



Paper 279 – The Benefits of ILI Signal Review Analyses in ILI Run-to-Run Comparisons – A Case Study

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ILI Run-to-Run Comparisons

- A powerful way to establish accurate CGRs along a pipeline (usually)
- There is no 'standard' process to follow
- Bare minimum: Spreadsheet comparison between the subsequent ILIs
- More advanced:
 - ILI reporting bias assessment
 - Statistical analysis to identify locations that are most likely to contain active corrosion
 - ILI signal review comparisons between the subsequent ILIs
- CGRs could be established
 - On a per-anomaly basis... sensitive to ILI error (very high CGRs... negative CGRs)
 - As a single CGR applied to the entire pipeline (i.e., 95th percentile among anomaly CGRs)... perhaps too conservative
 - On a per-joint basis... a reasonable balance between the two

Spreadsheet-Based CGRs

- This paper utilized joint-based CGRs

- Max CGR:
$$\frac{ILI2\ max - ILI1\ max}{Time}$$

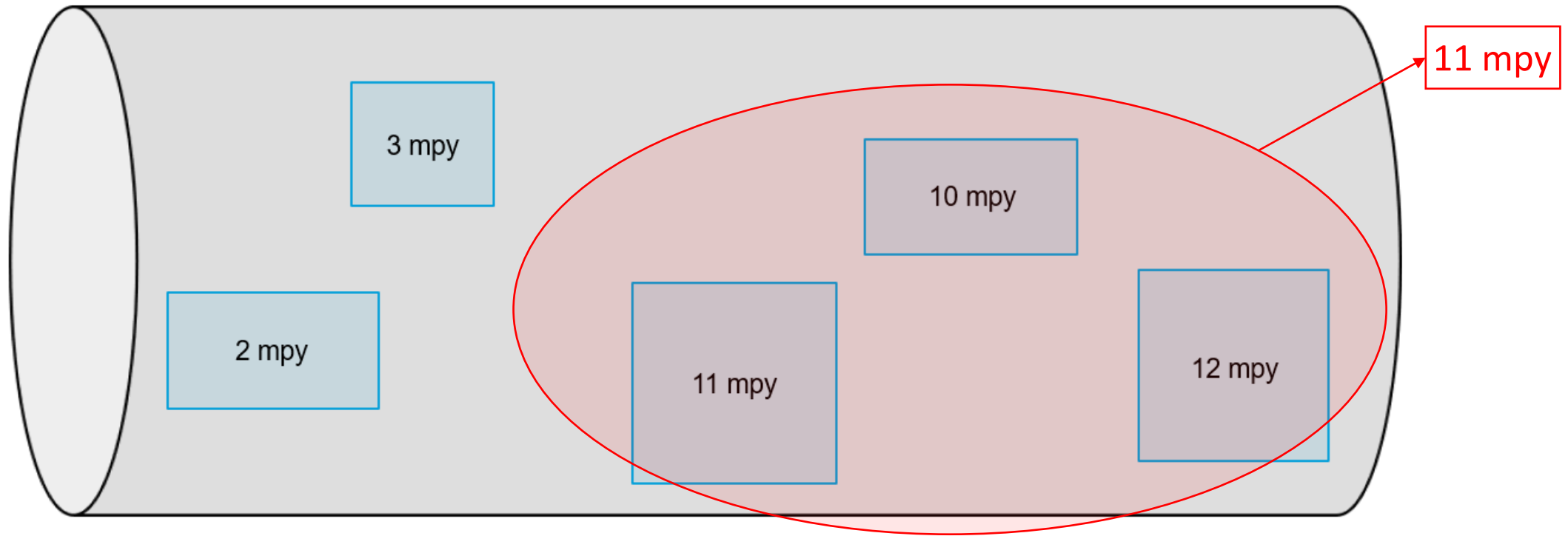
- Mean CGR:
$$\frac{ILI2\ mean - ILI1\ mean}{Time}$$

