Flow Assurance Optimisation for ILI Pigging of a Multiphase Pipeline with Subsea Launch

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Introduction

Flow Assurance Optimisation

- OLGA simulation was used to manage project risks.
- Execution method was optimised within wells, subsea and topsides constraints.

ILI Pigging

- Pigging was simulated for gauging, cleaning and inspection tools.
- Constraints of each pig type was considered (e.g. pig speed, temperature).

Multiphase Pipeline

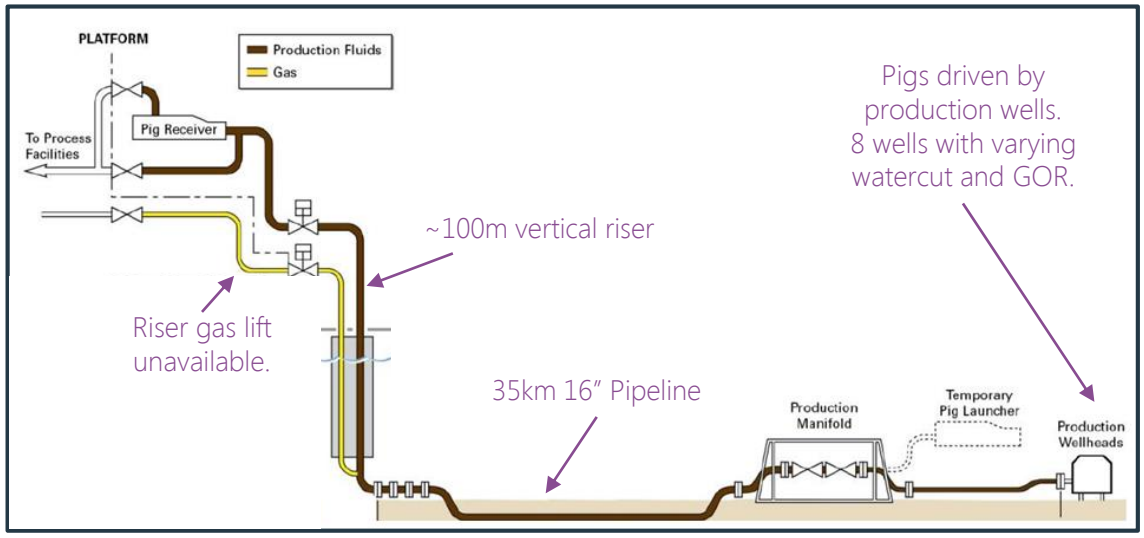
- Pigs were driven with flow from wells and received at platform.
- Unsteady flow and large slugs were expected (gas & liquid).

Subsea Launch

- A temporary pig launcher was installed subsea.
- Project cost/schedule driven by vessel time.

Overview

- Pipeline:
  - North Sea production pipeline.
  - Operating for ~20 years.
  - Tie-back to hub platform.
  - Producing 10-20 mbpd at 50% watercut and 2,000 scf/stb.



- 2019 Pigging Campaign
  - 30 day duration.
  - 6 gauge/cleaning pigs & 1 MFL inspection pig.
  - Temporary subsea launcher has been used for previous inspection pigging.

Flow Assurance Optimisation

Key Modelling Inputs and Impact on Project Risks

Study Inputs		Impact / Risk
Well Flow	• Flowrate. • Temperature.	• Minimise deferral. • Pig speed control. • Pipeline slugging & temperature.
Topsides Process	• Slugcatcher operating conditions. • Topsides choke control. • Plant Gas / Liquid handling.	• Pipeline trip. • Full plant trip. • Export BS&W.
Pig Design	• Bypass. • Friction/resistance. • ILI sampling speed. • Temperature limit.	• Stuck / stalled pig. • Lost inspection data.
Pipeline Limits	• Operating Pressure. • Design Pressure.	• Pipeline trip. • HISC pressure excursion.

