Effective Use of In-line Inspection Technologies to Support Pipeline Integrity Management

PPSA Annual Seminar

Ardoe House Hotel and Spa, Aberdeen, UK

19th November 2014

INTRODUCTION

- MACAW Engineering has been supporting Chevron North Sea Ltd (CNSL) with the implementation of their integrity management process since 2006
- Support has focussed on ensuring that CNSL maximise the value from their in-line inspection (ILI) campaigns:
  - Pre-inspection support (ILI tool selection and timing of ILI)
  - Post-inspection support (‘verification’ of ILI report, integrity assessment of ILI results, comparison of repeat ILI data, recommended updates to corrosion management strategy)

- Key to the success of the ILI campaigns has been combining corrosion knowledge with an understanding of the capabilities and limitations of available ILI technology
- This paper aims to share some key learning points in order to improve the input that ILI has into an overall pipeline integrity management programme

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CNSL'S UK OPERATIONS

CNSL operates more than 25 pipelines across three operated assets in the UK North Sea, **Alba**, **Captain** and **Erskine**, with pipelines service life of up to 20 years.

The pipelines are required to transport:

- Produced hydrocarbon fluids
- Gas import/export
- Injection water for enhanced hydrocarbon recovery
- Chemicals/hydraulic fluids for flow assurance, asset integrity and subsea equipment controls

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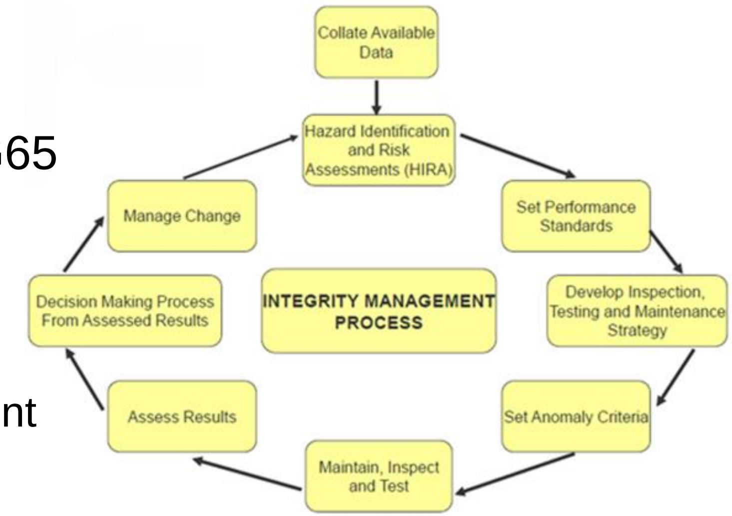
CNSL INTEGRITY MANAGEMENT PROCESS

- IM Process developed in-line with industry best practice (e.g. DNV RP F116)
- Processes adopted by CNSL for effective management of pipeline integrity and reliability follow the UK HSE recommended practice, HSG65
- Overall objectives of IMP:
  - Prevent hydrocarbon release
  - Make effective use of available integrity management resources
  - Identify and effectively manage all integrity threats
  - Ensure effective, regular monitoring to confirm the ongoing condition of the assets and verify the effectiveness of the corrosion management strategy
  - Drive continuous improvement in integrity management



THE ROLE OF ILI IN INTEGRITY MANAGEMENT

Requirements

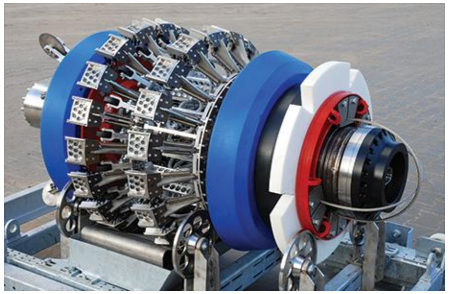
- Knowledge of pipeline history and required future use
- Understanding of active corrosion threats and likely corrosion mechanisms present in pipeline
- Knowledge of capabilities and limitations of ILI tools
- Sound integrity knowledge to be able to combine corrosion management experience with ILI data to estimate remaining life

PRE-INSPECTION

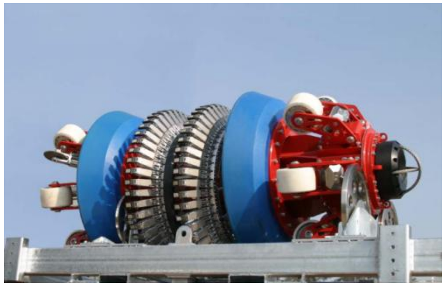
- Cleaning Requirements

- ILI Tool Selection:
  - Detection capabilities (metal loss size and shape)
  - Sizing accuracies
  - Compatibility / Repeatability compared to previous inspection data
  - Product used for propulsion
  - Pipeline cleanliness
  - Tool availability
  - Requirement for use of combined technology

Magnetic Flux Leakage



Ultrasonic



Geometry

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CASE STUDY 1: ILI TECHNOLOGY SELECTION

- Background:
  - 12” Alba Water Injection Pipeline, commissioned in 1998
  - Previously inspected using MFL technology on two occasions (2006 & 2009)
  - Inspections both reported internal corrosion throughout the pipeline, thought to have been caused by elevated O_2 levels
  - Corrosion risk assessment indicated potential for channelling corrosion
  - MFL tools known to be relatively insensitive to smooth channelling corrosion
  - No channelling corrosion reported by MFL inspections but indirect evidence (features at girth welds and increased magnetisation at the 6 o’clock position) supported potential for channelling

Channelling corrosion in Strathspey W.I. pipeline which was operated under similar conditions

