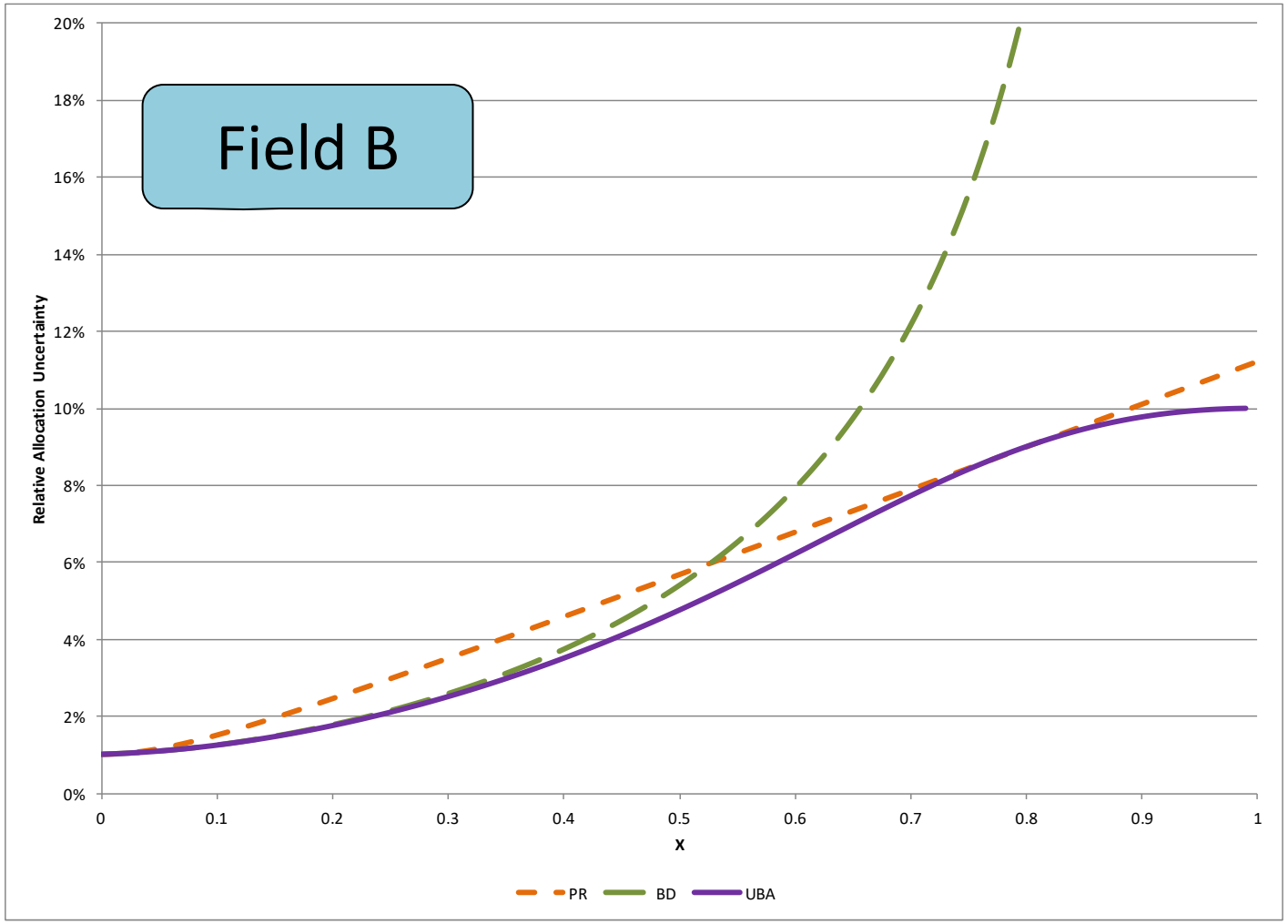
Where:
Apt – Arrival Point
Xpt – Exit Point
M – metered HC's
P – HC's potential

In this example, A's potential is a directly measured quantity whereas B is based on periodic well tests. Generally, the uncertainty in A's potential will be lower than in B's.