OLGA Modelling

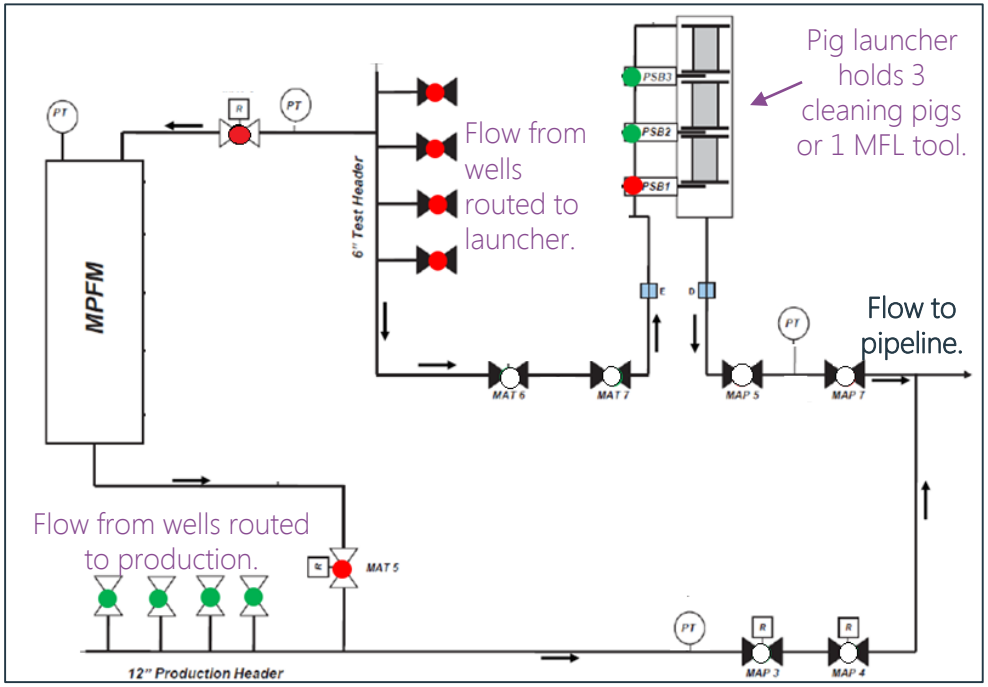
Pig Launch

Wells selected to give sufficient flow to overcome static friction (and magnetic resistance for ILI tool).

Too much flow could exceed manifold HISC pressure limit.

Different flowrates were required for each pig.

Using single-phase gas calcs will significantly over-predict flow requirement.



Onshore Pull-through Test Results (lubricated)				
Pig Type	Mass (kg)	Pig DP (bar)	Static Force (N)	Bypass Opening (%)
Proving Pig	50	0.4	4000	1.3%
1.5 Modules	100	0.5	5000	1.3%
Dual Module	150	0.7	7000	1.3%
Inspection	500	0.7	7000	0.7% to 1.3%

OLGA Modelling

Pig Transit – Uncertainties

Based on experience from previous pigging campaigns, the following uncertainties were identified and carried into 2019 modelling:

1. Flow bypass → potential wax or sand fouling.

Pig Type	Bypass Area: Design	Bypass Area: Benchmark	Comments
Cleaning Pigs	1.3%	~0.5%	Wax and sand fouling.
ILI Tool	0.9% at smallest restriction	0 to 0.7%	Fouling and design flowpath.

2. Wall friction → oil lubrication and disk wear,
   - Best correlation with friction values of 35% of pull-through tests measurements.

