Capacity calculation in pipelines

Present achievements and future challenges

1st Trondheim Gas Technology Conference, 2009

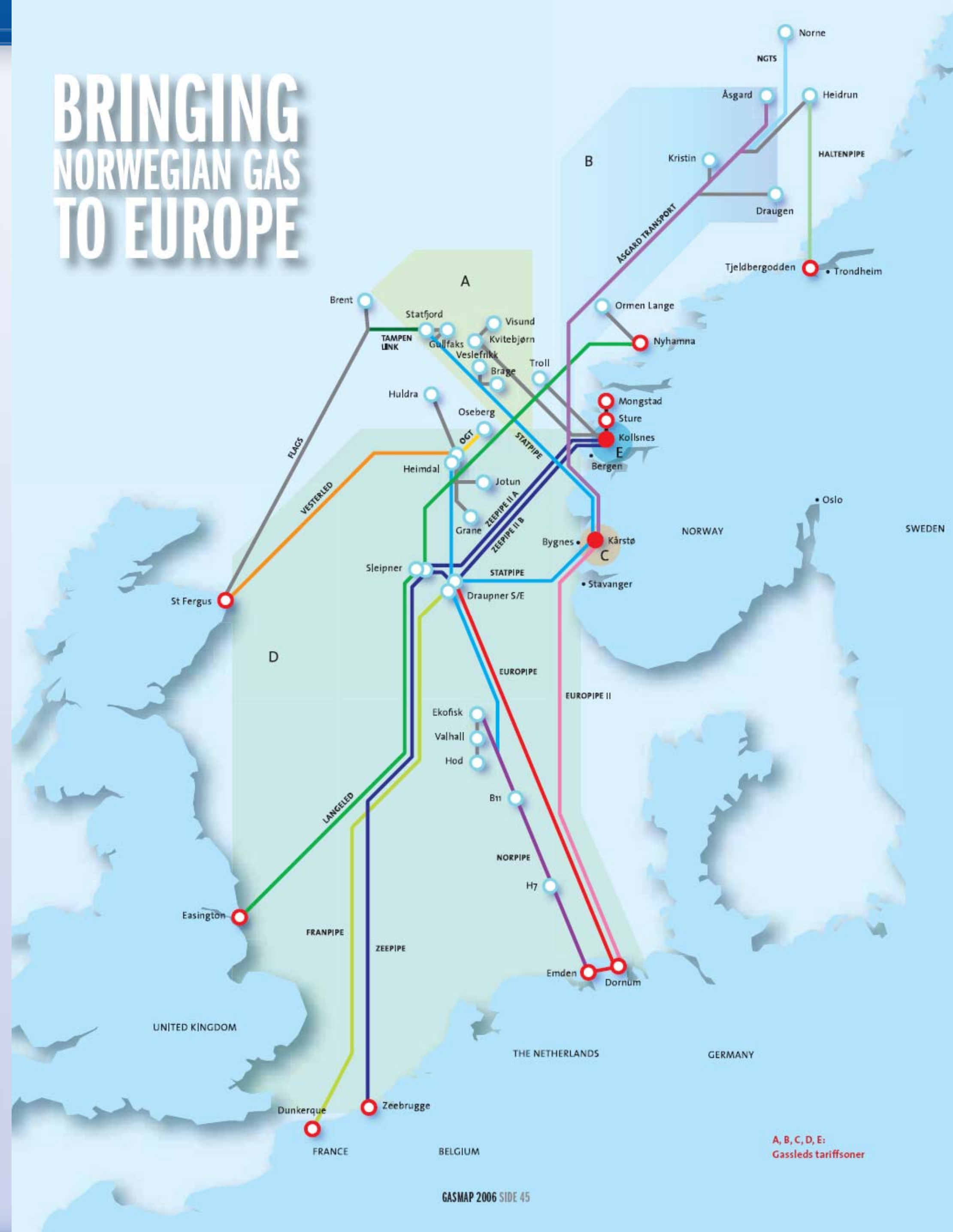
Leif Idar Langelandsvik

Outline

- Introduction, Gassco and transport capacity in pipelines
- Capacity Test
- Utilizing operational data
- Simulation model improvements
- Further challenges

About Gassco

- State-owned company established in 2001. Neutral and independent.
- Operator for natural gas transport network on Norwegian Continental Shelf
- Transports gas from entry point to exit point. Shippers own the gas.
- Infrastructure/assets are owned by joint venture, Gassled
- A total of 7,800 km pipelines
- Two gas processing plants
- Receiving terminals



Transport Capacity in pipelines

One of Gassco's main roles is *Capacity Administration*

- Shippers can book transport capacity on:
  - Long term → end of license period 2028
  - Intermediate term → 1-2 years ahead
  - Short term → weeks/days ahead, even within day
- Transport capacity is calculated by means of simulation software
  - Pipeline Studio from Energy Solutions is used
- Crucial to have accurate calculations of the physical transport capacity
  - Under estimation of capacity → too low utilization
  - Over estimation of capacity → over booking, failure to deliver contracted amount of gas

