Getting your Data Together
Machine Learning for Pipeline Integrity

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Presentation Outline

- Background
- Machine Learning
- Northern Trunkline
- Discussion on Assessments and Outcome
- Conclusion

Background

Risk

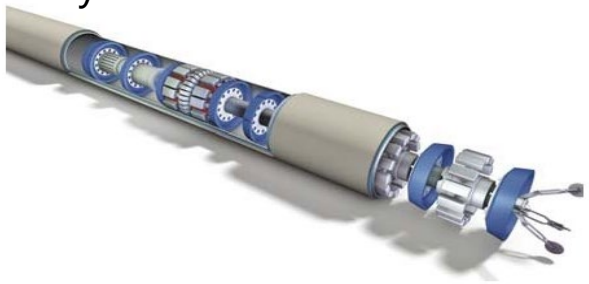
RISK = Probability × Impact

Risk is correlation of
- Probability of occurring
- Consequences/Impact.

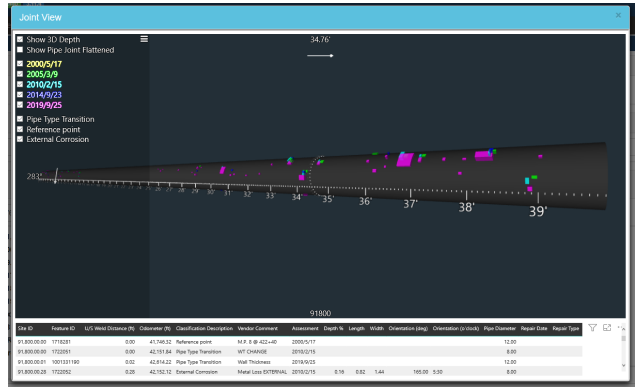
Quantifying Risk

Quality Data ➡ Accurate Probability

Modern Inspection techniques provides a significant amount of quality data



Reference Public image library of Nord Stream AG



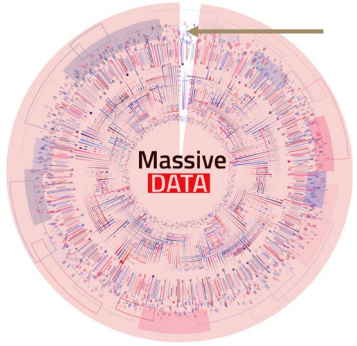
Challenge

Limited Resources

assessments are vendor driven,

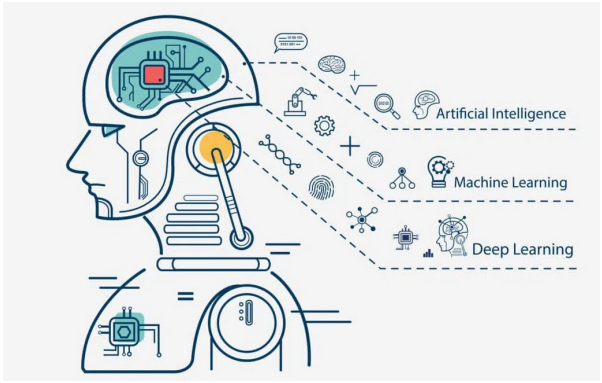
New data isn't correlated effectively with past data