Methods for Allocating Hydrocarbons

- Allocated in proportion to calculated potentials (proportional allocation)
- Allocate one Arrival Point (A) its potential and the Arrival Point B the remainder (by difference allocation)
- Using the proportional method, an inaccurate Arrival Point B's potential increases the uncertainty of the allocation to A
- Using By Difference, although Arrival Point A's potential is more accurate, this can produce significant relative uncertainty in B's allocation when production is low
- UBA takes advantage of the more accurate potential but also incorporates the less accurate potential and still accurately allocates at low rates

Comparing all three

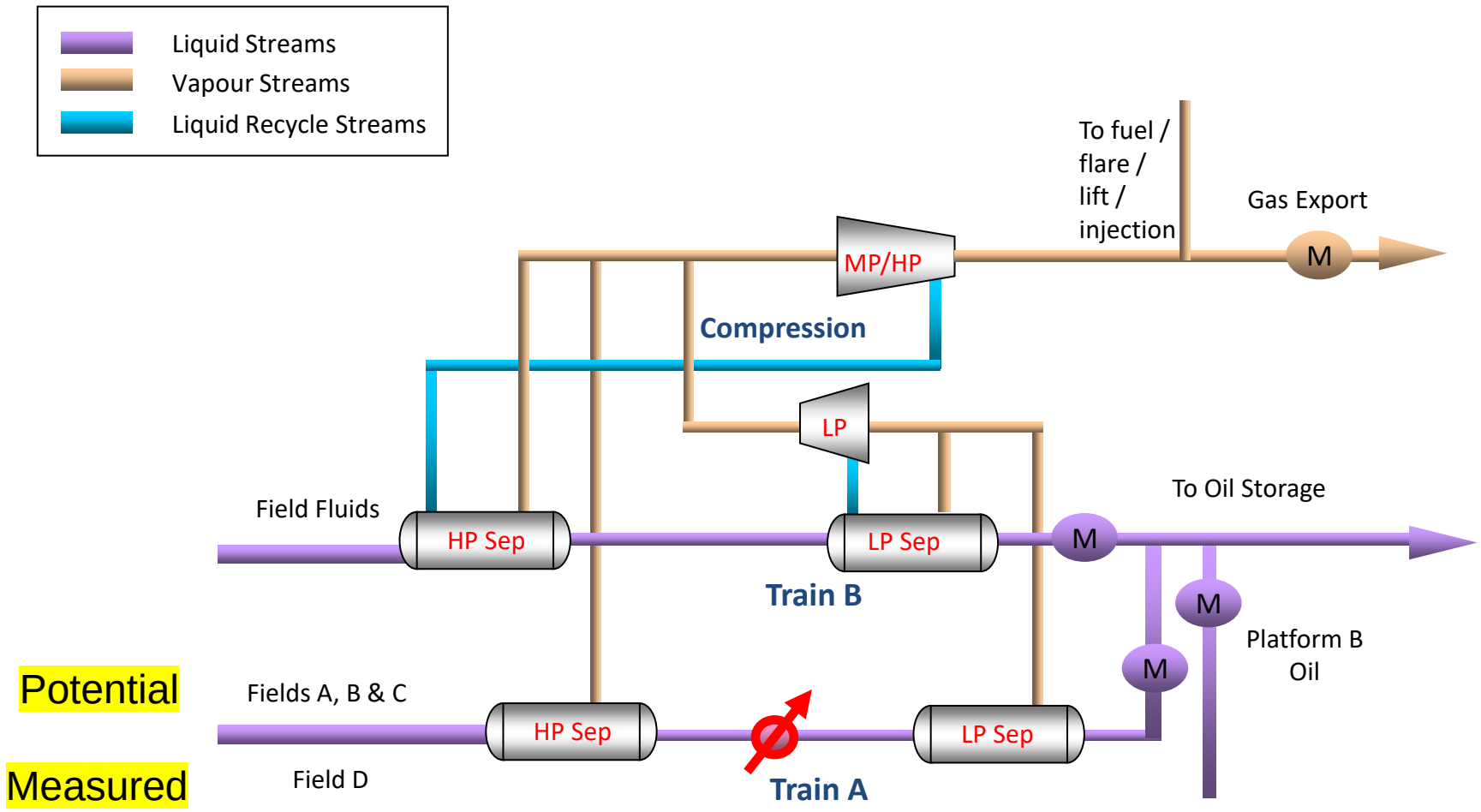


$\varepsilon_M = \pm 1\%$

$\varepsilon_{P,A} = \pm 5\%$

$\varepsilon_{P,B} = \pm 10\%$

Platform Process



Allocation Options

- Arrival Points' estimated potentials are determined with significantly different accuracies (or uncertainties), e.g.
  - Field D based on daily measured flows
  - Fields A, B & C based on intermittent well tests
- Pro Rata
  - Doesn't recognise lower uncertainty in Field D's potential
- By Difference
  - Discards information: Fields A, B & C's potentials
  - Can give significant relative errors in allocation at low flows of Fields A, B & C

Allocation Options

- UBA
  - Recognises better accuracy in Field D's potential
  - Incorporates Fields A, B & C's potentials
  - Allocates Fields A, B & C accurately at low / zero flow rates
- Method proposed based on recognised statistical techniques
- Minimise weighted sum of squares of difference between allocated and potential quantities
- Subject to constraint that allocated quantities sum to metered product