Transport Capacity Calculation

Design phase

- Design Capacity

Originally (after commence of operation):

- Capacity Test, used since 1990s
  - One or two tests

Recent improvements:

- Application of steady-state operational data
- Continuous effort to increase the accuracy in the models
  - Friction factor
  - Ambient temperature
  - Heat transfer partly buried pipelines
  - Measurements of physical roughness
  - Viscosity

Capacity Test

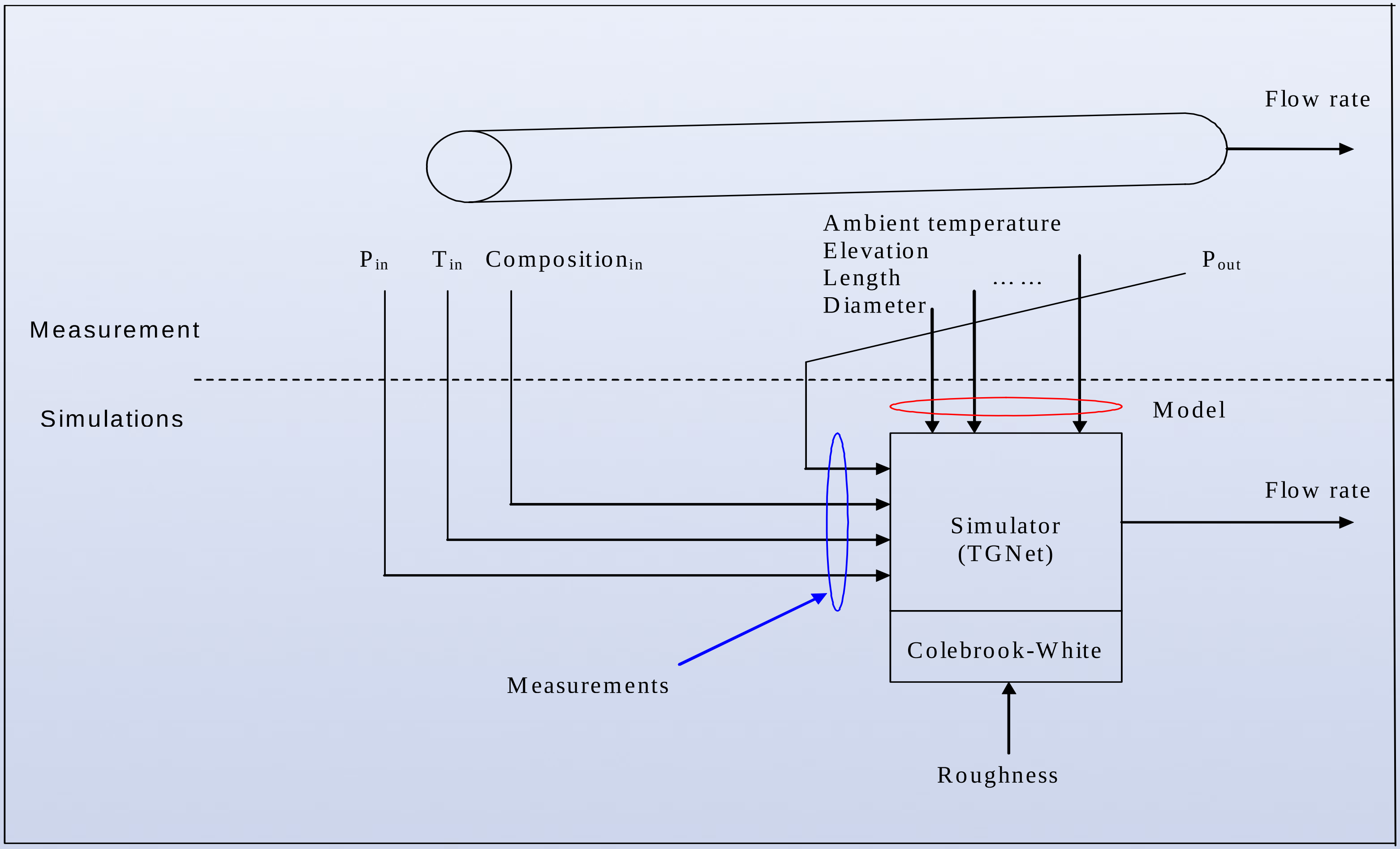
Step 1: Test: (tune pipeline model, find hydraulic roughness)

- Pipeline operated at well-controlled steady conditions (agreed with platforms and receiving terminals/customers)
- Typical duration 1-4 days
- Pipeline simulation model built. All input parameters are thoroughly validated
- Pipeline model tuned with hydraulic roughness to match the test conditions