- Anomaly CGR: Average of the highest individual anomaly rates within the joint

On a Per Joint Basis

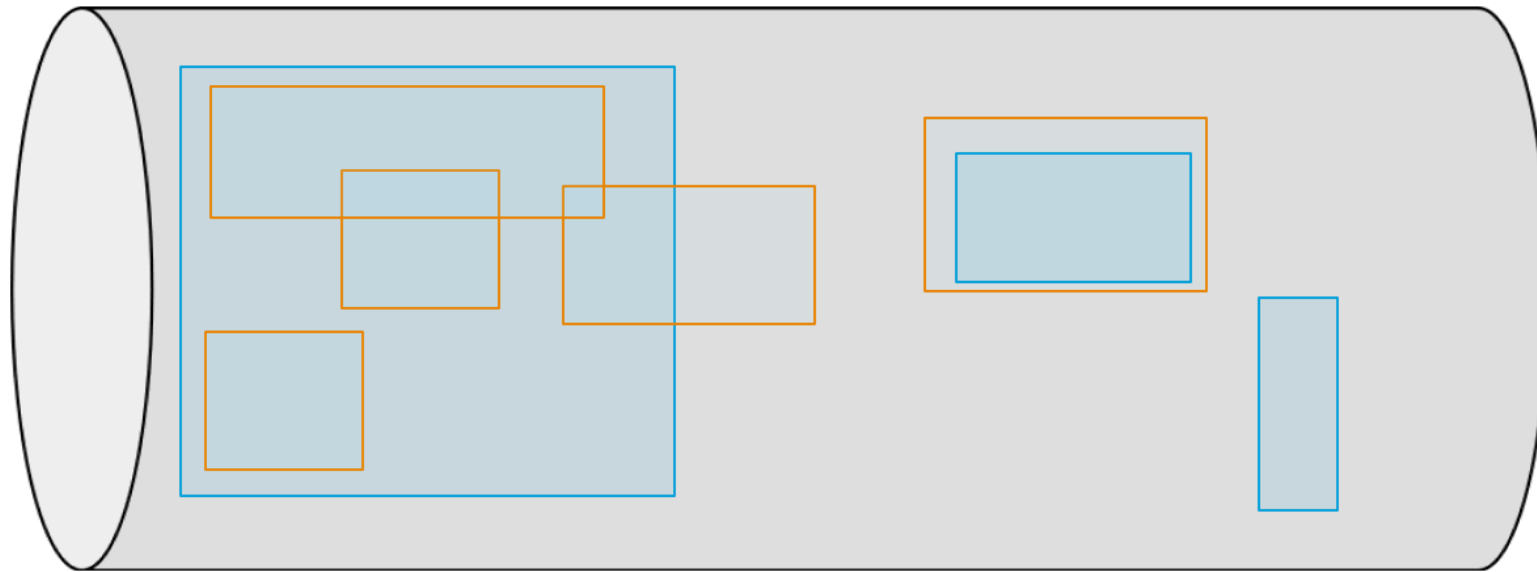
Anomaly CGRs

- Anomaly CGR: The highest individual anomaly rates within the joint are averaged



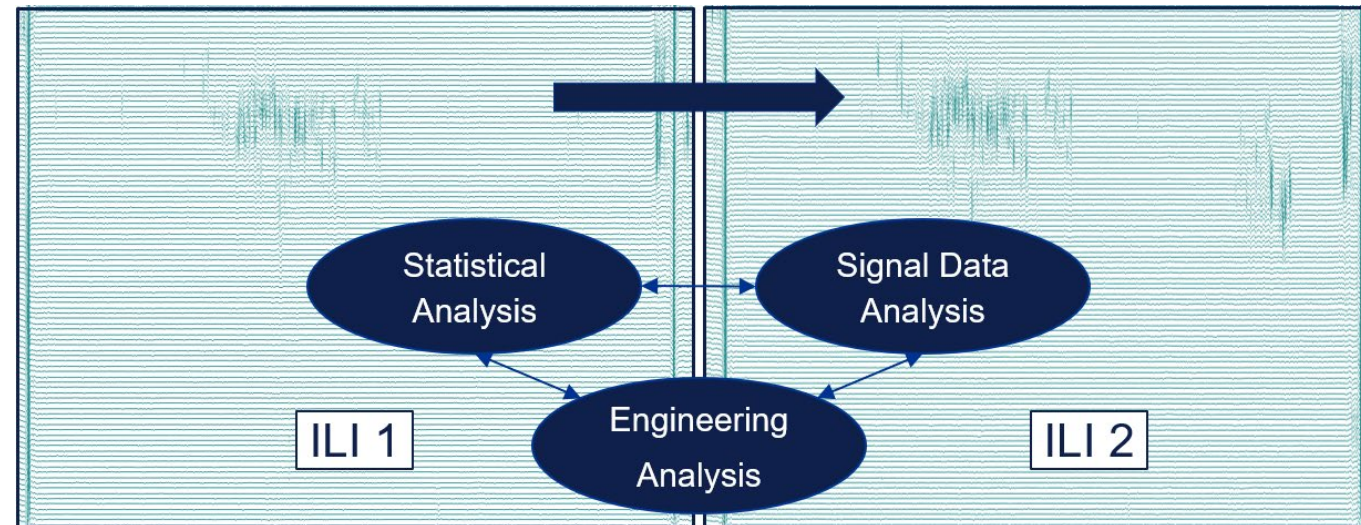
Anomaly Matching

- One-to-one matches – Simple matching
- One-to-none matches – Assumed depth at time of previous ILI
- One-to-many matches – Assumed match to the deepest