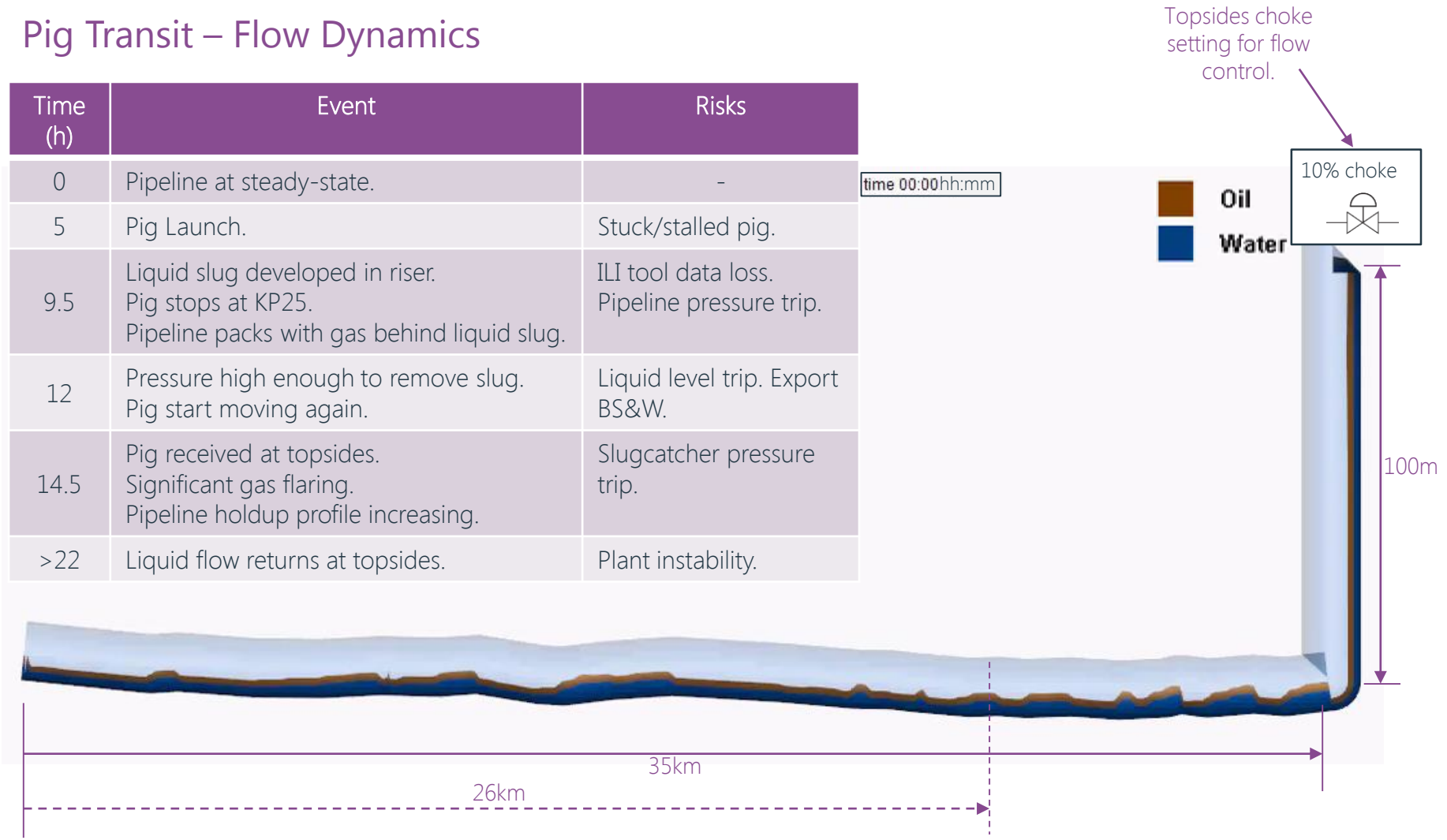
This gave a wide range of possible pig run times:

- Pre-campaign predicted run time range = 9 to 17 hours,
- Actual run time = 9.5 hours,
- Flow Assurance benchmarked each pig run and optimised flowrates.