Step 2: Study: (calculate hydraulic capacity)

- Tuned model used to calculate the hydraulic capacity of pipeline
- Typical uncertainty is around 1 %

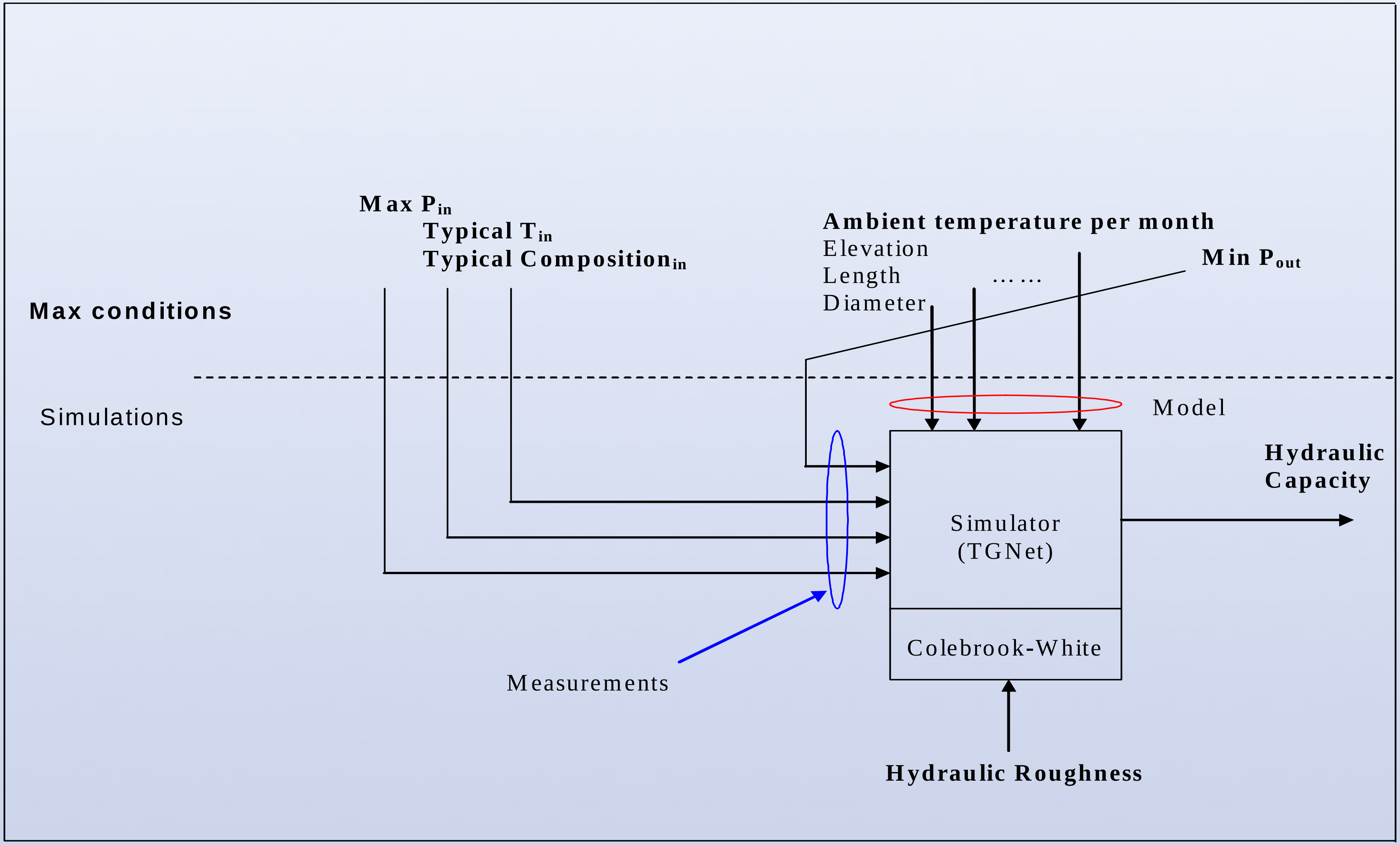
Capacity Test, step 1



Main disadvantage:

- Relies on one working point

Capacity Test, step 2



Main disadvantage:

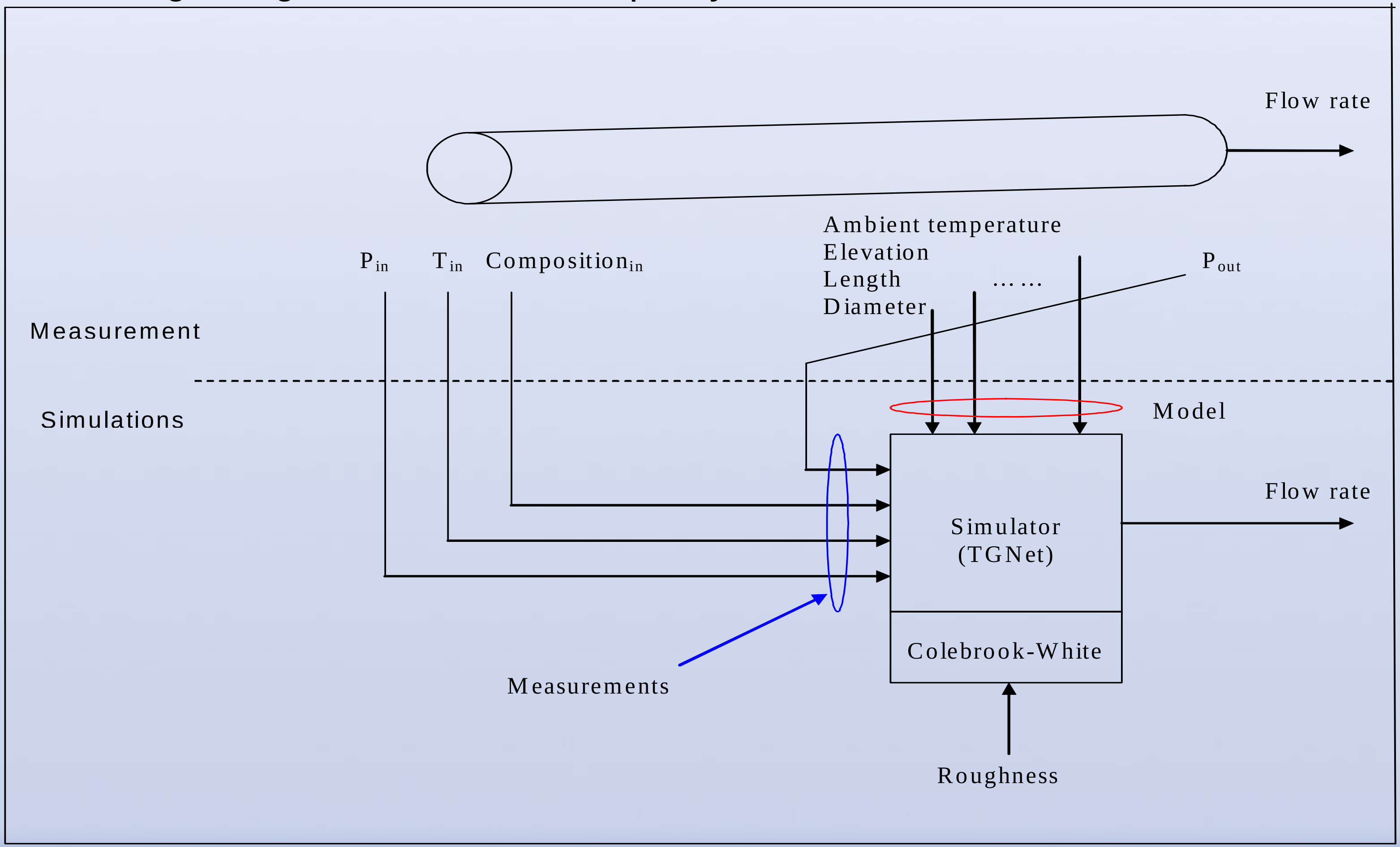
Relies on the specific friction factor correlation in use, ie. Colebrook-White