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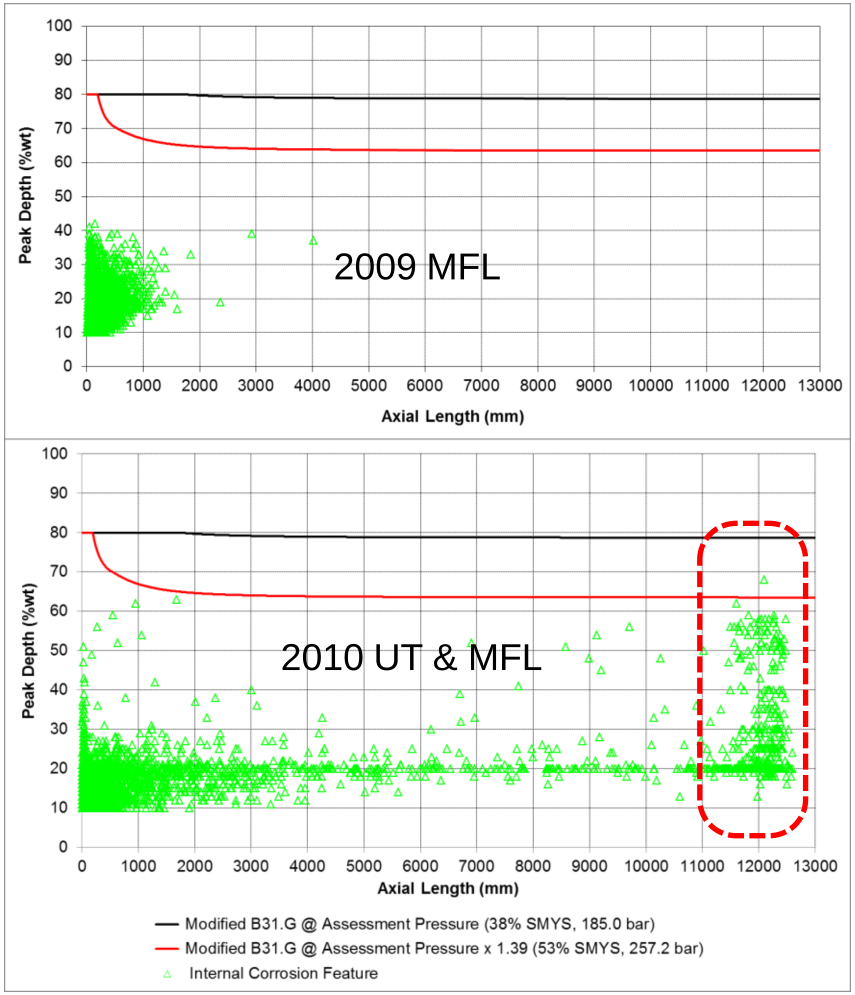
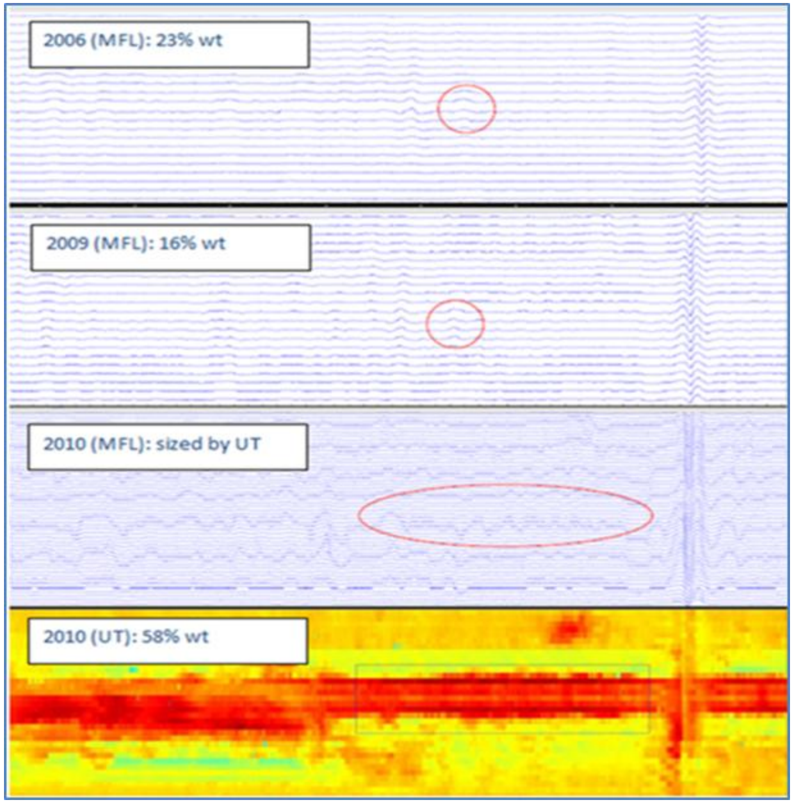
CASE STUDY 1: ILI TECHNOLOGY SELECTION

- Approach for next ILI:
  - Pipeline was re-inspected in 2010 using both MFL and UT technology
  - MFL was used to enable a direct comparison against the previous data
  - UT was used to improve detection capability with reference to channelling
  - UT reported significant channelling corrosion in the bottom of the pipeline
  - Comparison of 2009 and 2010 data highlights significant differences in depths and lengths of reported features



CASE STUDY 1: ILI TECHNOLOGY SELECTION

- Key Learning Points:
  - Limitations of ILI technology must be understood and considered: distribution of reported corrosion may not be reliable
  - Findings from a corrosion risk assessment should be considered when selecting ILI technology
  - Lessons learnt from other pipelines (e.g. Strathspey W.I. pipeline) should be communicated effectively throughout the organisation
  - If channelling corrosion is suspected, an alternative / supplementary technology should be considered (UT or high resolution calliper)



POST-INSPECTION INTEGRITY ASSESSMENT

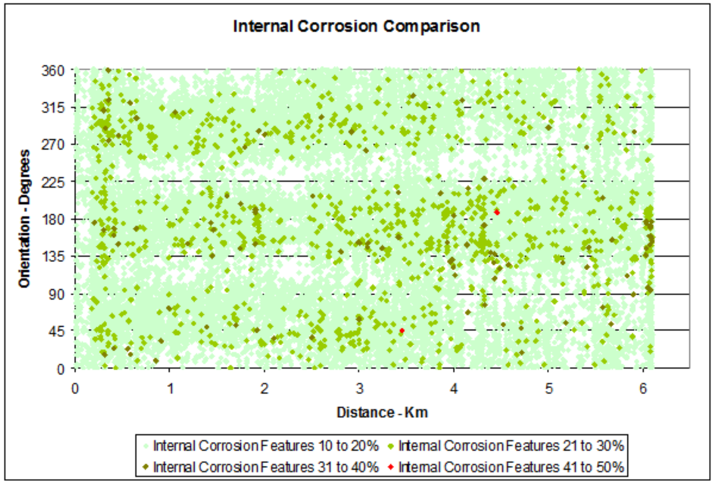
- ILI Data ‘Verification’
- Corrosion Diagnosis based on ILI Results
- Integrity Assessment of Reported Features
- Corrosion Growth Rate Estimation
- Application of Corrosion Rates to Estimate Remaining Life
- Develop / Modify Corrosion Management Strategy

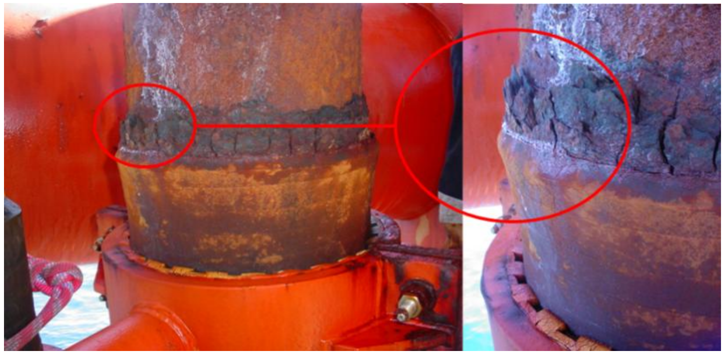
ILI DATA VERIFICATION

- Requirement to determine the quality of the ILI data and, where possible, confirm ILI performance specifications have been met
- Verification performed directly and / or indirectly
- Direct verification
  - Typical approach for onshore pipelines
  - Direct verification methodology outlined in standards such as API 1163, In-line inspection systems qualification standard
- Indirect verification
  - Review run speed and acceleration, sensor malfunction / data loss, magnetisation (for MFL tools) and echo loss (for UT tools)
  - Sense check of results against what was expected from CRA
  - Comparison of results against previous ILI or ILI data from alternative technology

ILI DATA REVIEW AND CORROSION DIAGNOSIS

- Review of the reported **distribution** of corrosion features to diagnose cause of corrosion
- Diagnosis of **internal** corrosion is reliant on reviewing the distribution throughout the length and around the circumference of the pipeline
- Diagnosis of **external** corrosion on offshore pipelines is normally reliant on accurate alignment of ILI data with as-built riser drawings





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CASE STUDY 2: EXTERNAL CORROSION DIAGNOSIS