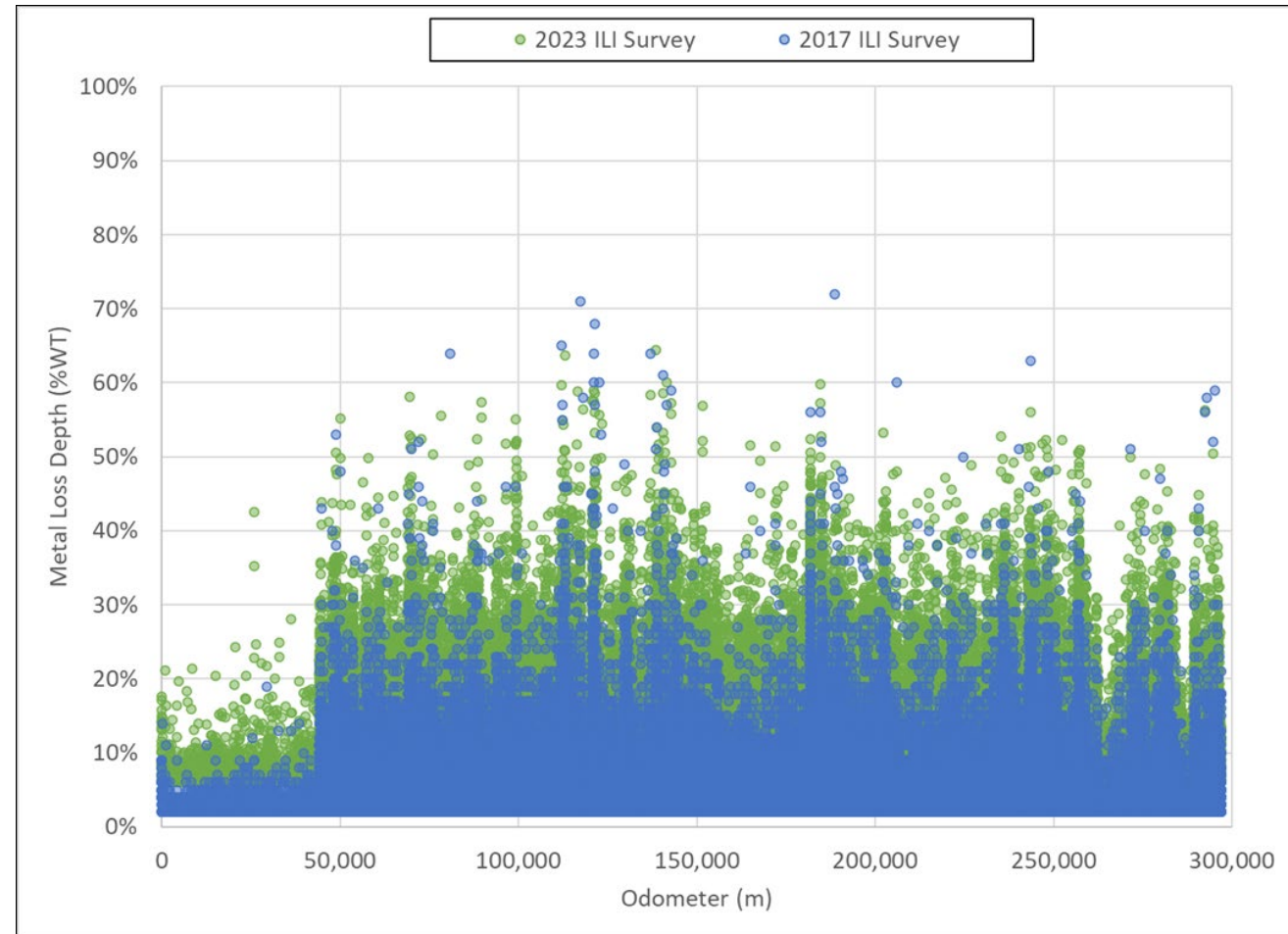
Spreadsheet-Based CGRs vs. More Advanced Analyses

- Spreadsheet-based CGRs can be misleading
- ILI signal review can increase accuracy and confidence in CGRs
- Question: What are the impacts of incorporating ILI signal review into an ILI run-to-run comparison?