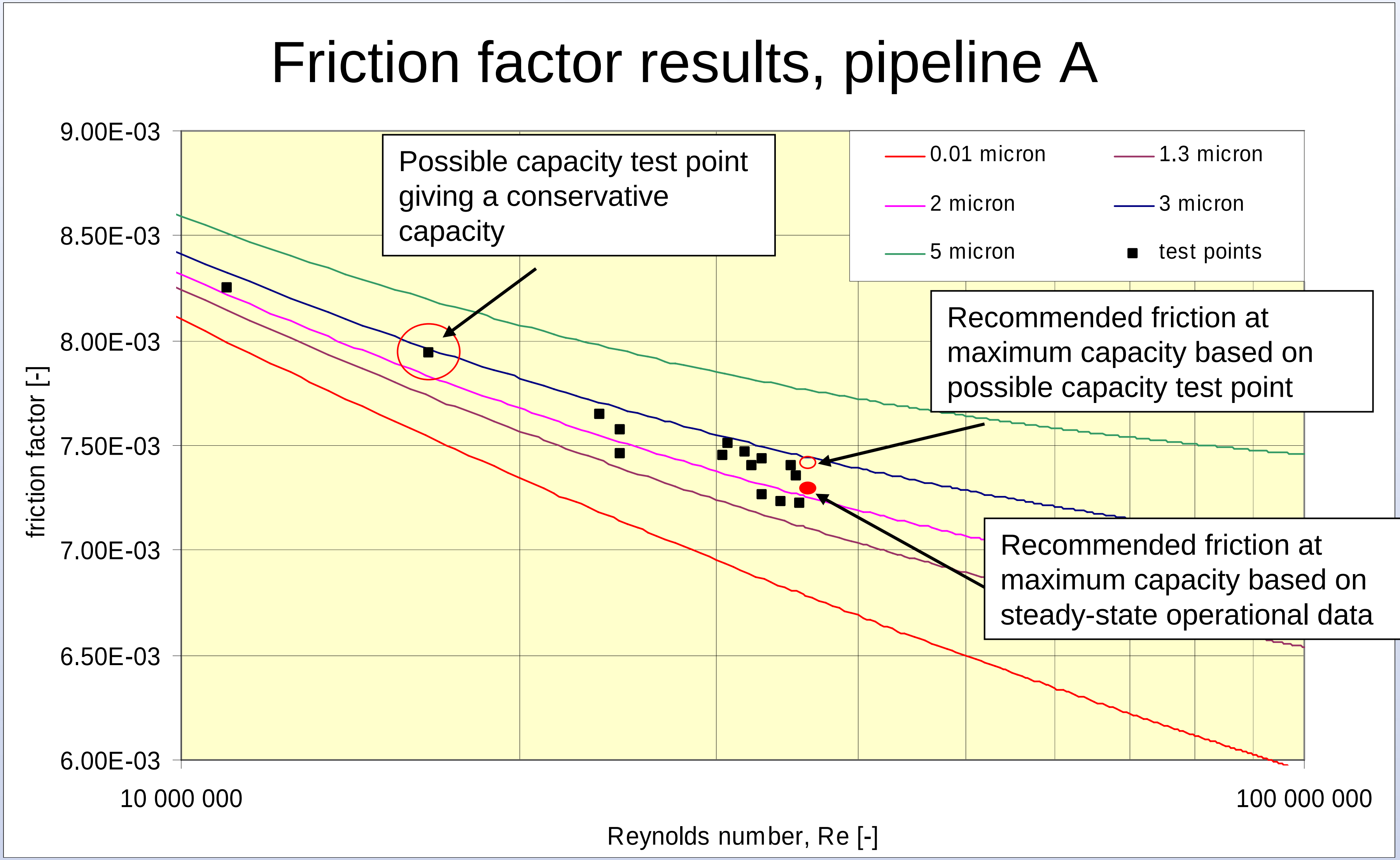
Steady-state operational data

- After some years of operation, ”near-steady-state” operational periods have occured arbitrarily sometimes
- Logged pressure, flow rate etc. for all pipelines stored in a database
- Automated search tool is implemented in the database to identify these periods
- Certain steady-state criteria have been developed
  - Duration of period
  - Steadiness in pressure and flow rate
  - Packing rate (difference between total inlet and outlet flow rate)

Steady-state operational data

- Every single steady-state period is treated as a capacity test point
- Roughness tuned → set of roughness values
- Average roughness is used for capacity calculation





- More data points decreases uncertainty
- Working points with high flow rates decreases extrapolation uncertainty

Instrumentation

Accurate pipeline modelling and capacity calculation require high accuracy instrumentation