- 16” Captain Oil Export riser
- GVI reported an area of corrosion immediately above the neoprene splash zone coating. Corrosion was subsequently repaired.
- Although records of repair (including photographs) were retained, it was not clear if and how far the neoprene coating was stripped back
- Following the repair, the pipeline was internally inspected and external corrosion was reported at various locations on the riser
- Comparison of repeat ILI data indicated some features had grown since previous inspection
- Initial comparison between ILI data and riser drawings were inconclusive and there was uncertainty whether all active corrosion had already been repaired

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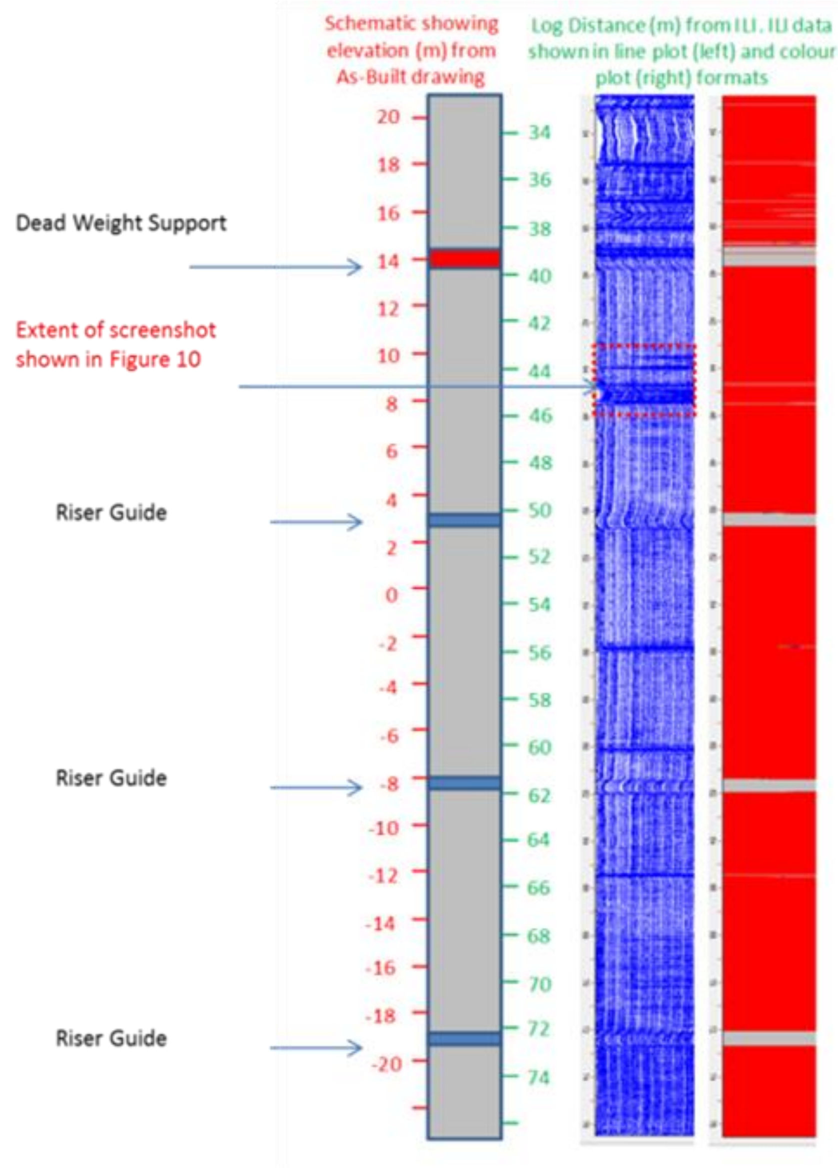
CASE STUDY 2: EXTERNAL CORROSION DIAGNOSIS

- ILI data aligned with riser schematic
- Alignment used ILI signals to increase accuracy
- Based on alignment, clear guidance was given to investigation team to enable positive identification of riser corrosion



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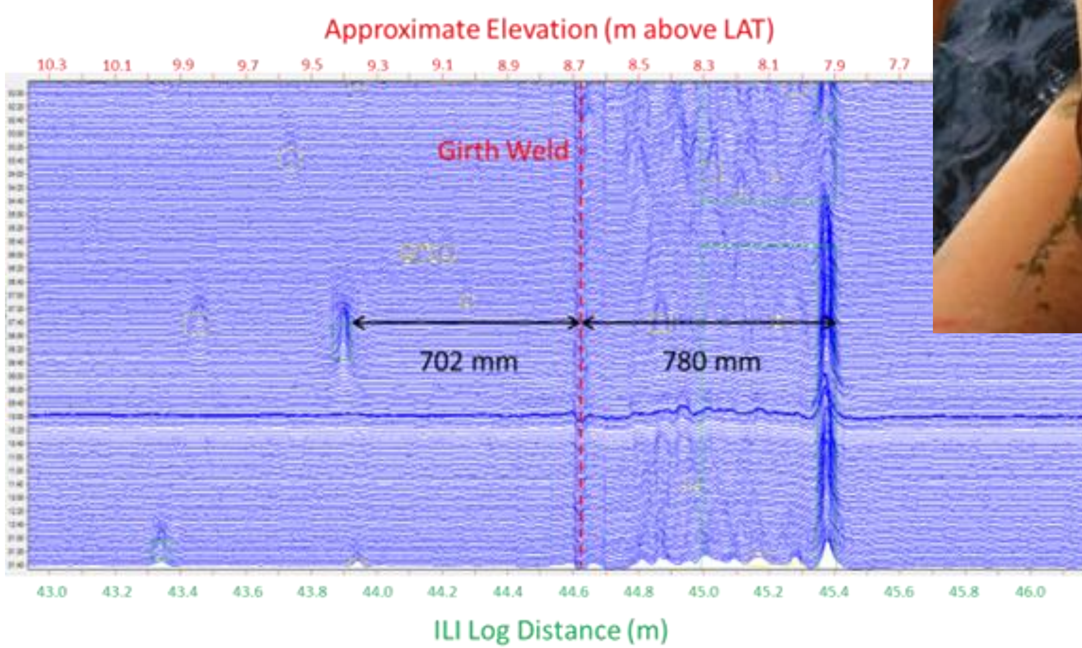

