NFOGM
NORWEGIAN SOCIETY FOR OIL AND GAS MEASUREMENT

Using Uncertainty Analysis to Optimise Allocation Measurement System Performance

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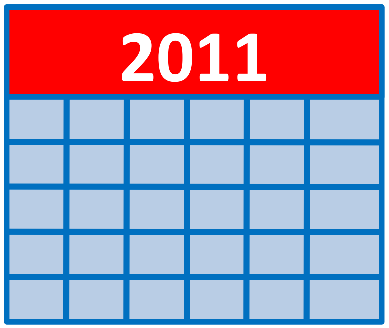
Contents

The Impact of Uncertainty

88 Million barrels of Oil per day



The total cost was approximately
$9.9 Billion

Uncertainty was **0.25%**

Financial exposure

$25 Million per day

The Cost of Errors

Cost per barrel: **$50**

Revenue: **$1.0M per day**

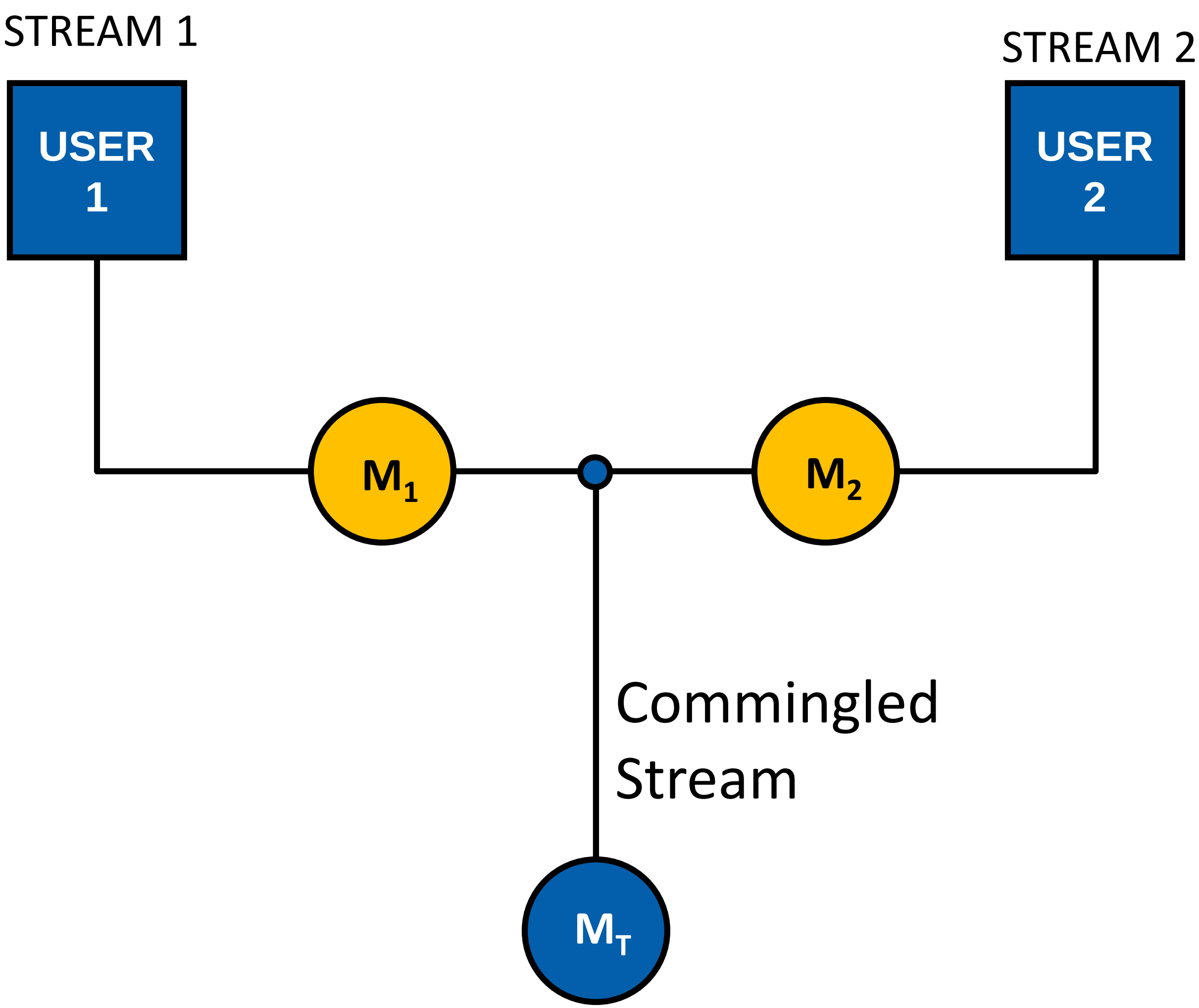
20,000 BBL/Day

Suppose the meter **under-reads** (error) by

1% → Loss of **$10,000** per day

3% → Loss of **$30,000** per day

Hydrocarbon Accounting



Determination of the quantity of products belonging to each user when processed together in a commingled system

Why Do We Need Allocation?