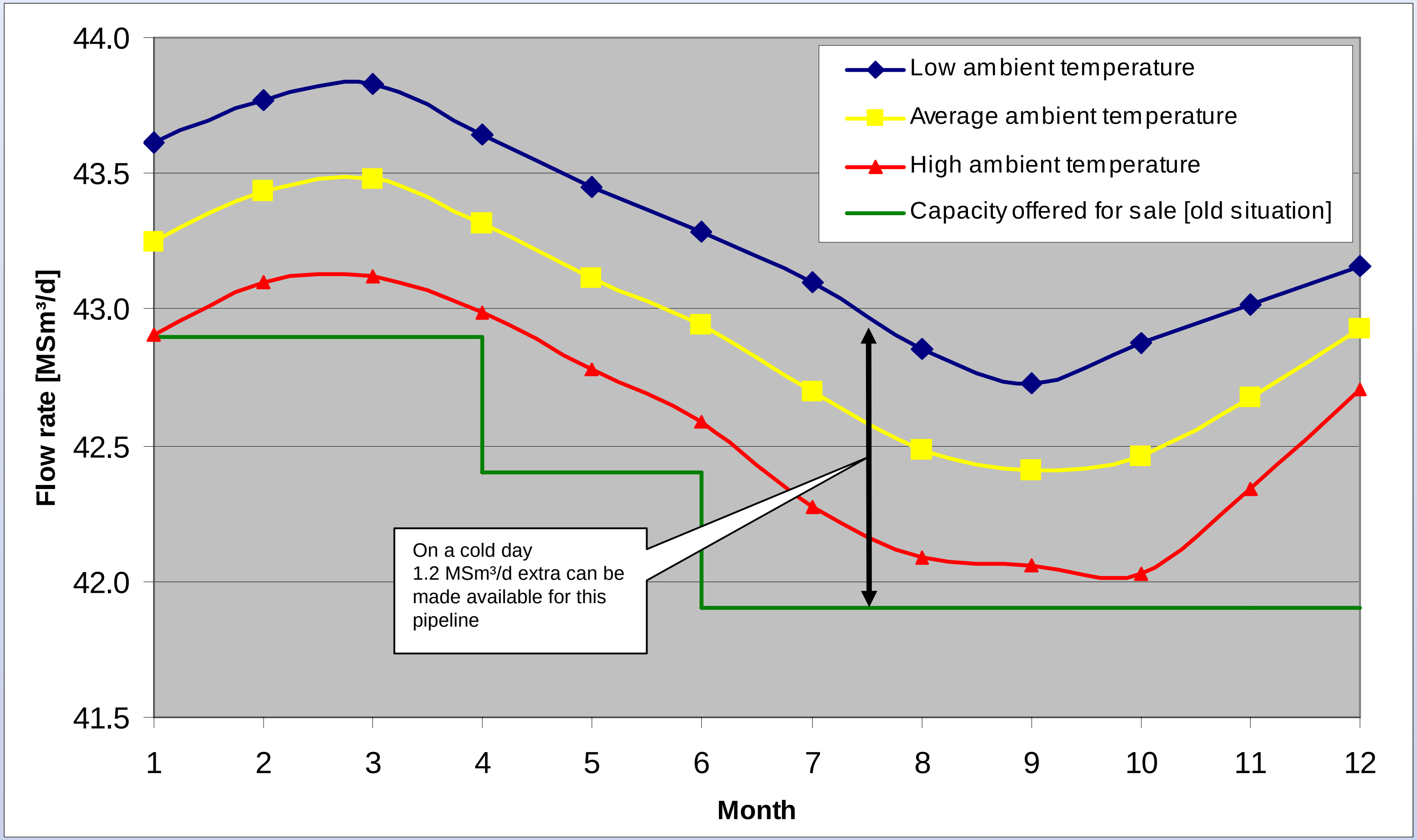
- Pressure transmitters
  - Typical ParosScientific/PEX with uncertainty 52 mBar
- Flow meters
  - Typical USM meters with fiscal accuracy → 0.5-0.8 %
- Gas composition
  - Does not contribute significantly to the uncertainty
- Temperature transmitter
  - Does not contribute significantly to the uncertainty

Recent model improvements, ambient temperature

- An automated link to UK Met Office's ocean temperature model has been implemented
- Provides daily now-casts and two-day-forecasts for the whole North Sea.
- Historical now-casts are used when calculating hydraulic roughness for each operational period (or capacity test).
- Climatological temperature data from World Ocean Atlas are used in intermediate and long term capacity predictions.
  Monthly capacities are used.
- Two-day-forecasts enable utilization of short-term variations in temperature to sell additional capacity.