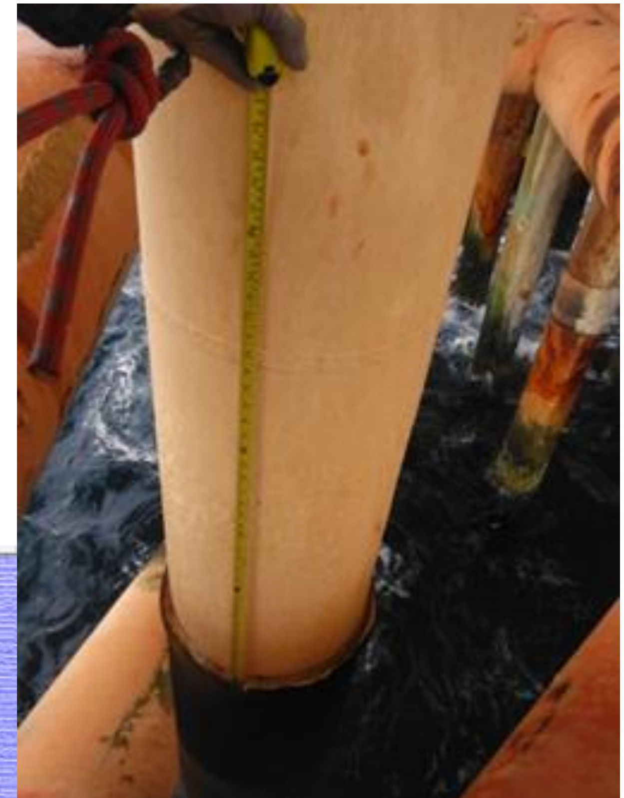

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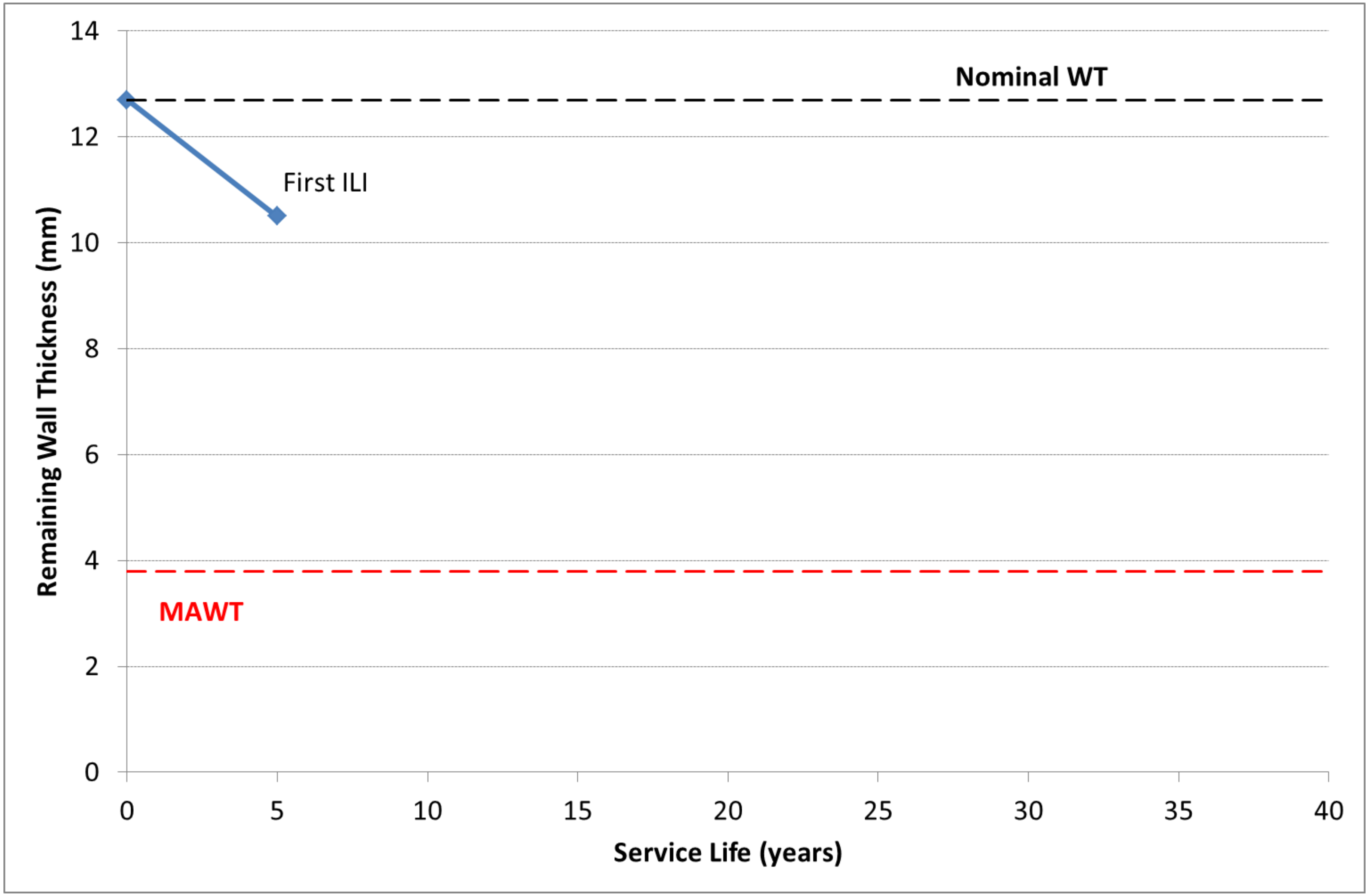
REMAINING LIFE ANALYSIS

- **Corrosion rates** estimated from comparison of repeat ILI data, supported by corrosion modelling (e.g. NORSOK) where feasible (i.e. dominant mechanism is sweet corrosion)
- **Future** corrosion rates critically dependent on effectiveness of corrosion management and compliance with performance targets (e.g. C.I. injection)
- Two primary requirements from remaining life analysis:

1. To determine a suitable timeframe for re-inspection based on a conservative estimate of corrosion growth rate
2. To estimate the potential remaining life of the pipeline based on a less conservative / more representative corrosion growth rate

Note: Remaining life for offshore pipelines normally defined as the time until the most significant defect is predicted to exceed critical dimensions

REMAINING LIFE ANALYSIS



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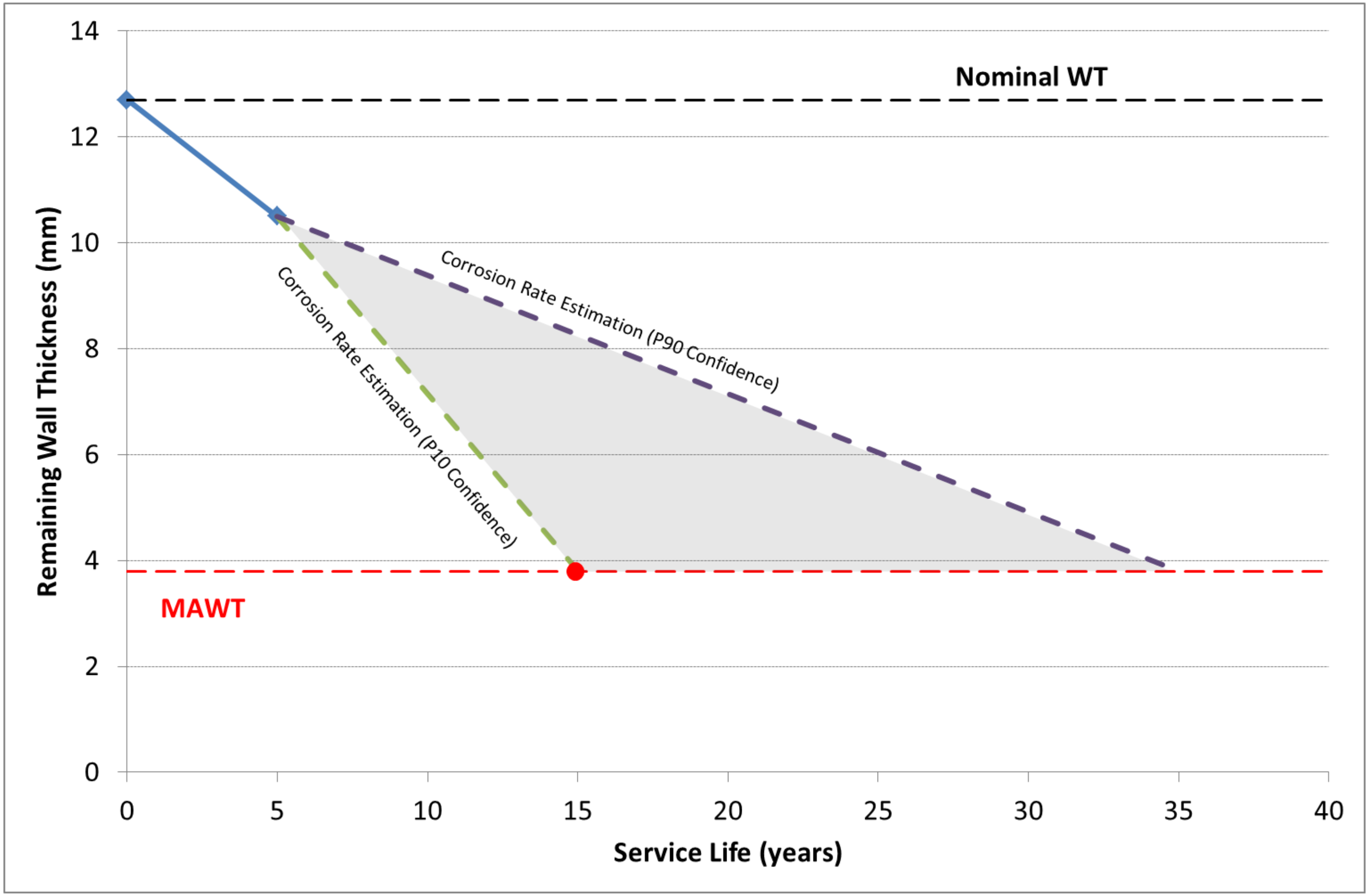