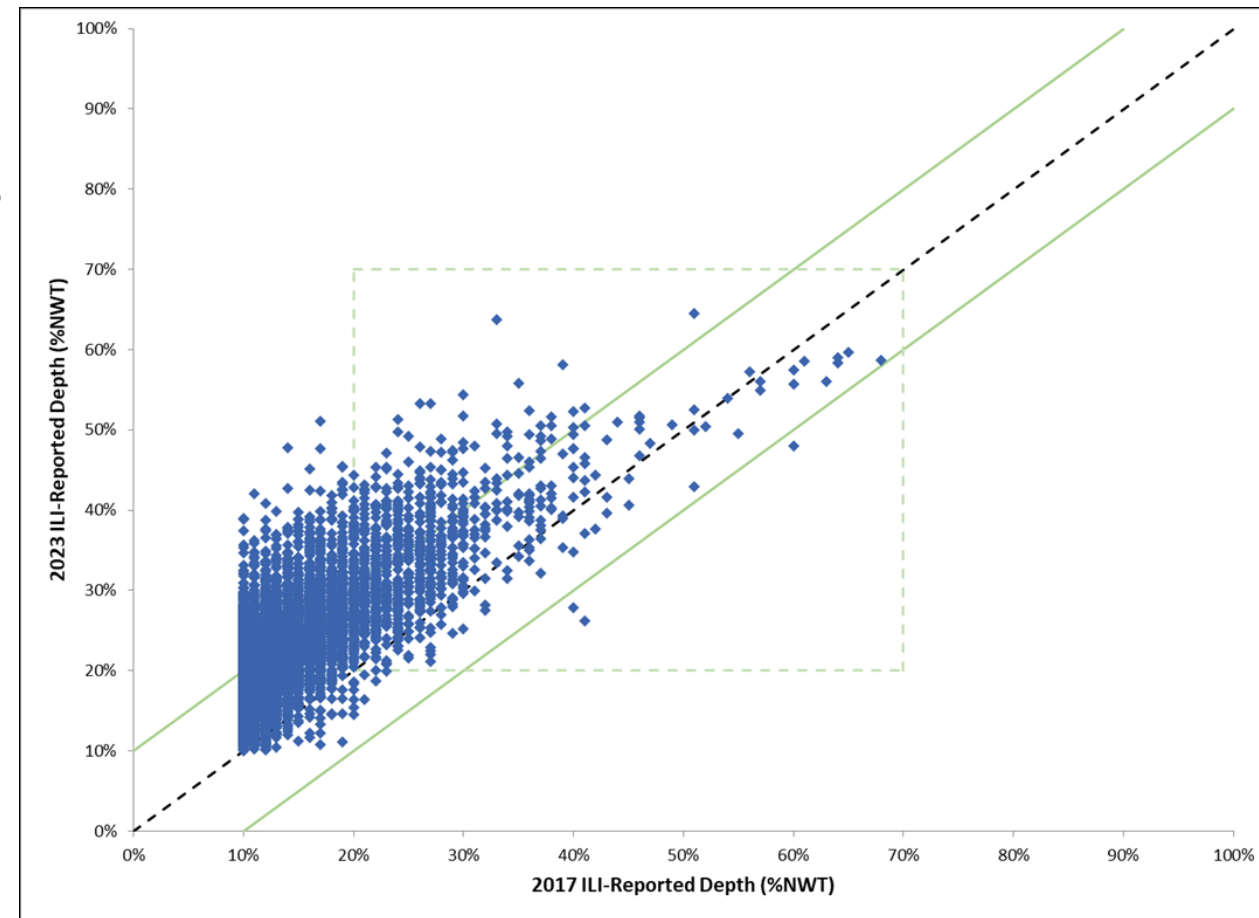
Case Study

- 2017 axial MFL: 15,288 reported metal loss anomalies
 - 15,209 EXT ML
 - ML reported on 14,172 pipe joints
- 2023 axial MFL: 139,968 reported metal loss anomalies
 - 139,072 EXT ML
 - ML reported on 11,915 pipe joints



Relative Reporting Bias

- One-to-one matches: 2023 ILI reported deeper than 2017
- Non-growing anomaly matches: 2023 ILI reported deeper than 2017
- 2017 field-to-tool matches: 2017 ILI undercalled
- 2023 field-to-tool matches: 2023 ILI undercalled (by a similar margin as the 2017)
- Relative bias present among shallow anomalies... no evidence of bias among deeper anomalies