- Common for production facilities to process fluids from multiple fields
- Fields have different compositions, ownership and tax regimes
- Not uncommon for a single platform from several distinct formations and have several users.

Why Do We Need Allocation?

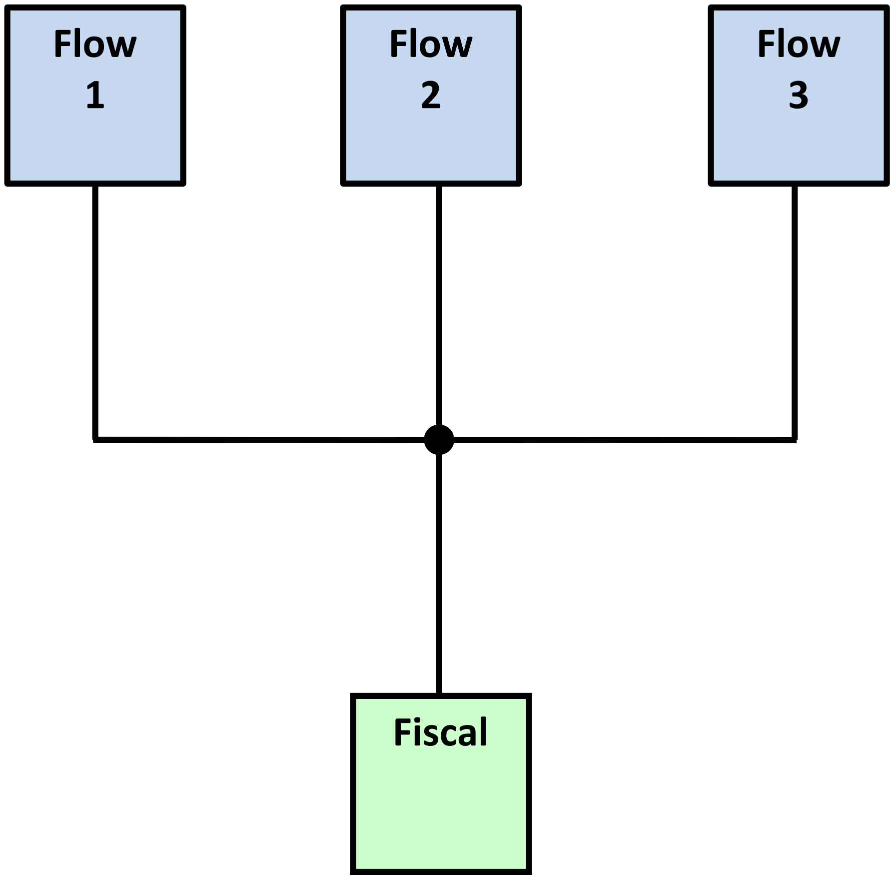
Field delivering 500,000 Barrels per day.

Revenue of $25,000,000 per day

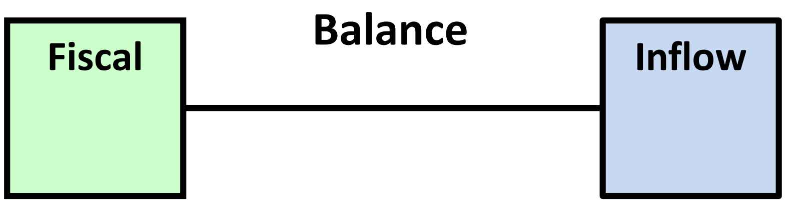
A **bias** of 0.1% in the system would generate $7,500,000 per annum misallocation.

SO IT'S IMPORTANT!