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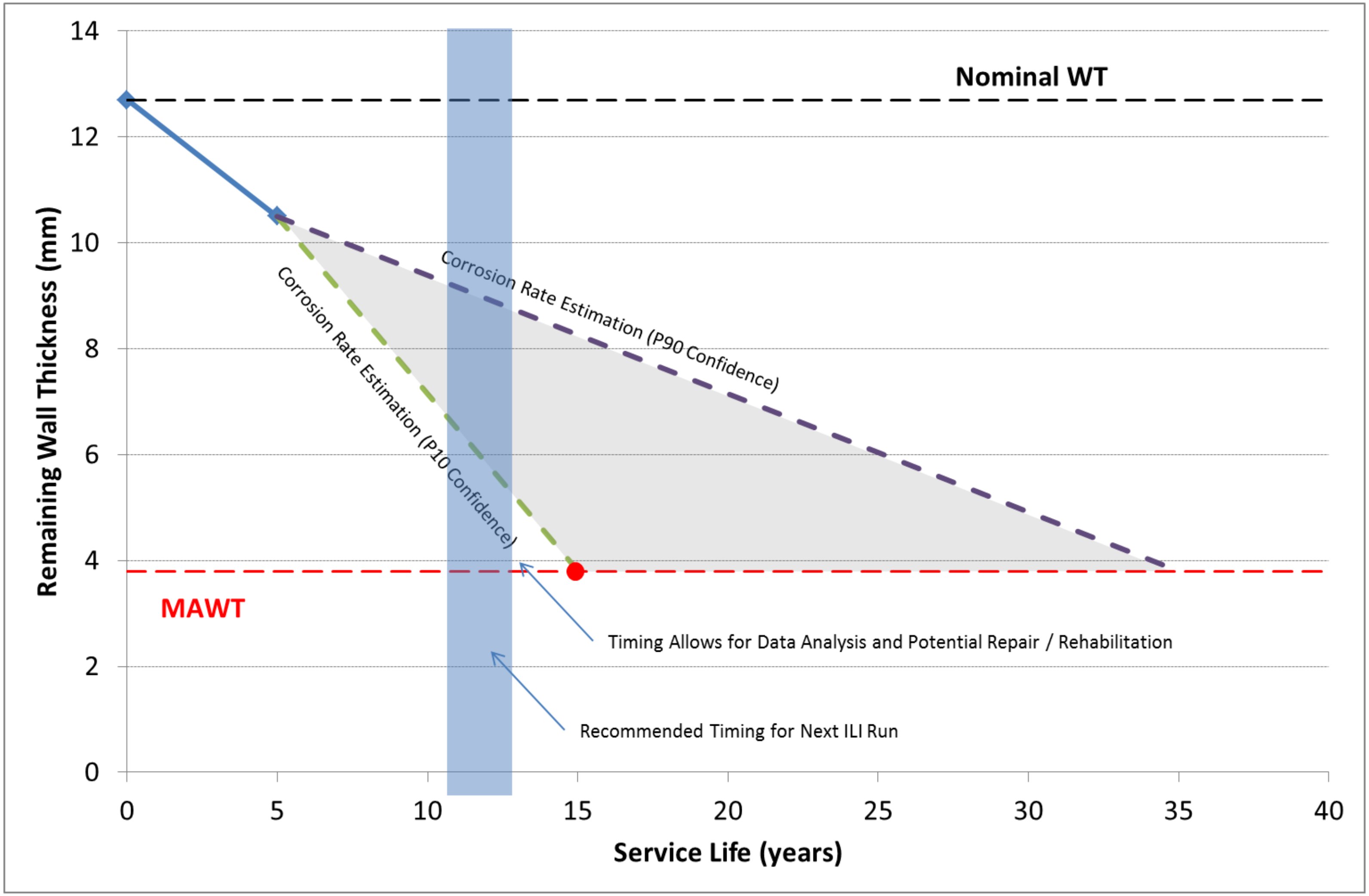