OLGA Modelling

Pig Transit – Flow Dynamics

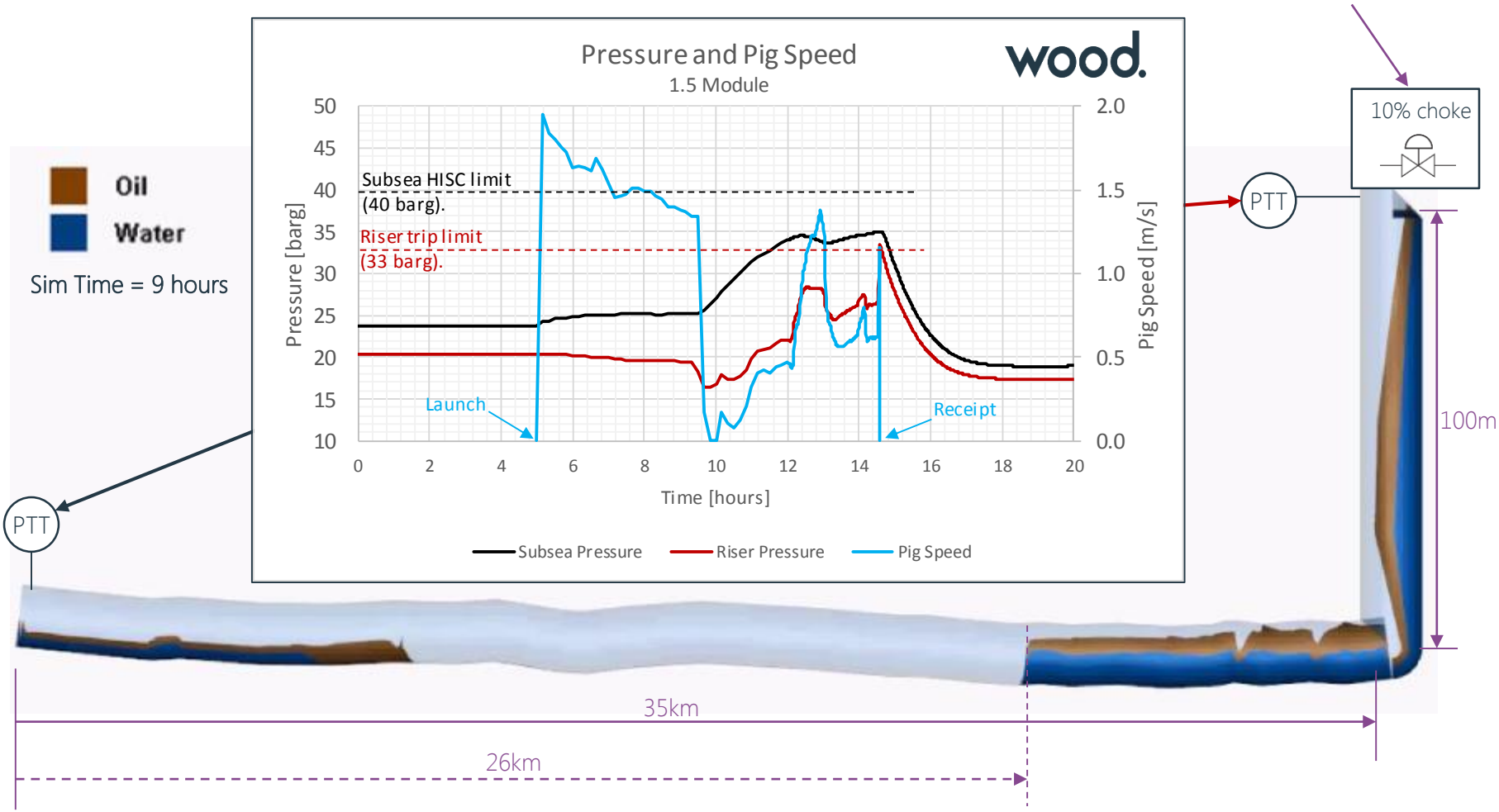
Time (h)	Event	Risks
0	Pipeline at steady-state.	-
5	Pig Launch.	Stuck/stalled pig.
9.5	Liquid slug developed in riser. Pig stops at KP25. Pipeline packs with gas behind liquid slug.	ILI tool data loss. Pipeline pressure trip.
12	Pressure high enough to remove slug. Pig start moving again.	Liquid level trip. Export BS&W.
14.5	Pig received at topsides. Significant gas flaring. Pipeline holdup profile increasing.	Slugcatcher pressure trip.
>22	Liquid flow returns at topsides.	Plant instability.