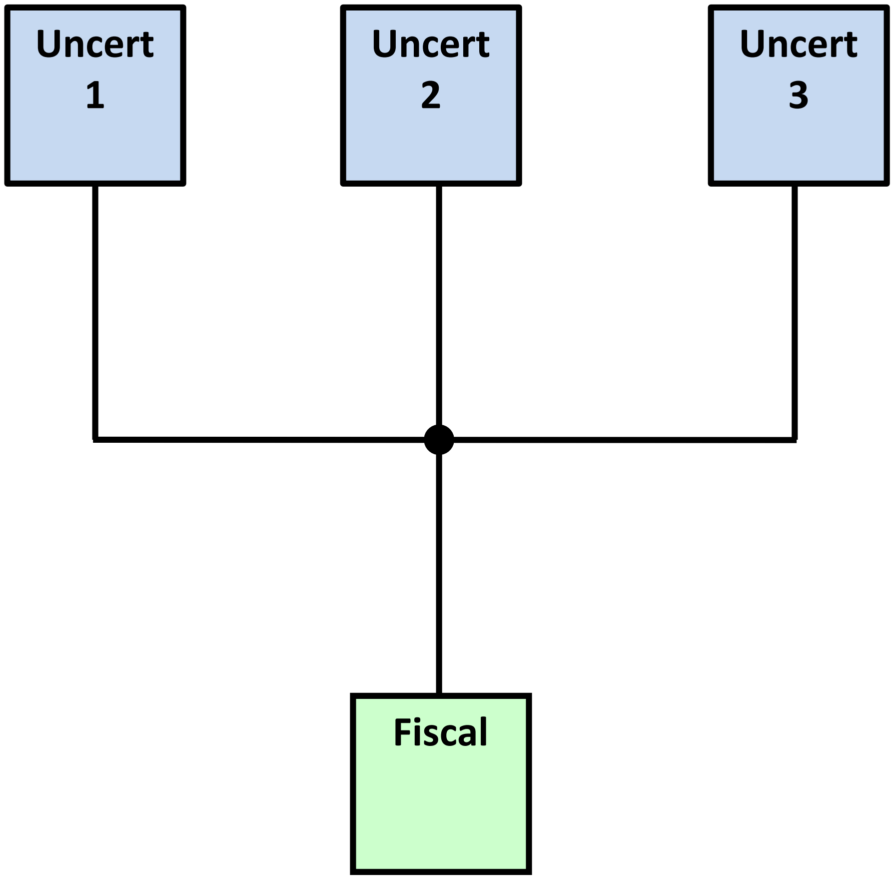
Proportional Allocation



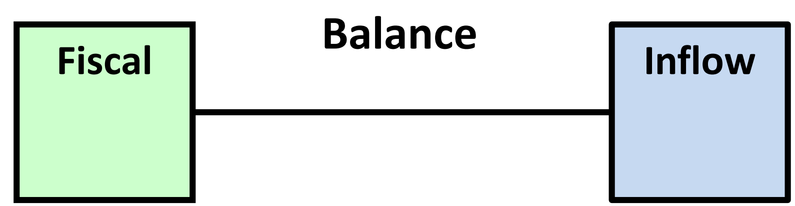
Adjusted flow is calculated from **flow proportions**
Note that allocated flows sum to fiscal flow



Uncertainty Based Allocation



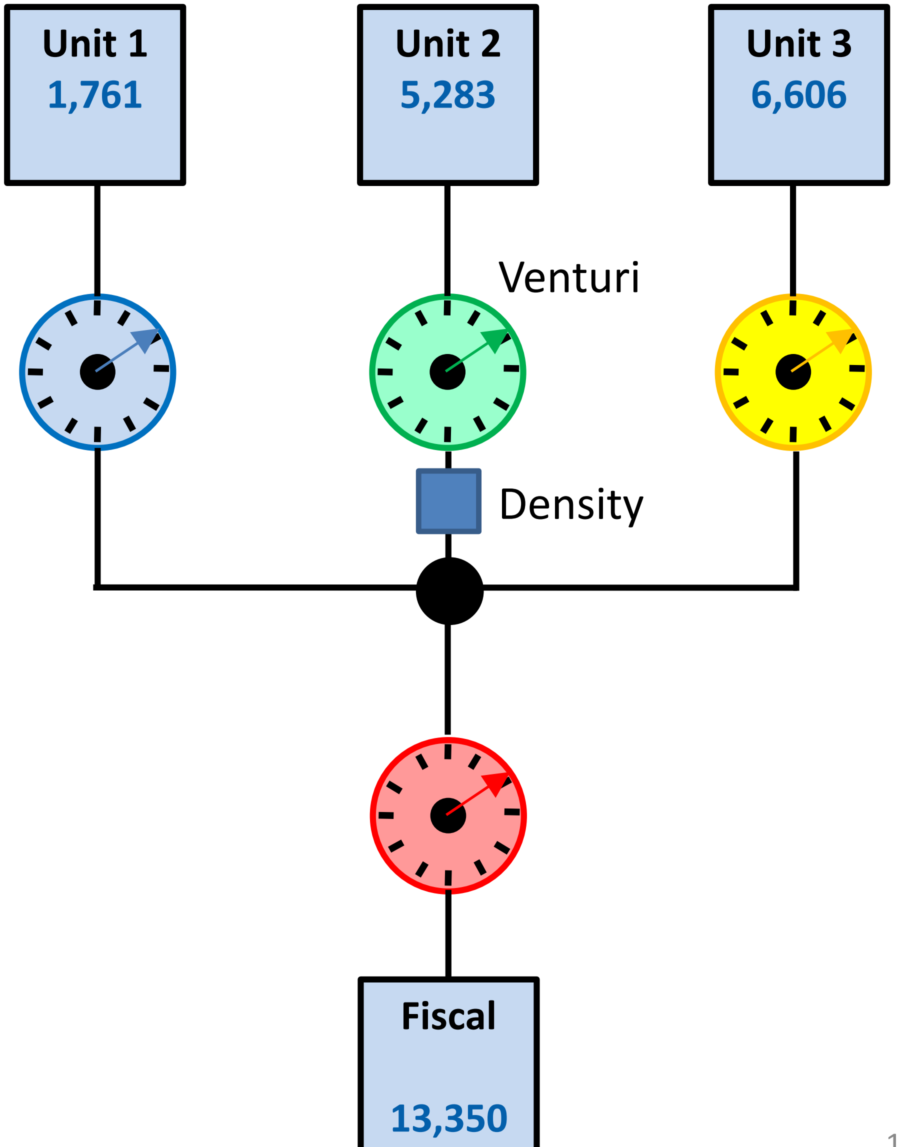
Fraction of the imbalance between the reference quantity and the sum of the production units **proportioned to the uncertainty**