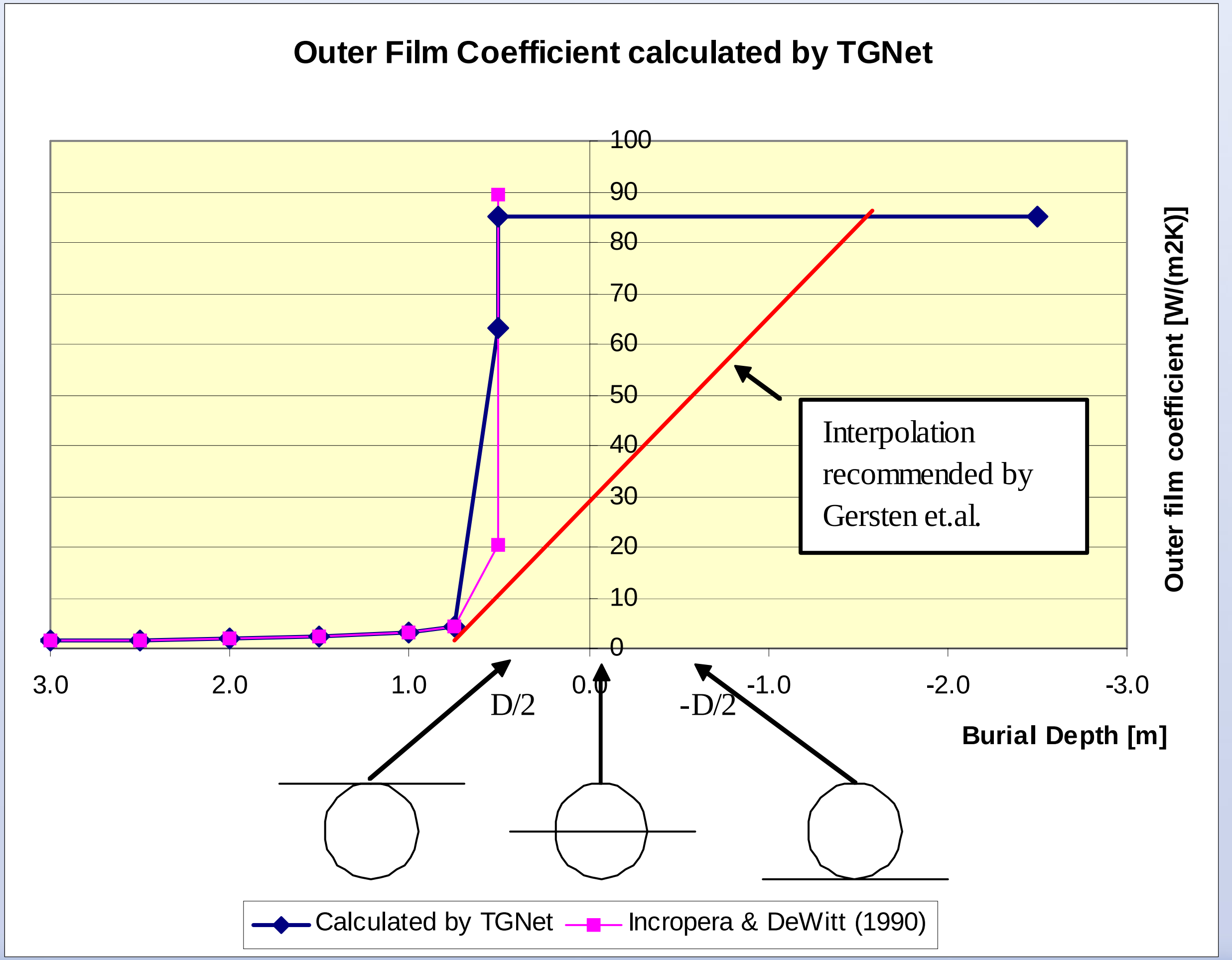
Ambient temperature model

Illustrates how capacity utilization is improved with improved temperature model.



Heat transfer to partly buried pipes

- Heat transfer well modelled for buried and exposed pipeline, but NOT for partly buried pipelines