Consequence



The industry utilises less than 5% of the collected data

Modern Solution



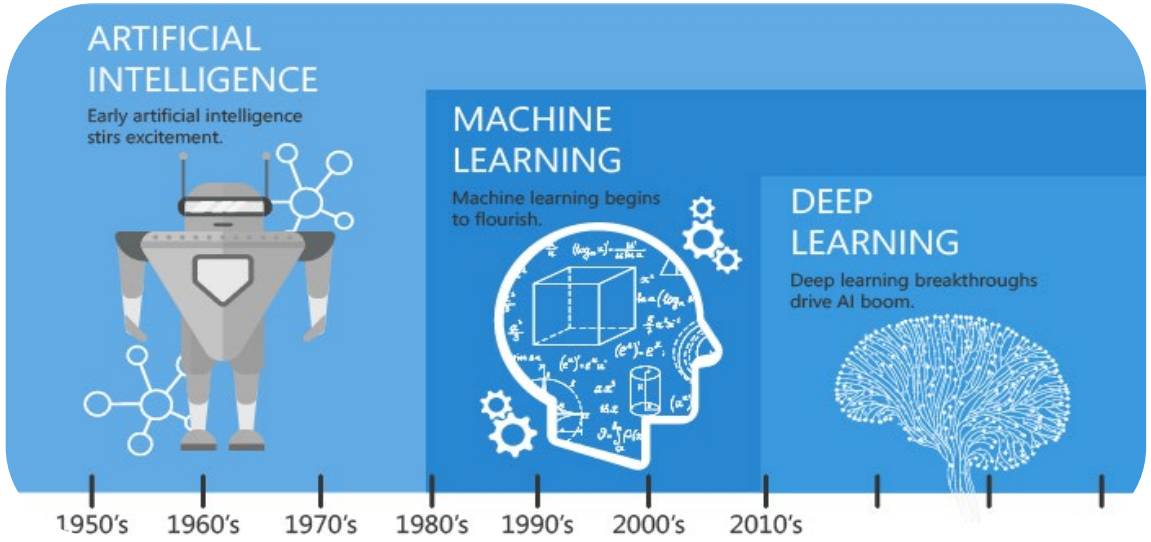
In 20th Century, we invented machine to collect the data, in 21st Century we can train new generation to analyse the data

https://www.atriainnovation.com/en/machine-learning-in-industry/

What is Machine Learning?

- Machine learning is a field of computer science that use statistical techniques to learn and predict ‘events’ based on pattern recognition

- It has been applied to:
  - Finance Industry
  - Health Industry
  - Supply Change



Reference : Artificial Intelligence vs. Machine Learning vs. Deep Learning , Artem Oppermann, Link

24/7 real time monitoring

We have dedicated teams working 24/7 looking for suspicious transactions and activity across your accounts. If we detect anything, we'll contact you so please ensure your contact details are up-to-date.

Where we suspect activity or transactions may be unauthorised, we may then contact you to confirm whether the activity and transactions were undertaken by you. We may contact you using the below methods:

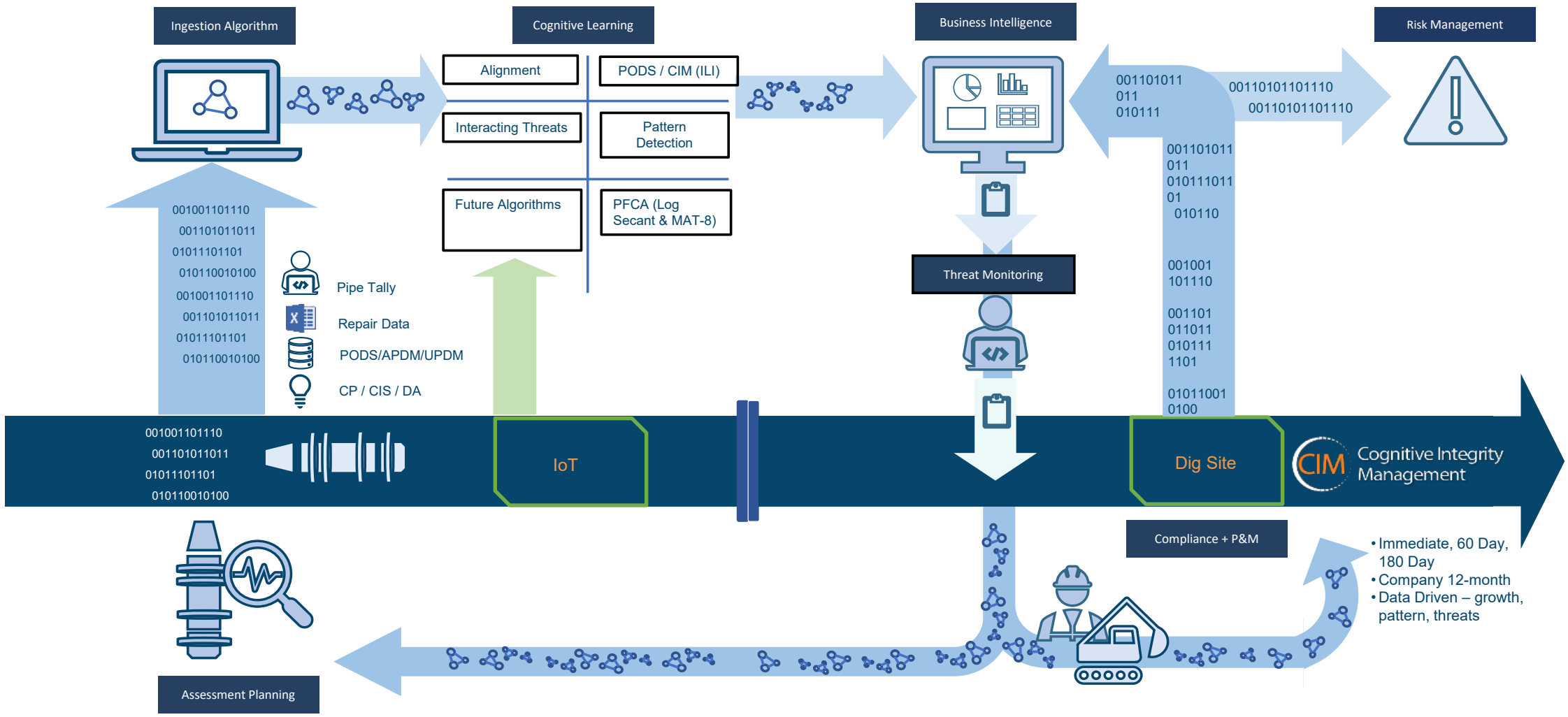
- A phone call from one of our fraud analysts
- An automated voice-activated call from our telephone alert system, from 1300 754 566
- An automated SMS from our SMS service system (this will appear from + 61427741911, + 61447268622, or appear as CommBank)