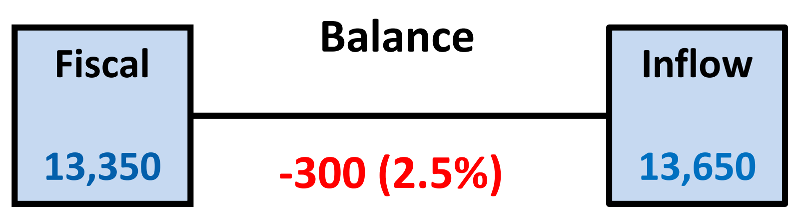


The Problem

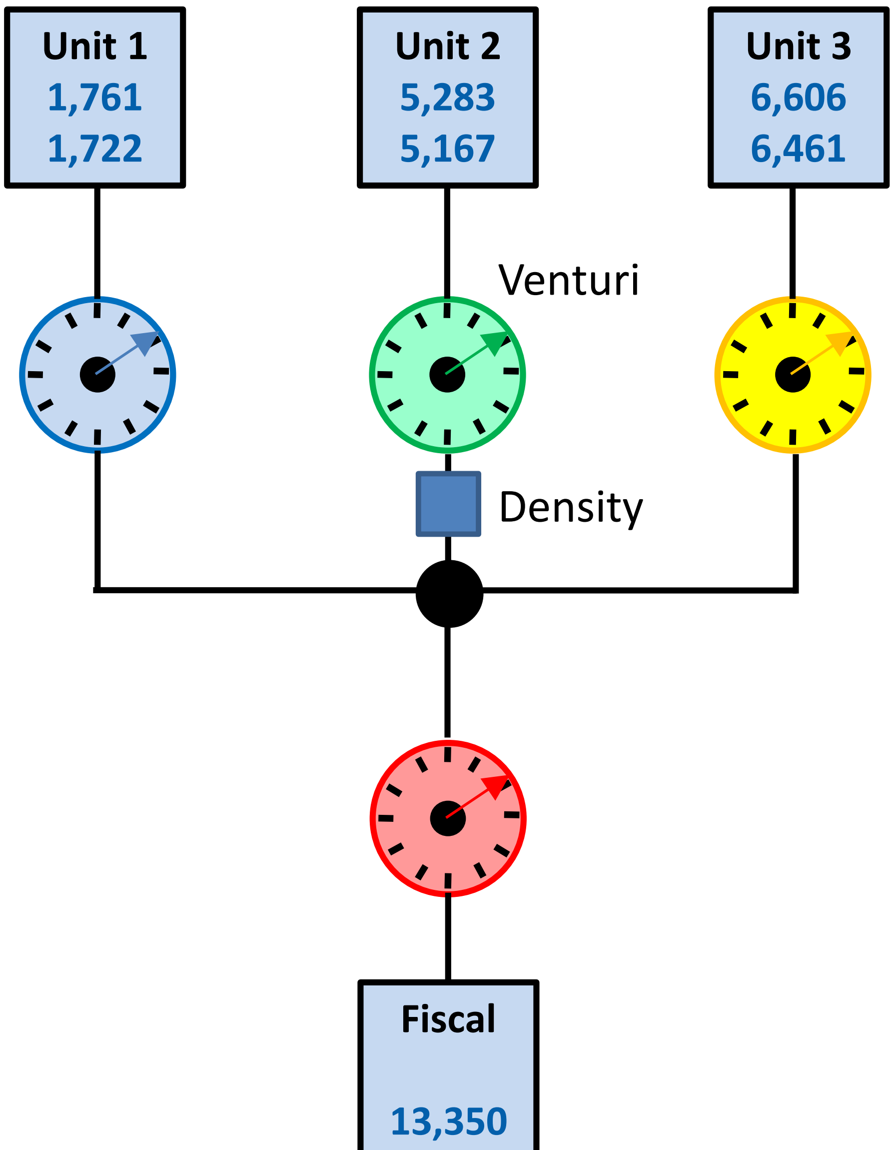
- Three partners sharing a gas pipeline
- Using Uncertainty Based Allocation (UBA) to allocated gas to each partner
- Partner 2 had large flow uncertainty, caused by high densitometer uncertainty (roughly 5.0%)
- Caused in turn by instability in the instrument
- Considered that this may be losing them revenue
- Changed to gas chromatograph with uncertainty of 0.5%
- Compared allocated hydrocarbons
- Calculate savings

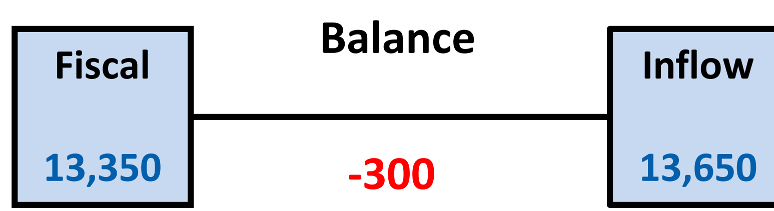
Flow System (Gas Flow)