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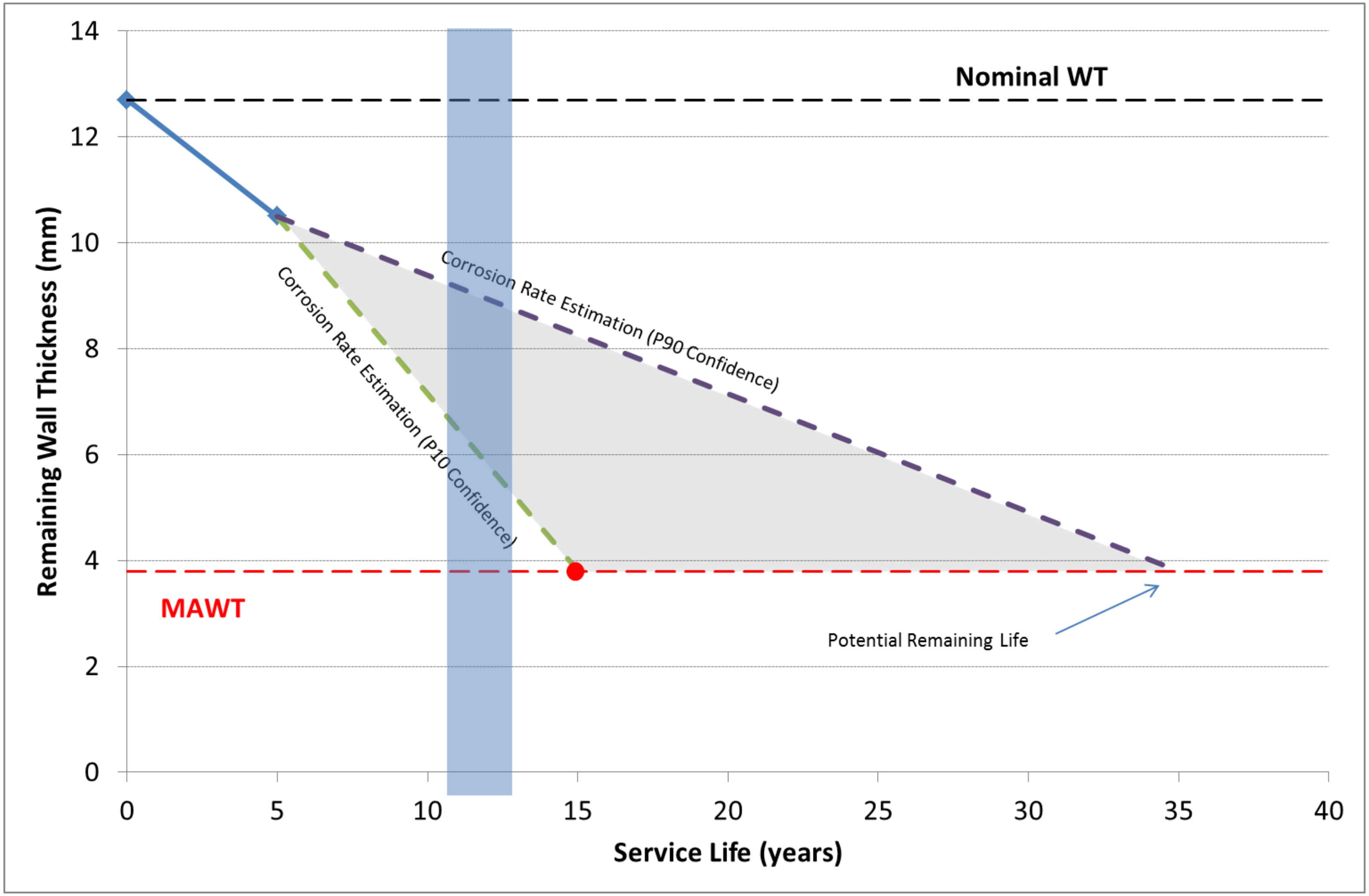

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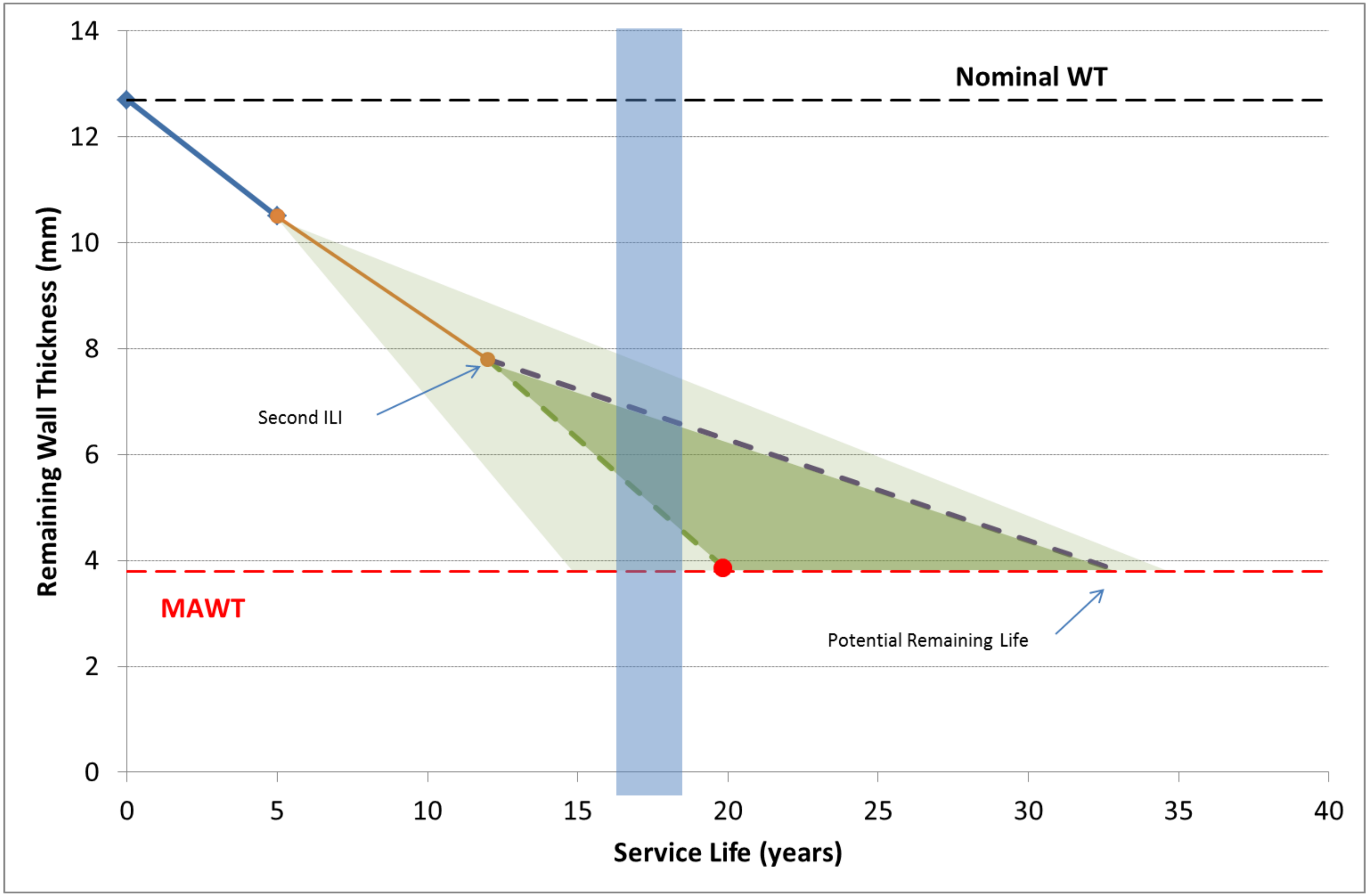