Uncertainty Based Allocation

- Calculates well potentials on a “commingled” basis, rather than stand-alone. This should mean the sum of potentials is closer to the measured oil and gas production, thus reducing the uncertainty of allocated products
- Uncertainty for each field based upon either the meter or the well test
- UBA accounts for the uncertainty in the estimated production from the various fields.
- Ensures zero production is allocated to a field that is shut in – by difference allocation would allocate a small volume.

Gas Allocation

- UBA allocates:
  - Total mass utilising uncertainties in potentials
  - First between Arrival Points, e.g. continuously measured versus well test based
  - Then to wells pro rata
  - Then allocates components pro rata

Oil Allocation

- Oil allocated similar to Gas

- UBA allocates:

  - Total mass utilising uncertainties in potentials
  - First between Arrival Points, e.g. continuously measured versus well test based
  - Then wells

Uncertainty Based Allocation - Calculations

- Masses allocated to the Arrival points must sum to the metered mass at the Exit Point.

$$A_{A,XPt} + A_{B,XPt} = M_{XPt}$$

- Arrival Points potentials will not sure to the metered quantity at the Exit Point

$$P_{A,XPt} + P_{B,XPt} \neq M_{XPt}$$

- UBA Method adjusts the allocated quantities such that the sum of the squares of the differences between potential and allocated numbers is minimised.

$$\psi = \left(\frac{A_{A,XPt} - P_{A,XPt}}{U_{P_{A,XPt}}}\right)^2 + \left(\frac{A_{B,XPt} - P_{B,XPt}}{U_{P_{B,XPt}}}\right)^2$$

Application of UBA – Field Calculations

Allocated	Field D (A_D)	Fields ABC (A_{ABC})
Potentials	Field D (P_D)	Fields ABC (P_{ABC})
Uncertainty	U_D	U_{ABC}