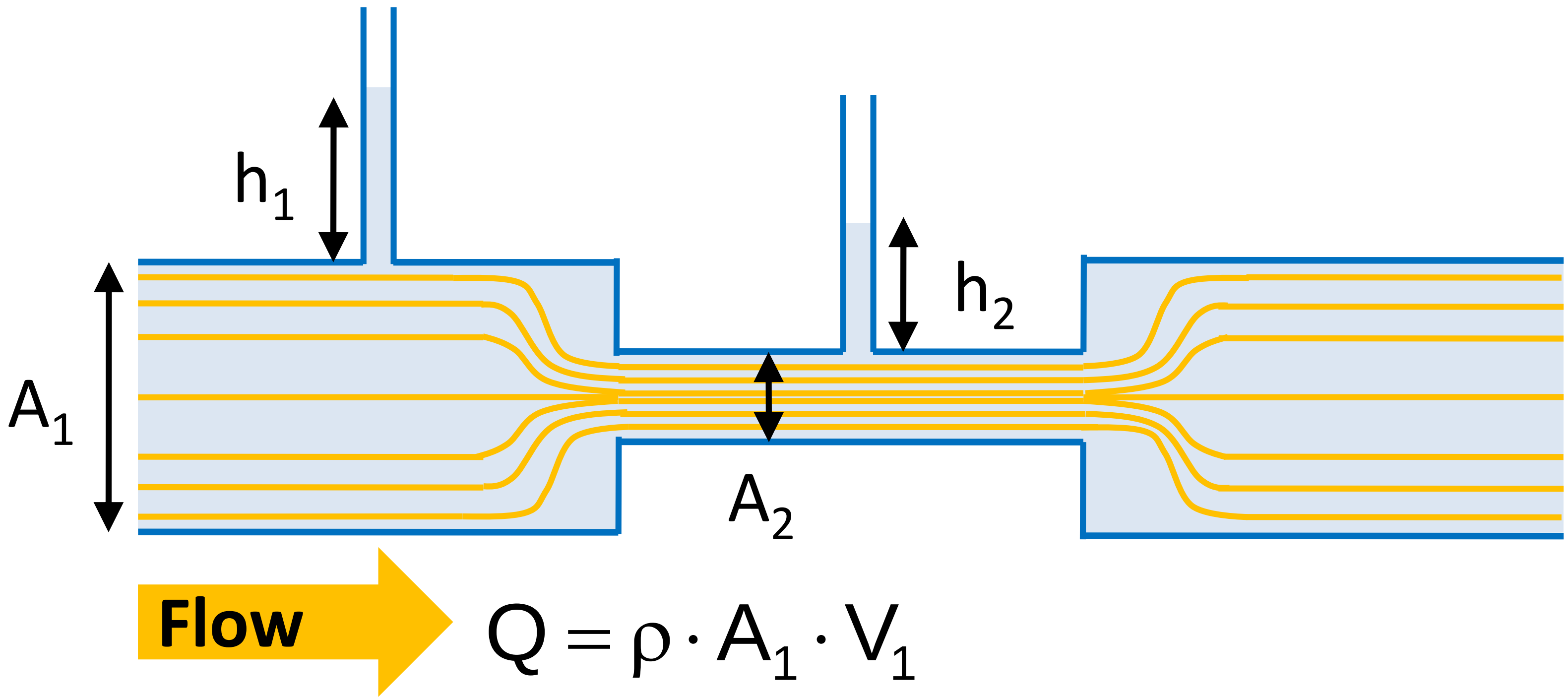
Proportional Allocation





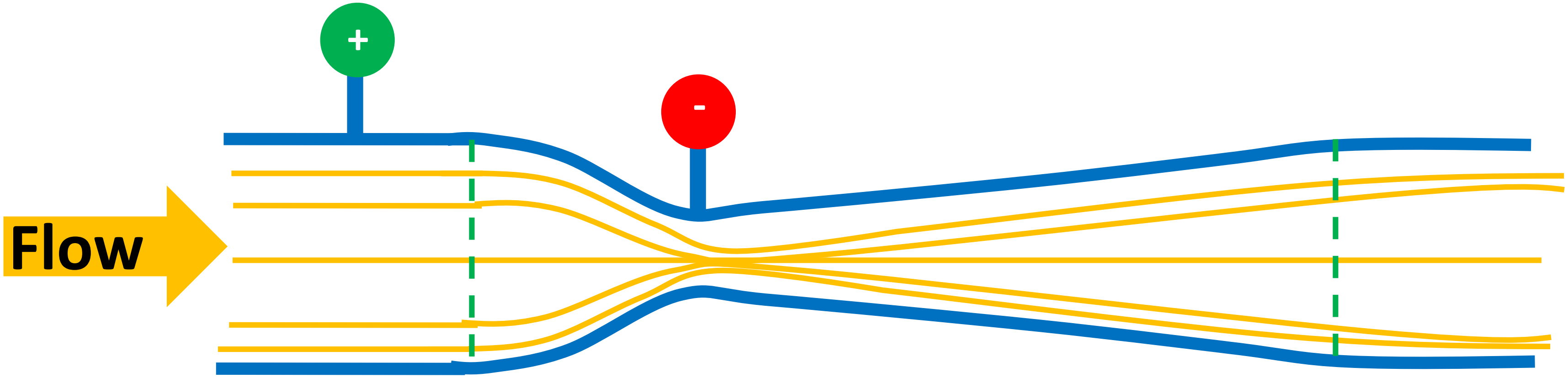
Differential Pressure Principle

- Fluid flows through a restriction
- Accelerates to a higher velocity
- Static pressure decreases
- Δp is proportional to the **square** of the flowrate

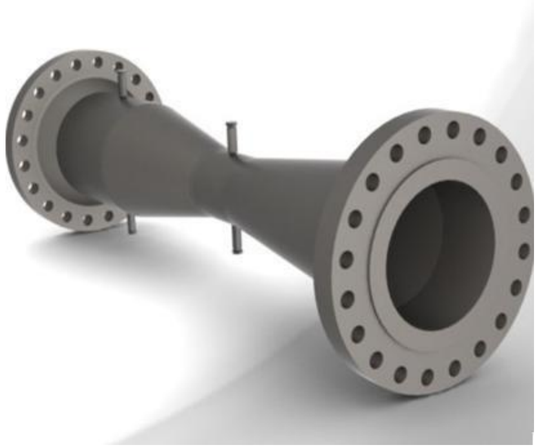


$$Q = \rho \cdot A_1 \cdot V_1$$

Venturi Meter



- Δp measured across the upstream to throat section
- Typical discharge coefficient C of **0.95**
- Here measuring gas flow