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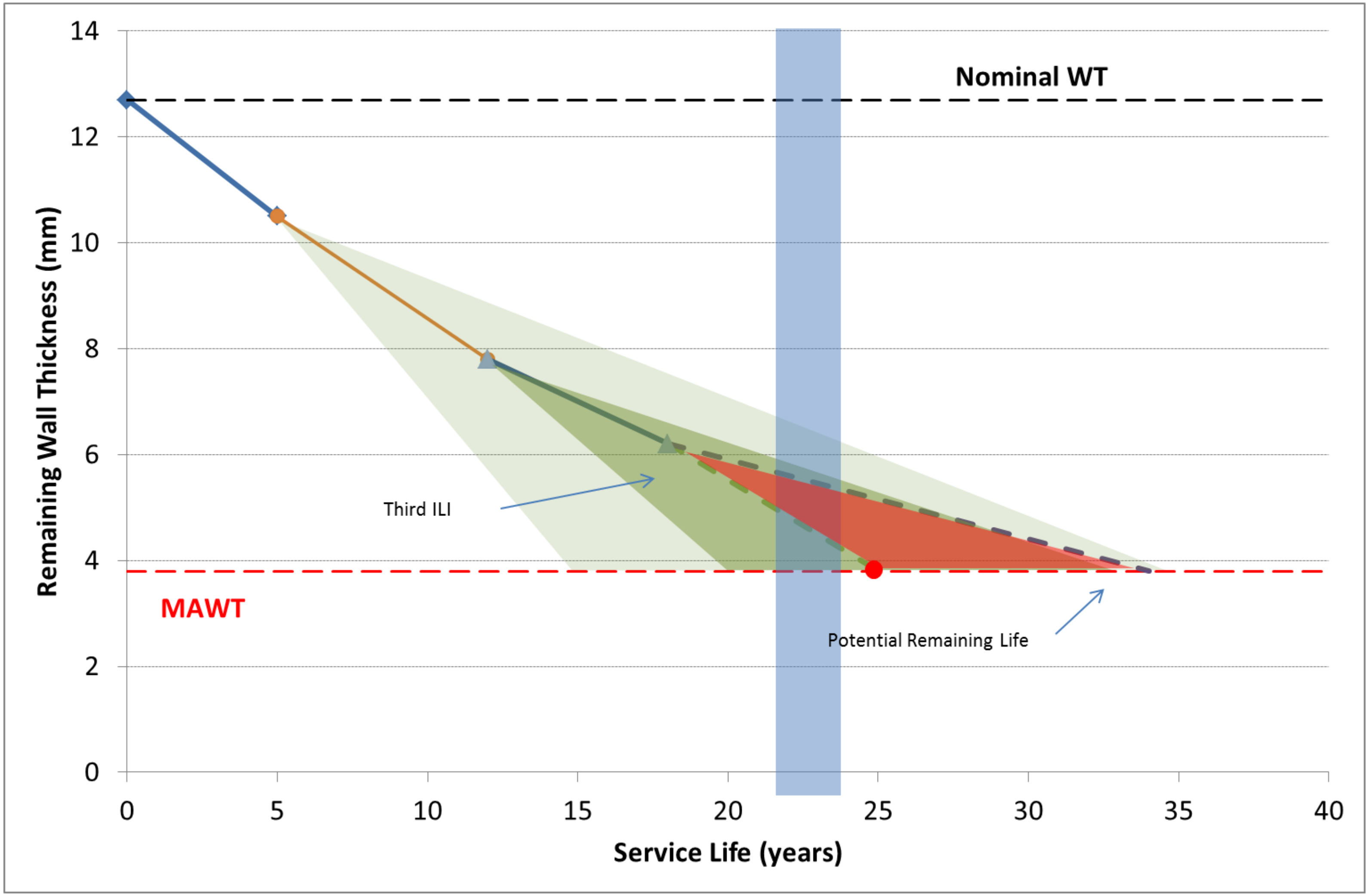
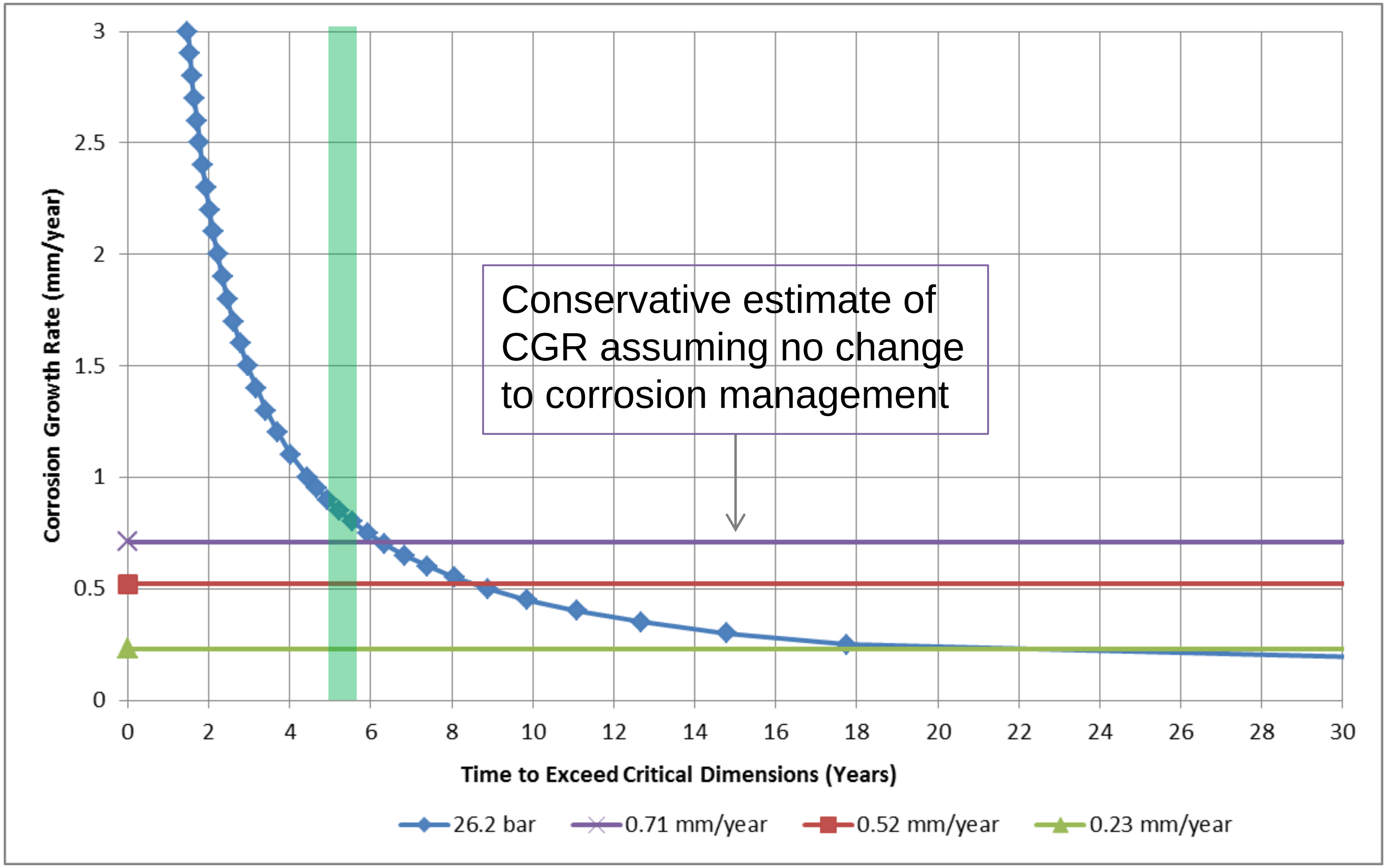