Depth Range (percent wall thickness)	One-to-One Match Count	Mean Ratio (2023 ILI Depth / 2017 ILI Depth)	95% Confidence Interval
All	8,712	1.671	[1.663, 1.679]
≥ 20%, ≤ 70%	1,051	1.340	[1.325, 1.355]
≥ 30%, ≤ 70%	182	1.172	[1.144, 1.199]
≥ 40%, ≤ 70%	46	1.047	[1.009, 1.084]
≥ 50%, ≤ 70%	15	0.972	[0.920, 1.024]

Sensitivity Study – Impact of ILI Signal Review

- Establish spreadsheet-based CGRs using the three approaches described previously:
 - Max CGRs
 - Mean CGRs
 - Anomaly CGRs (average of ‘top’ CGRs in a given joint)
- Perform ILI signal review analysis
 - Driven (in part) on spreadsheet-based CGRs (e.g., locations calculated to reach criticality prior to next planned ILI were included in reviews)
 - Establish refined CGRs
- Quantify impacts of ILI signal review analysis
 - Reduction / increase in joints calculated to reach criticality prior to next ILI

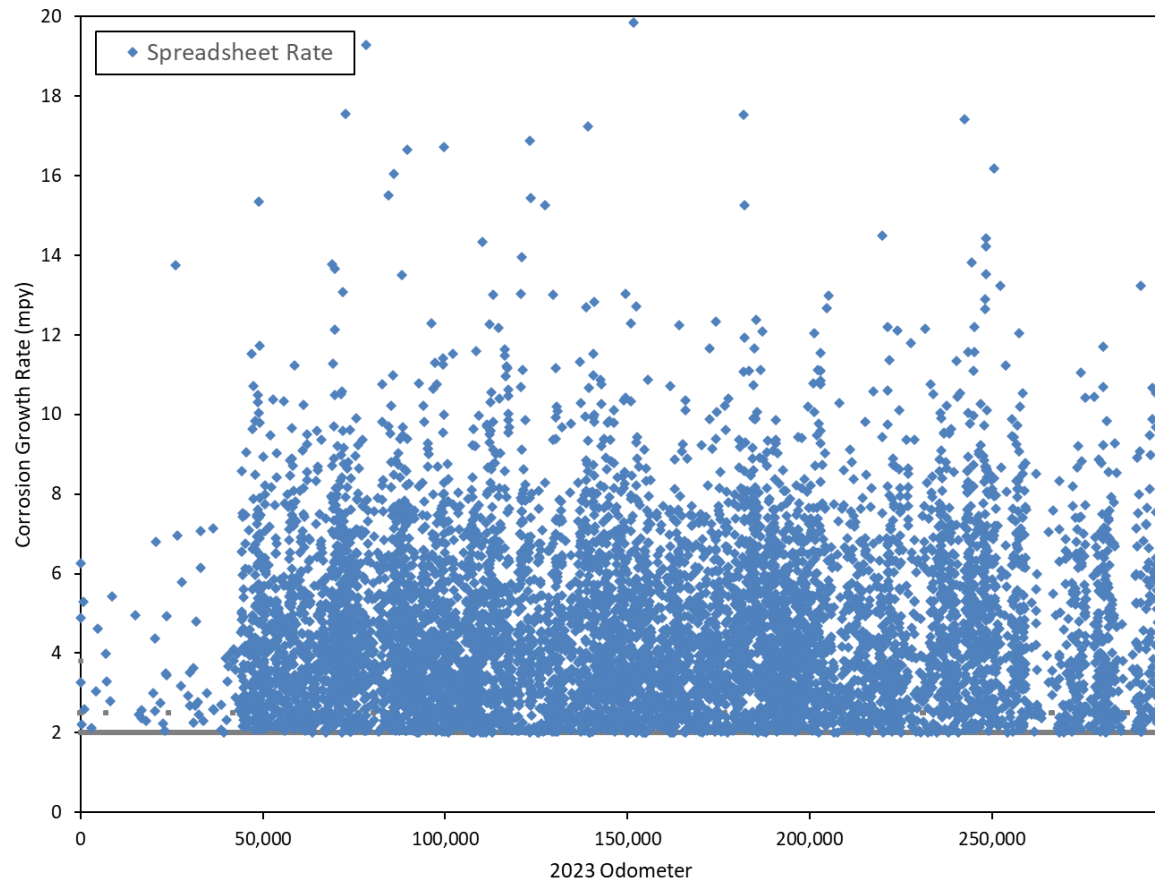
Definition of Criticality

- Scenario 1 – Depth Criteria
 - The ILI-reported depth is grown until it is greater than or equal to 80% NWT
- Scenario 2 – Pressure Criteria
 - The ILI-reported reported length and depth are grown until they result in a calculated failure pressure less than the maximum allowable operating pressure (MAOP), as calculated using Modified B31G (i.e. $85dL \text{ burst pressure} \leq \text{MAOP}$). The growth is assumed to occur in both depth and length (i.e., constant growth rates were applied to both the depth and the length).