OLGA Modelling

Pig Transit – Flow Dynamics

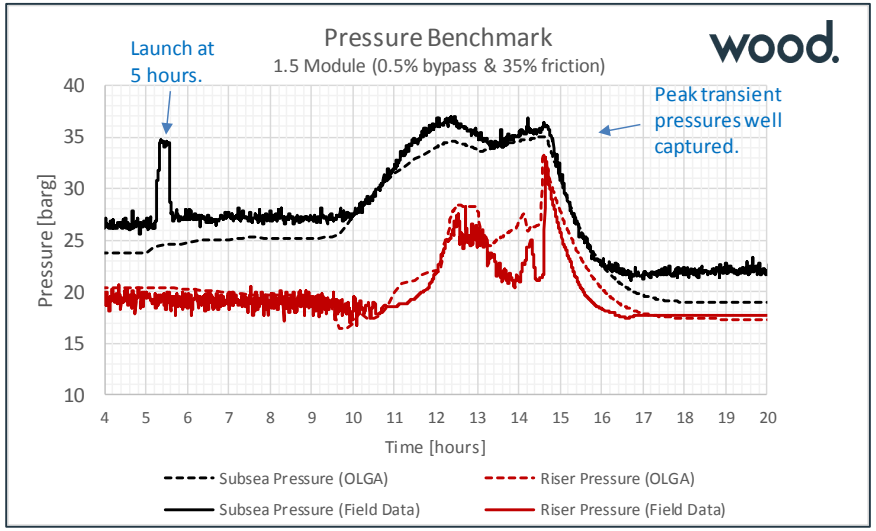
Well flowrates and topsides choking balances to control pig speed, pipeline pressure and topsides surge flowrate.

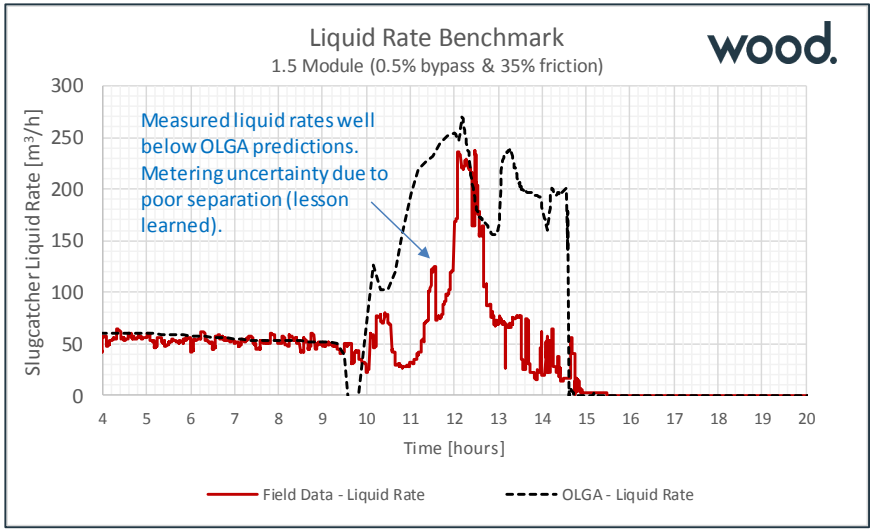


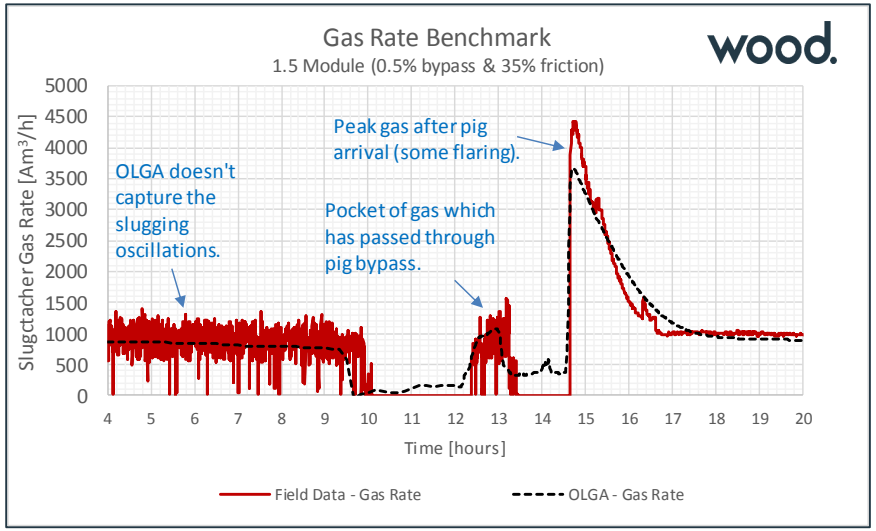
OLGA Modelling

Pig Transit – Benchmarking

- OLGA performed well for hydraulic predictions… once the model has been tuned.
- The key is to understand the uncertainties in order to:
  - Bound the risks.
  - Optimise using available 'levers'.