The voice-activated telephone or SMS alert can contact you within seconds of any potential fraudulent activity on your account.

If you receive a SMS from us asking you to confirm the transaction with a 'yes' or a 'no', simply respond:

- 'yes' if it was you that attempted the transaction, or
- 'no' if you did not attempt the transaction and one of our agents will give you a call to go through the next steps.
- If the original transaction was declined, you can re-attempt it after responding 'yes' and the transaction should be successful.

Application of Machine Learning to Pipelines – Cognitive Integrity Management



What does Machine do for us?

Align Multiple Inspections

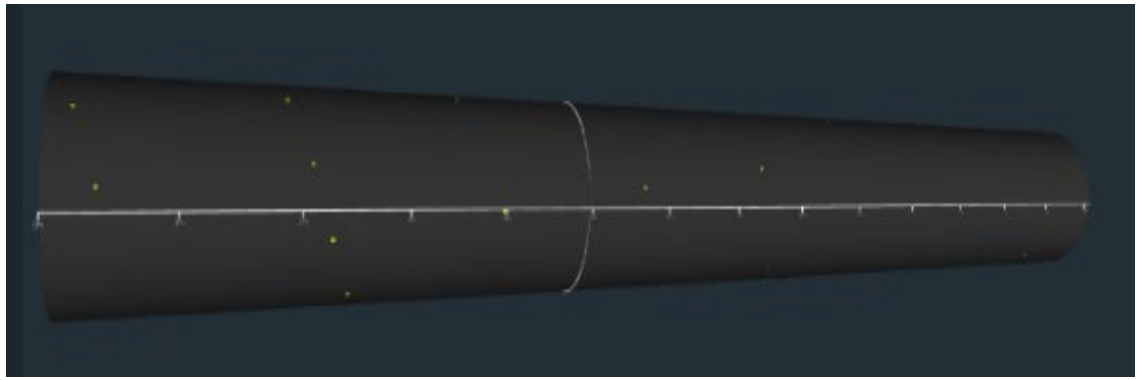
- Align multiple inspection reports to calculate growth rate on anomaly level.