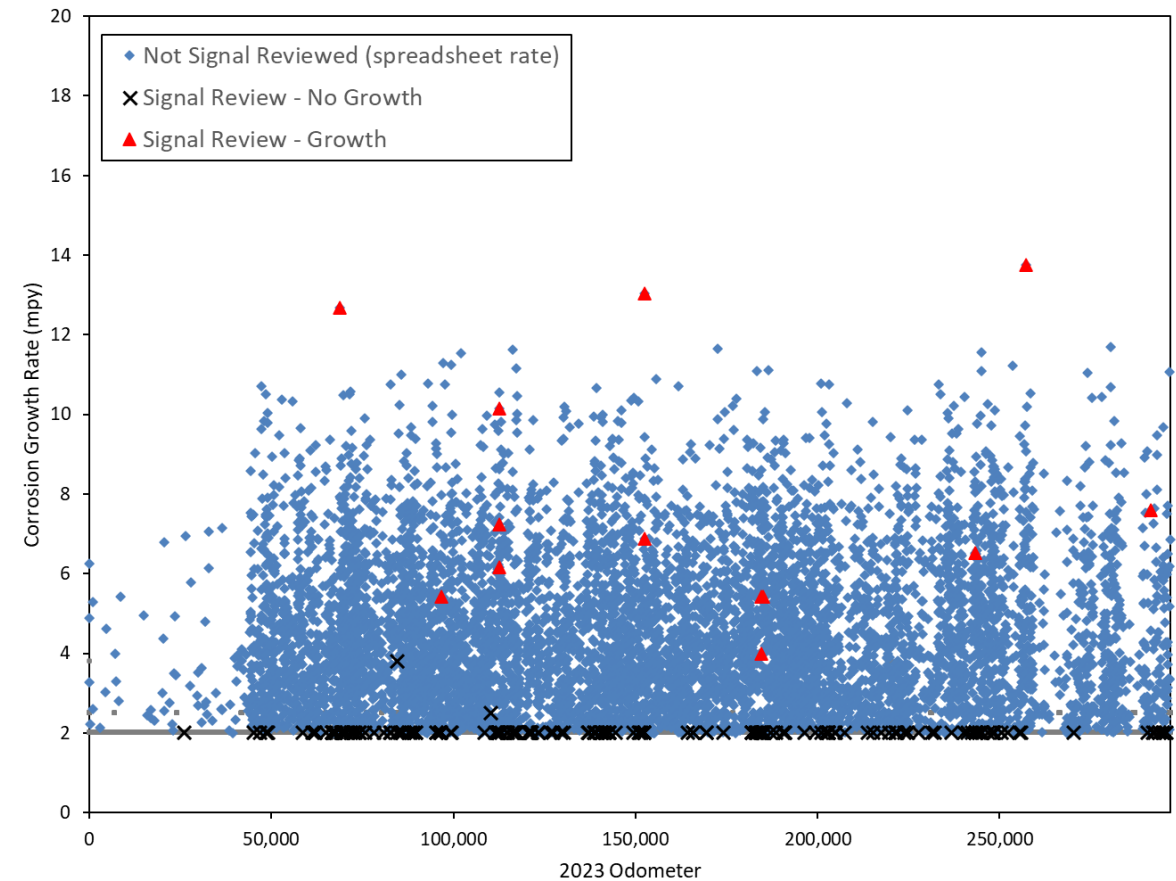
ILI Signal Review Analysis

- Previous and current ILI signal data were reviewed at targeted locations to look for evidence of corrosion growth
- Joints selected for signal review based on various criteria
 - Highest spreadsheet-based CGRs
 - Relatively large depth increases between matched anomalies
 - Locations calculated to reach criticality prior to next ILI
 - Etc.
- 201 joints included in ILI signal review analysis
 - 13 contained observed growth. CGRs assigned based on specific anomalies in the joints that were growing. CGRs ranged from ~4 mpy to 14 mpy
 - 188 had no visible growth. These joints were assigned a default minimum CGR (e.g., 2 mpy)