SELECTION OF RE-INSPECTION INTERVAL



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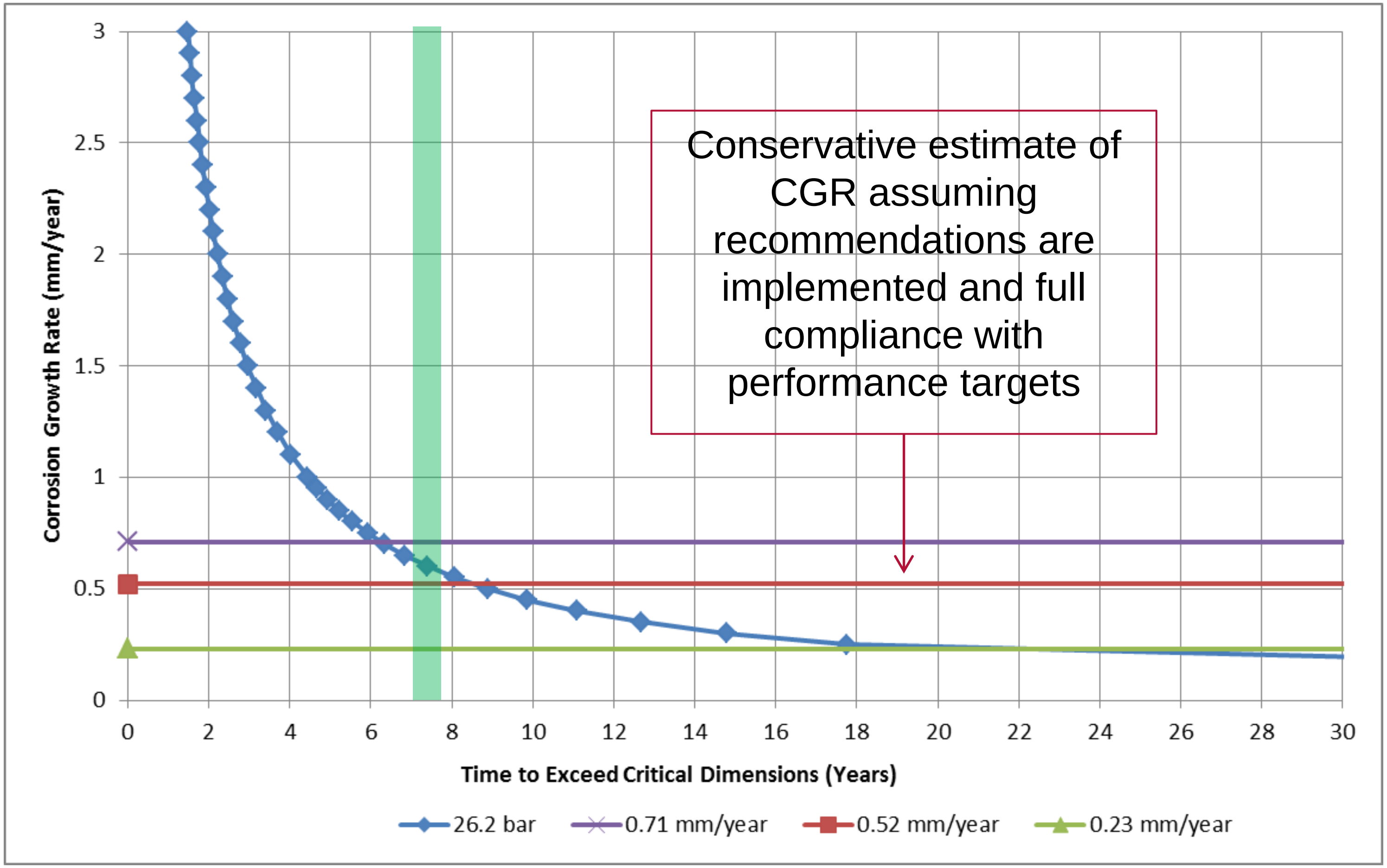

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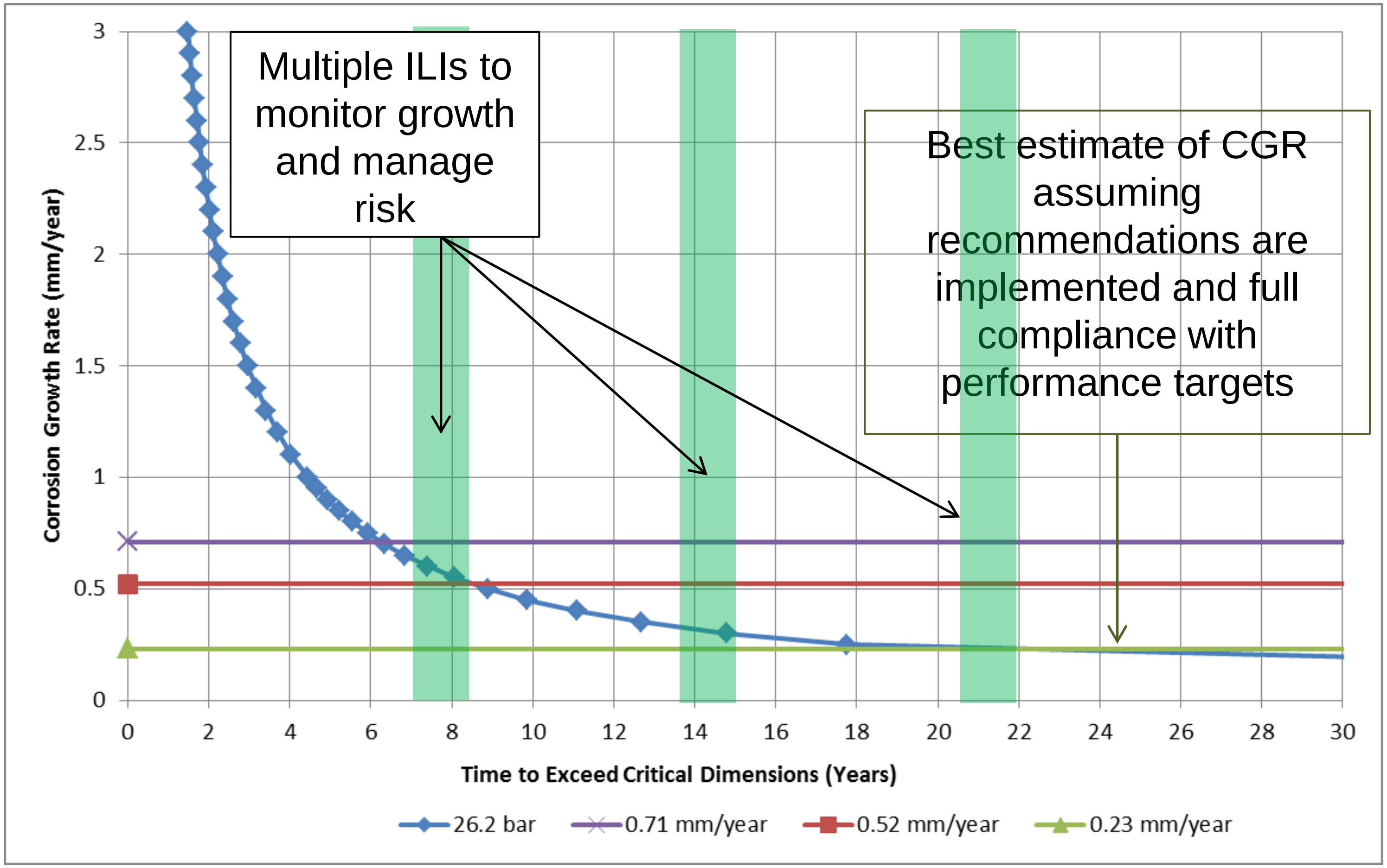

SUMMARY

- Extending the safe remaining life of a pipeline requires effective integrity management. ILI plays a critical role by confirming the condition of the asset and the effectiveness of the applied mitigation.

- Direct and indirect costs and operational impact of running inspections can be significant so it is important that the value of the inspection be maximised.

- Combining corrosion knowledge with ILI experience is a fundamental requirement:
  - Understand active corrosion mechanisms
  - Be aware of ILI technology limitations and select a tool / tools capable of detecting all active mechanisms

Thank you for your attention

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