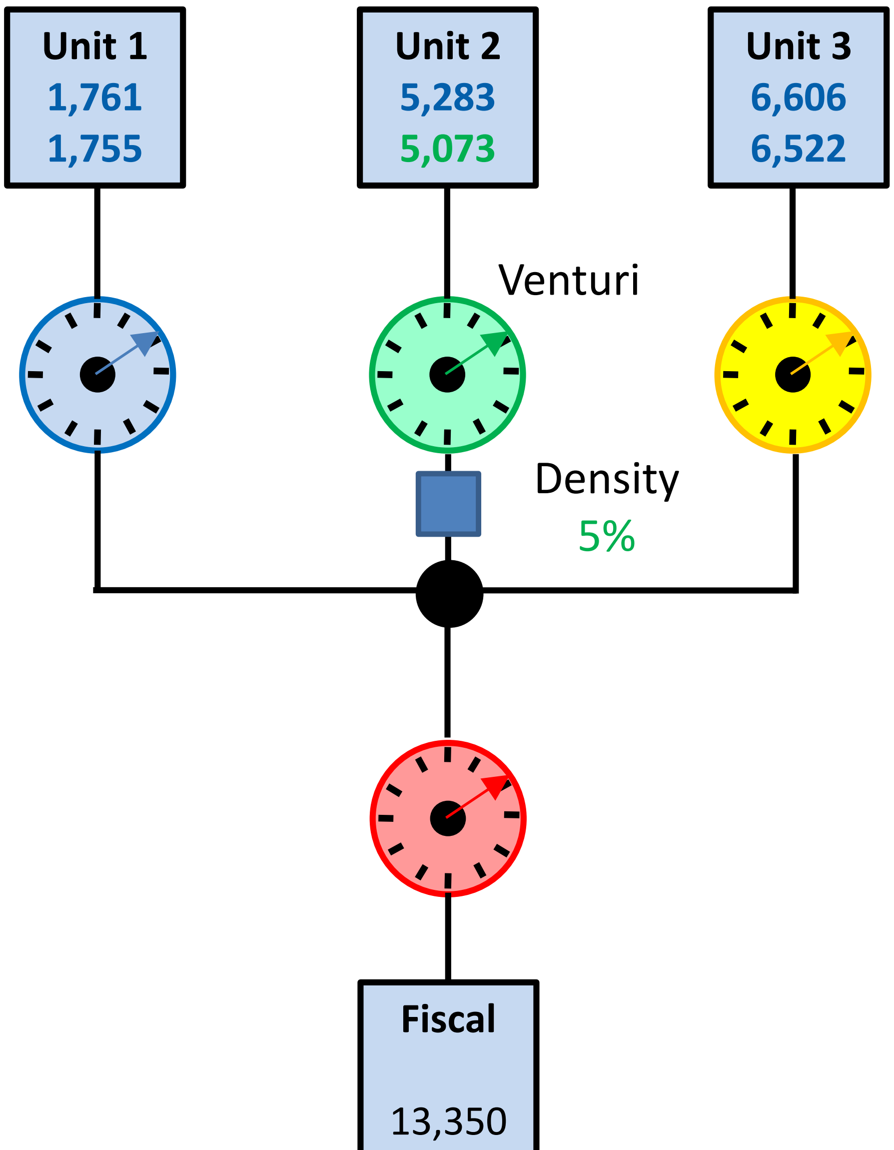


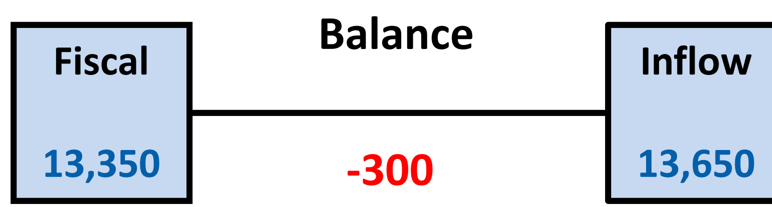
Venturi Meter Uncertainty

Quantity	Value	U	K	u	C	u.c	$(u.C)^2$
Discharge Coefficient	0.995	0.0075	2	0.00373	88.5	0.330	1.09E-1
Pipe Diameter	0.700	0.0035	1.72	0.00202	-5.7	-0.012	1.32E-4
Orifice Diameter	0.300	0.0006	1.73	0.00035	352.1	0.122	1.49E-2
Pressure Drop	16,295	16.30	2	8.148	0.0014	0.011	1.30E-4
Static Pressure	101325	506.62	2	253.313	0.0000	0.006	4.10E-5