Corrosion Growth Rates Pre-ILI Signal Review



Corrosion Growth Rates Post-ILI Signal Review



Criteria	Joint Counts			Comment
	Max CGR	Mean CGR	Anomaly CGR	
Joints with time to criticality ≤ 6 years – Pre-Signal Review	32	5	62	Joints potentially included in dig program if no signal review analysis was conducted
Joints with time to criticality ≤ 6 years – Post-Signal Review	10	10	10	Joints potentially included in dig program following comprehensive ILI run comparison analysis
Joints with time to criticality ≤ 6 pre-signal review; but > 6 years following ILI signal review	27	1	54	Possible removal from dig program
Joints with time to criticality > 6 years pre-signal review; but ≤ 6 years following signal review	5	6	2	Possible additions to dig program

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- Pre-signal review: 32 joints; 42 anomalies
- Post-signal review: 10 joints; 15 anomalies
- Total reduction of 22 joints

- We ‘remove’ 27 from the dig program (cost implications)
- We ‘add’ five into the dig program (safety implications)

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- Pre-signal review: 5 joints; 6 anomalies
- Post-signal review: 10 joints; 15 anomalies
- Total increase of 5 joints

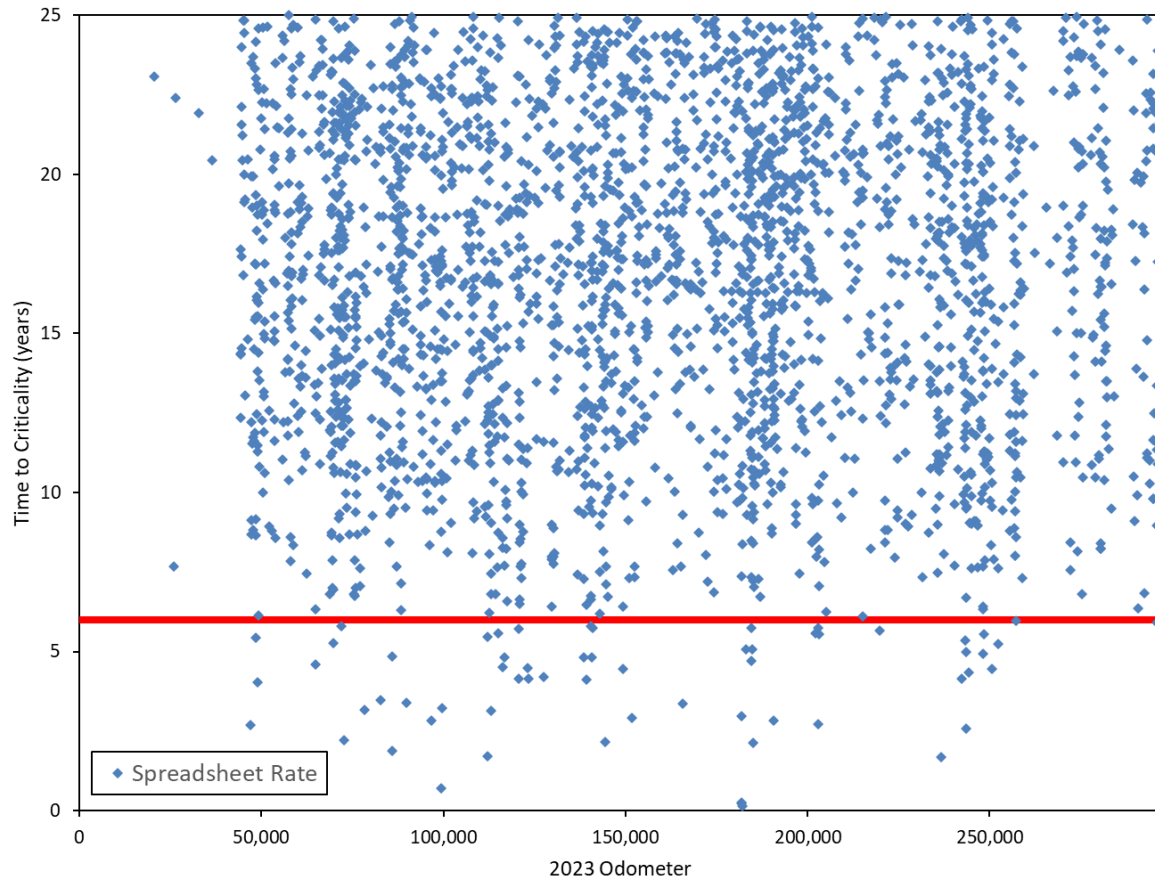
- We 'remove' 1 from the dig program (cost implications)
- We 'add' 6 into the dig program (safety implications)