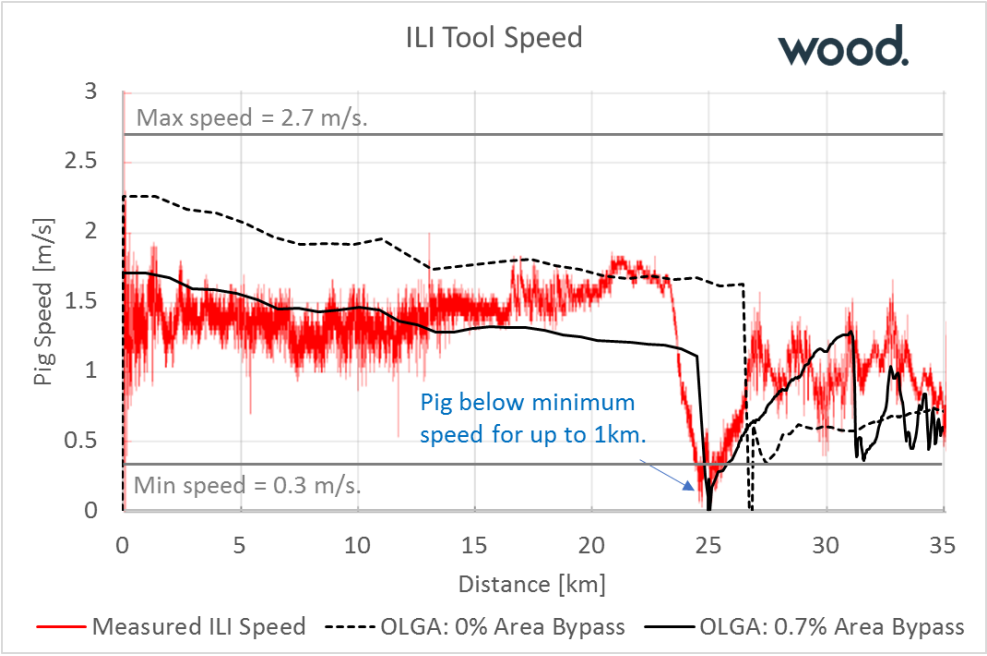


OLGA Modelling

Pig Transit – ILI Tool

- Flow Assurance provided support and benchmarking during the cleaning pigs to advise flowrates and plant set-up for ILI tool run:
  - Pipeline known to be 'low friction' from cleaning pig runs,
  - Uncertainty remaining on flow bypass due to ILI tool having more restrictive flowpath than cleaning pigs.

- Target ILI speed was 0.3 to 2.7 m/s:
  - Actual pig speed was generally within the contractual requirement,
  - Excursion below 0.3 m/s was predicted by OLGA (slug forming as pig approaches riser) and factored into acceptance criteria for integrity calcs.



Outcomes & Lessons

Flow Assurance Optimisation

- FA is best-placed to understand upstream (wells) and downstream (topsides) constraints to optimise subsea operations.
- Offshore FA presence reduced risk from unplanned operational issues:
  - Subsea isolations on old equipment,
  - Failed pig launch,
  - Topsides metering issues,
  - Plant vulnerabilities (reduced PWRI pump capacity),
  - loss of gas lift during pig run.

ILI Pigging

- Acceptance criteria was achieved; pipeline integrity qualified for >5 years.

Multiphase Pipeline

- There is no substitute for dynamic modelling (e.g. OLGA) for multiphase pipelines.
- It will never be correct – understanding uncertainties and bounding risks is essential.

Subsea Launch

- Connecting to old subsea equipment impacted schedule.
- Good vessel and topsides comms ensured safe campaign execution.

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