Expansibility	0.997	0.0015	2	0.00075	88.3	0.0660	4.36E-3
Density	46.75	2.3375	2	1.169	0.543	0.635	4.03E-1
Calculated Flow	88.05	1.459	2	0.7293	1	0.7293	5.32E-1

1.6%

Uncertainty Based Allocation





Venturi Meter Uncertainty

Quantity	Value	U	K	u	C	u.c	(u.C)²
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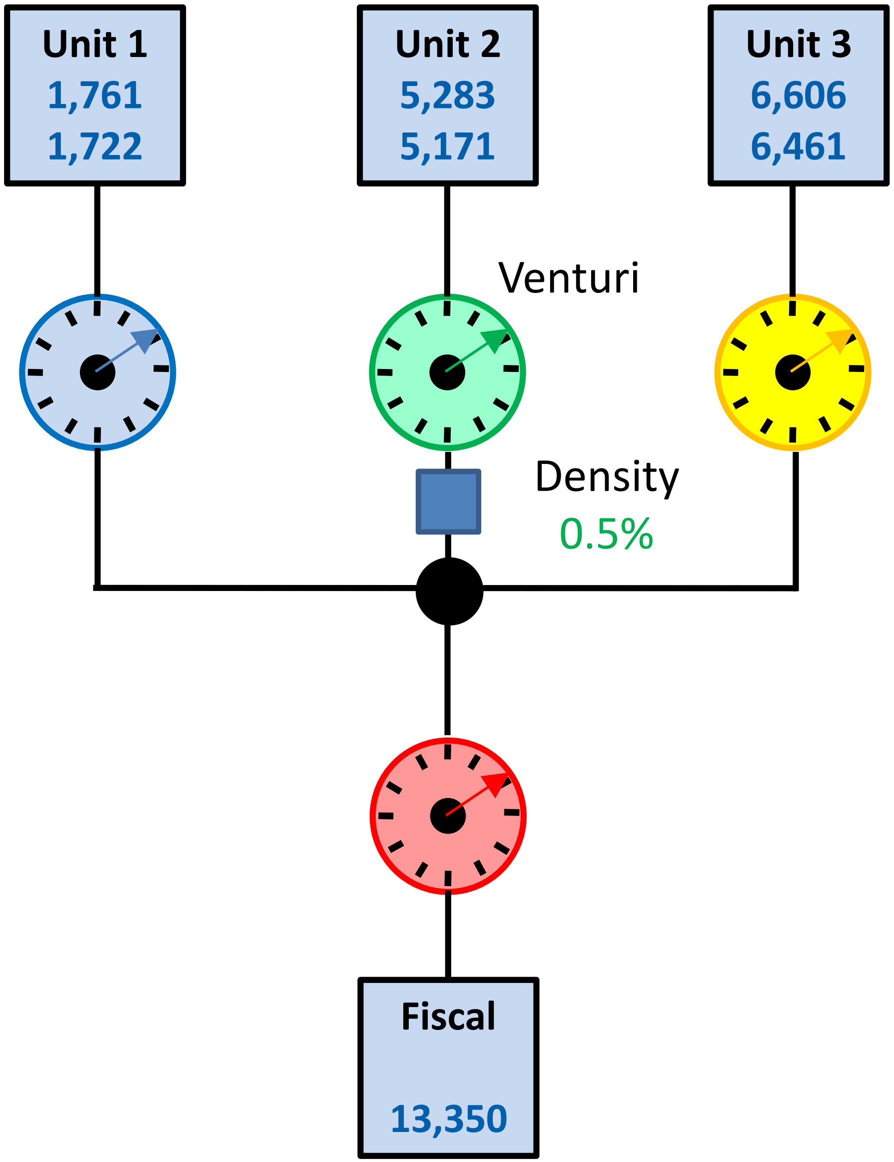
Density	46.75	0.2333	2	0.11662	0.543	0.0640	4.03E-3
Calculated Flow	88.05	0.728	2	0.3641	1	0.3641	1.33E-1