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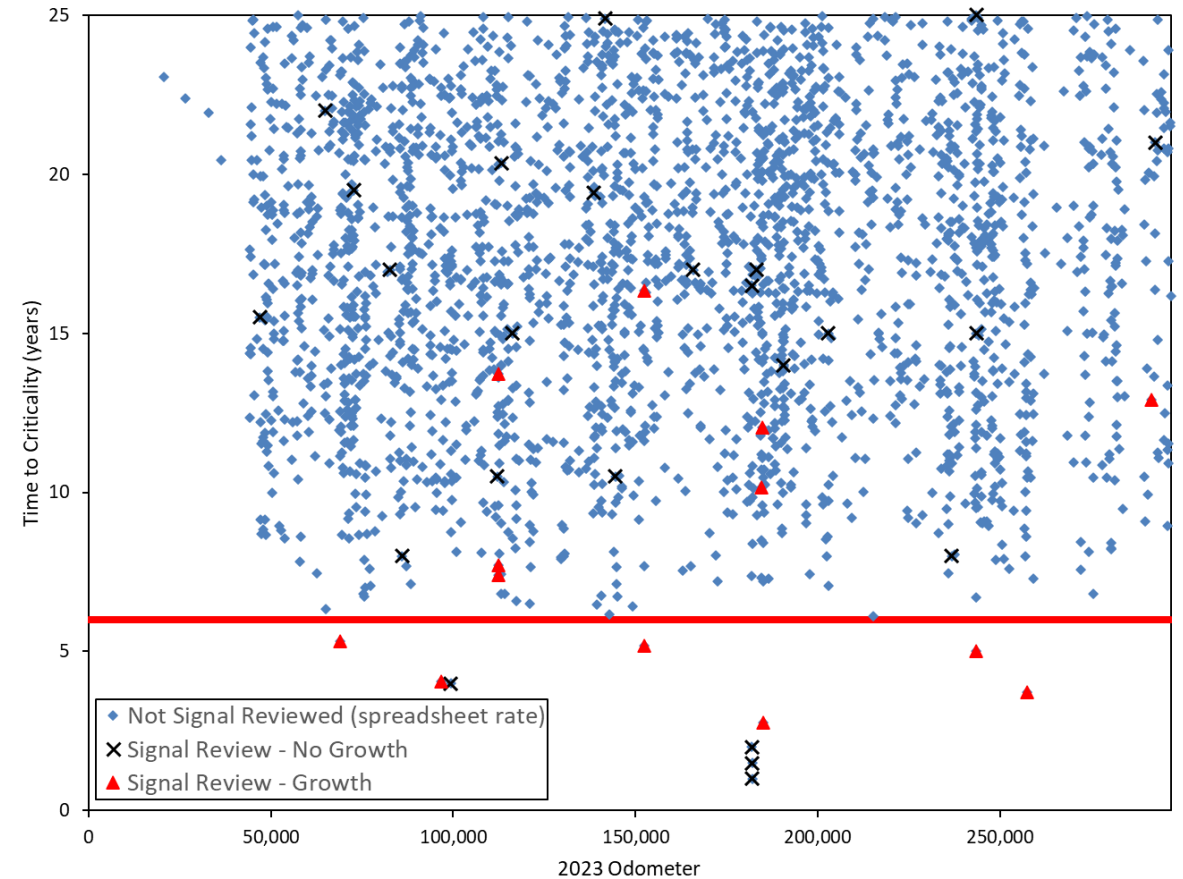
- Pre-signal review: 62 joints; 181 anomalies
- Post-signal review: 10 joints; 15 anomalies
- Total decrease of 52 joints

- We ‘remove’ 54 from the dig program (cost implications)
- We ‘add’ 2 into the dig program (safety implications)

Time to Criticality Pre-ILI Signal Review



Time to Criticality Post-ILI Signal Review



Conclusions and Path Forward

- ILI run-to-run comparisons can provide valuable information about the future of your pipeline asset.
- However, we must go beyond spreadsheets!
 - Consider ILI bias... create an ‘apples-to-apples’ comparison
 - Consider statistical analyses to establish locations most likely to contain active corrosion
 - **Perform ILI signal review comparisons**
- Optimize dig plans and establish meaningful and data driven reassessment intervals

Conclusions and Path Forward, Cont.

- ILI signal review analyses may reduce the digs without compromising the integrity of your pipeline asset
 - The spreadsheets comparisons were ‘fooled’ (indicated non-growing locations were growing)
- However, ILI signal review analyses may make you aware of potentially critical locations that you were previous unaware of
 - The spreadsheet comparisons suggest lower CGRs than what is actually occurring in the pipeline
- Path forward: Prepare an accompanying paper by incorporating dig results (digs to take place in the coming months)

Thank You!

Questions?



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