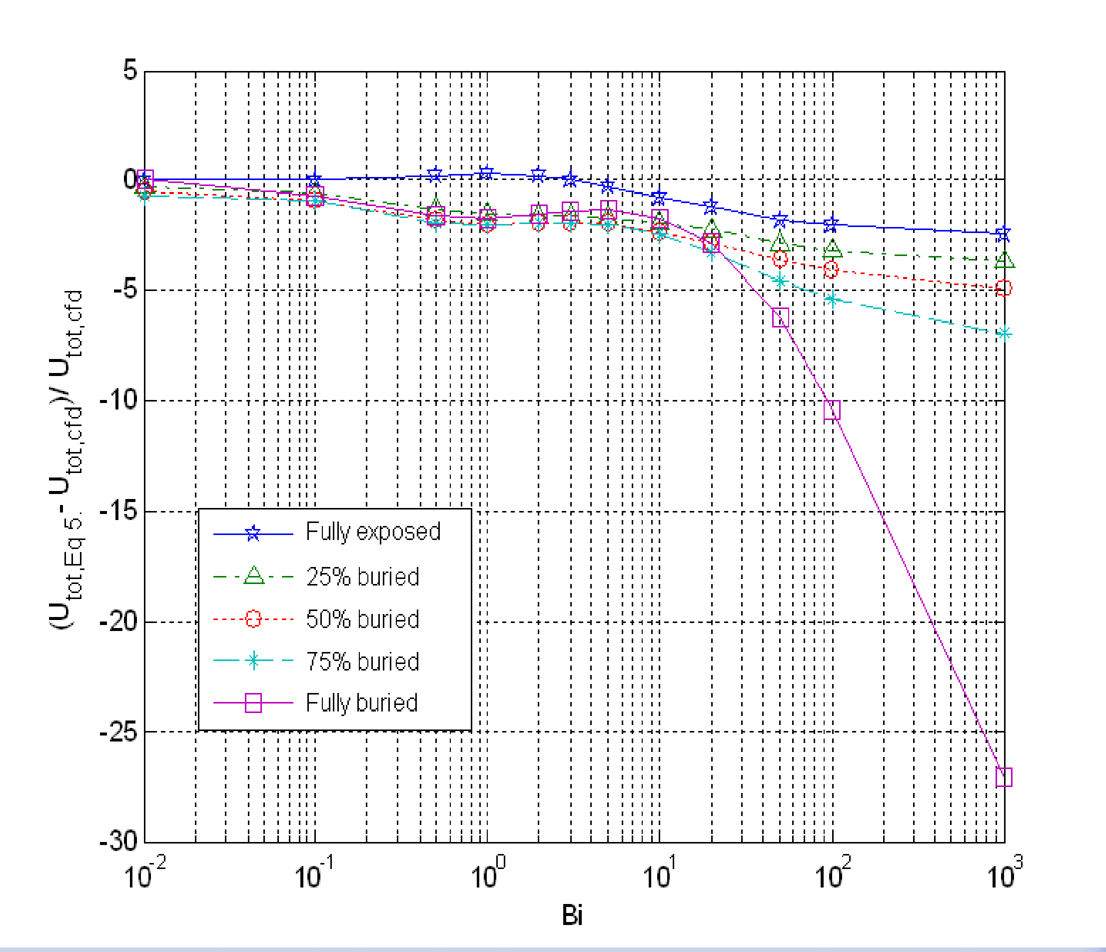


Heat transfer to partly buried pipes

CFD simulations performed by SINTEF show that a model developed by Morud's fits well for Biot-numbers < 30

$$\mathrm{Bi} = \frac{U_w \cdot R}{k_{\mathrm{soil}}},$$

Better calculation of heat transfer to/from partly buried pipelines



Results

Improved methodology

Increased overall accuracy in capacity calculations

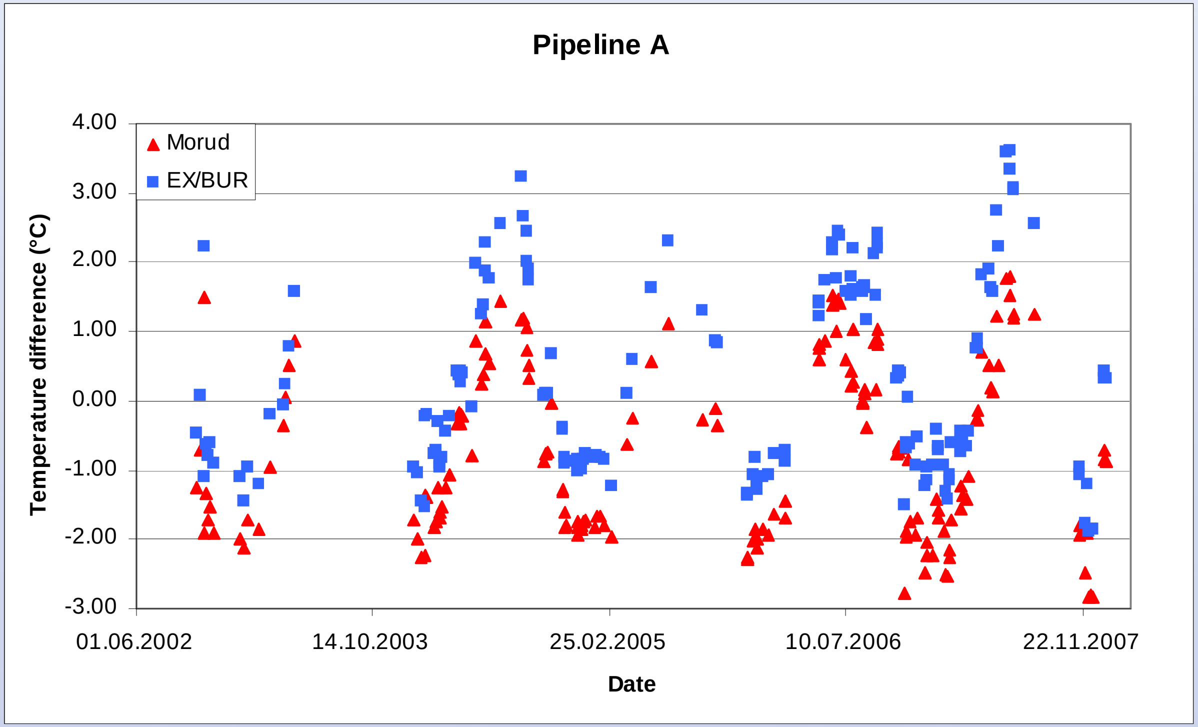
And also increased commitable capacity for 4 of 5 pipelines for which the updated methodology has been used:

- Pipeline A: +0.3 MSm3/d (~ 0.7%)
- Pipeline B: +1.1 MSm3/d (~ 2.0%)
- Pipeline C: +0.5 MSm3/d (~ 1.0%)
- Pipeline D: +2.7 MSm3/d (~ 3.5%) *
- Pipeline E: + 0 MSm3/d (no change)

* For all pipelines the capacity change refers to the capacity test capacity, except for Pipeline D, where the design capacity was the existing capacity when the updated methodology was employed.

Further challenges

- Model accuracy: temperature calculations
  - deviation between measured and modelled temperature seems to depend on season:



- Initiatives to further improve the ocean temperature models would be welcomed

Further challenges

- Initiatives to further improve the ocean temperature models would be welcomed
- Steady-state operational periods
  - Analyze how the steadiness in the periods affect the uncertainty

Thank you for
your attention