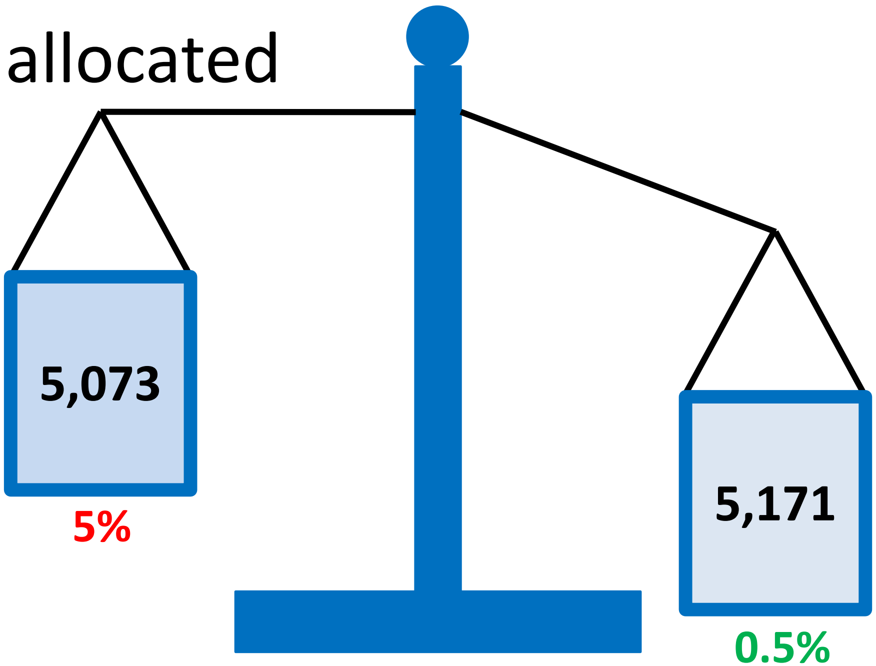
0.8%

Venturi Meter Uncertainty



Part 2: Effect of Reduced Uncertainty

On partner 2 allocated flow



Difference

98 kg/min → **0.77 Therm/s**

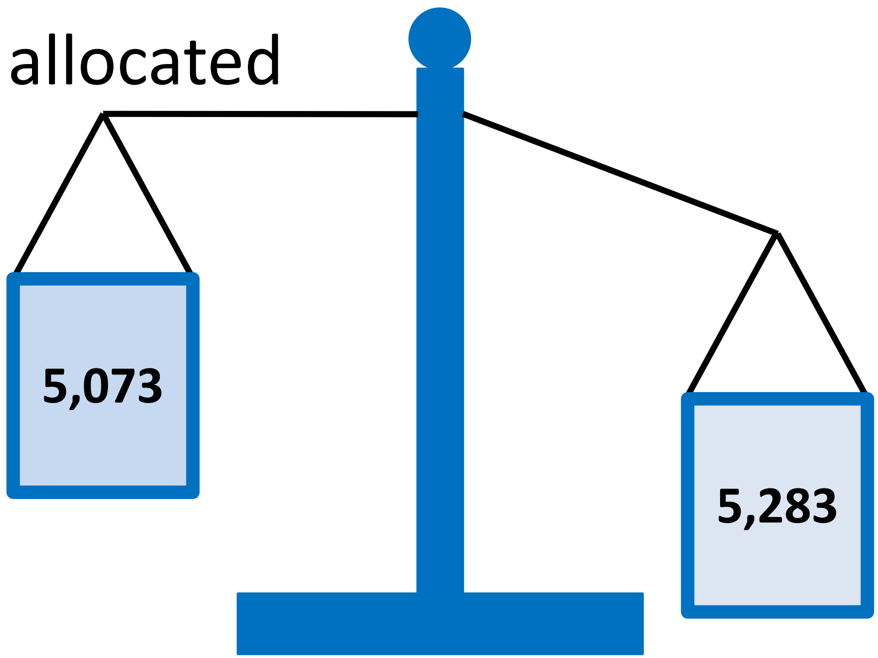
→ **0.85 $/s**

COST
$1.10 per Therm

£27m Per annum

Difference from Measured Value

On partner 2 allocated flow



Difference

210 kg/min → **1.66 Therm/s**

→ **1.82 $/s**

COST
$1.10 per Therm

£57m Per annum

Conclusions

- Reducing the uncertainty in density increases the allocated flow to partner 2 (using UBA)
- This increases Partner 2 flow from 5,073 kg/min to 5,171 kg/min.
- Increases revenue by **$27 million** per year.
- Illustrates the effect of uncertainty on a measurement system in an allocation scenario.