$$Imb = M_{Prod} - P_D - P_{ABC}$$

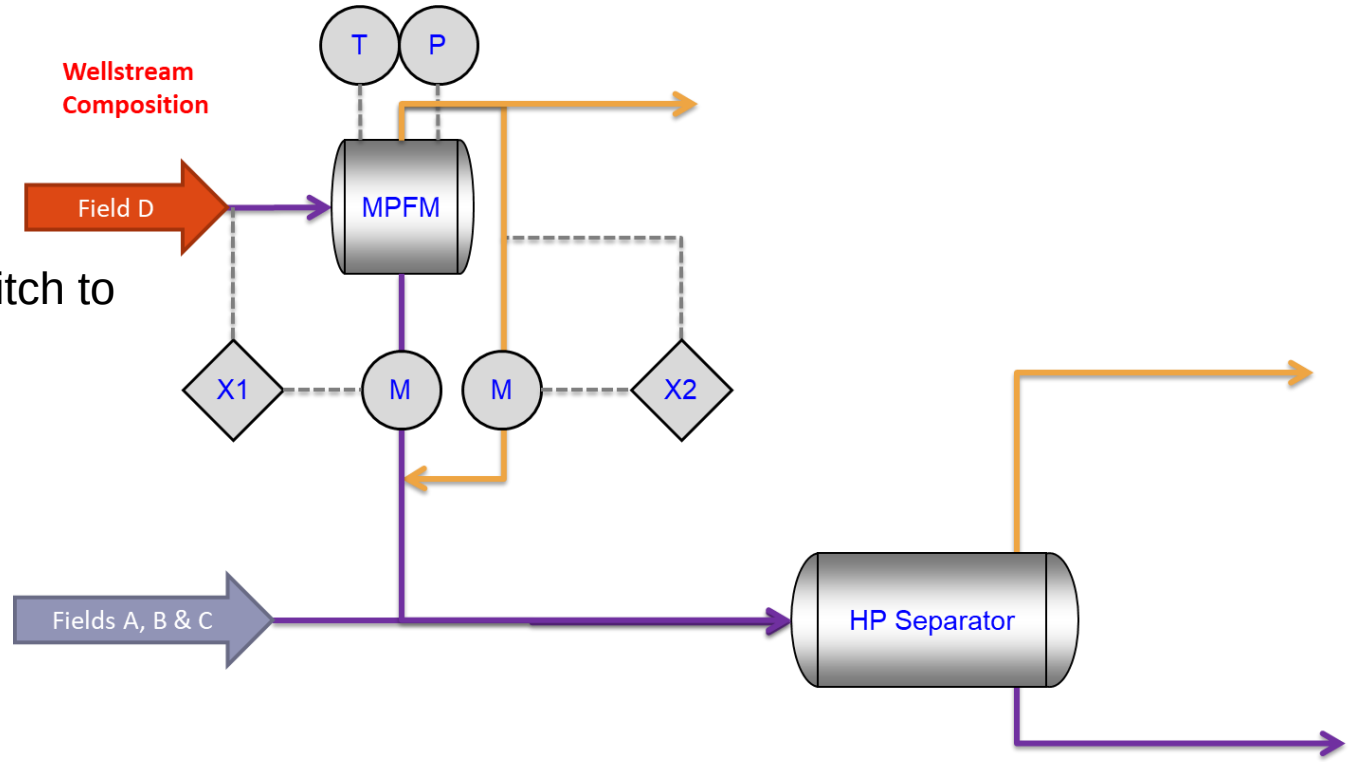
$$A_D = P_D + Imb * \left(\frac{{U_D}^2}{{U_D}^2 + {U_{ABC}}^2} \right) \qquad A_{ABC} = P_{ABC} + Imb * \left(\frac{{U_{ABC}}^2}{{U_D}^2 + {U_{ABC}}^2} \right)$$

Potentials & Allocation

- Flowrates from each well produced are determined by periodic sampling (well tests)
- Allocation utilises latest well test
- Process Simulation Model (CHARM) used to adjust well test, accounting for:
  - GOR/Stream Composition
  - Hours online
  - Other process conditions
- Well potentials calculated and summed by Arrival Point.
- For each Day, the potential oil and gas flows produced from the producing wells are summed and compared to Arrival Point allocated oil and gas, and normalised to calculate Allocation Factor
- Allocation Factor is then applied to Potential Well flows, to allocate the Day's production from each Well

Application of UBA – Field D

- Additional Field brought online in 2018
- Measured by Multiphase Phase Meter
- Inconsistent meter readings resulted in a switch to using well tests in allocation during meter investigation
- Ability to change uncertainty for field
- Following meter verification and data review, returned to using MPFM data in allocation
- Verification checks performed to ensure uncertainty factors applied within allocation are correct



Operator Experience

- In some instances, there can be very slight differences between export and arrival point compared to metered data – although these cant be resolved, specific issues can be highlighted within the simulation software
- Negative allocation can occur – although this only happens when meter is faulty, data is missing or hours online are incorrect therefore draws attention to specific area of concern
- Important to review uncertainties and verify data periodically so bias isn't tending to an individual field over time
- If an Operator is experiencing issues such as performing regular well tests through reduced access to test separator, application of Uncertainty Based Allocation should be considered