2007 EMAT			2012 MFL A			2017 MFL C			2022 MFL Combo		
Joint No.	Log Distance	Joint Length	Joint No.	Log Distance	Joint Length	Joint No.	Log Distance	Joint Length	Joint No.	Log Distance	Joint Length
140	113.03	26.57	140	113.02	26.58	140	113.02	26.58	140	113.02	26.58
150	139.60	26.21	150	139.60	26.22	150	139.60	26.22	150	139.60	26.22
160	165.81	14.99	160	165.82	15.00	160	165.82	15.00	160	165.82	15.00
170	180.81	40.39	170	180.82	40.39	170	180.82	40.39	170	180.82	40.39
180	221.19	26.15	180	221.21	26.12	180	221.21	26.12	180	221.21	26.12
190	247.34	26.31	190	247.33	26.34	190	247.33	26.34	190	247.33	26.34
200	273.66	40.52	200	273.66	40.51	200	273.66	40.51	200	273.66	40.51
210	314.17	21.29	210	314.18	21.30	210	314.18	21.30	210	314.18	21.30
220	335.47	40.62	220	335.48	40.62	220	335.48	40.62	220	335.48	40.62
230	376.08	40.55	230	376.09	40.54	230	376.09	40.54	230	376.09	40.54
240	416.63	39.21	240	416.64	39.21	240	416.64	39.21	240	416.64	39.21
250	455.84	40.45	250	455.84	40.46	250	455.84	40.46	250	455.84	40.46
260	496.29	40.62	260	496.30	40.59	260	496.30	40.59	260	496.30	40.59
270	536.91	40.29	270	536.90	40.31	270	536.90	40.31	270	536.90	40.31
280	577.20	40.55	280	577.20	40.54	280	577.20	40.54	280	577.20	40.54
290	617.75	40.29	290	617.75	40.31	290	617.75	40.31	290	617.75	40.31
300	658.04	40.42	300	658.05	40.42	300	658.05	40.42	300	658.05	40.42
310	698.46	40.32	310	698.47	40.31	310	698.47	40.31	310	698.47	40.31
320	738.78	40.35	320	738.78	40.35	320	738.78	40.35	320	738.78	40.35
330	779.13	3.58	330	779.13	3.58	330	779.13	3.58	330	779.13	3.58
340	782.71	40.65	340	782.71	40.64	340	782.71	40.64	340	782.71	40.64
350	823.36	16.60	350	823.35	16.61	350	823.35	16.61	350	823.35	16.61
360	839.96	37.96	360	839.96	37.95	360	839.96	37.95	360	839.96	37.95
370	877.92	40.58	370	877.91	40.59	370	877.91	40.59	370	877.91	40.59
380	918.50	38.55	380	918.50	38.55	380	918.50	38.55	380	918.50	38.55
390	957.05	37.40	390	957.05	37.42	390	957.05	37.42	390	957.05	37.42
400	994.46	37.57	400	994.47	37.55	400	994.47	37.55	400	994.47	37.55
410	1,032.02	37.86	410	1,032.02	37.86	410	1,032.02	37.86	410	1,032.02	37.86
420	1,069.88	37.70	420	1,069.88	37.69	420	1,069.88	37.69	420	1,069.88	37.69
430	1,107.58	40.32	430	1,107.57	40.34	430	1,107.57	40.34	430	1,107.57	40.34
440	1,147.90	38.71	440	1,147.91	38.72	440	1,147.91	38.72	440	1,147.91	38.72

Automatic alignment of reverse pigged inspection

Assessment Name	ILI2010			ILI2020		
Master Joint ID	Joint No.	Log Distance	Joint Length	Joint No.	Log Distance	Joint Length
500,005,700.00	68070	1,972.39	58.56	68070	389,849.05	58.62
500,005,800.00	68060	2,030.95	60.16	68060	389,790.43	58.61
500,005,900.00	68050	2,091.11	57.96	68050	389,730.26	60.17
500,006,000.00	68040	2,149.07	59.73	68040	389,672.31	57.96
500,006,100.00	68030	2,208.80	46.11	68030	389,612.91	59.39
500,006,200.00	68020	2,254.92	59.42	68020	389,566.41	46.50
500,006,300.00	68010	2,314.34	57.44	68010	389,506.86	59.55
500,006,400.00	68000	2,371.78	59.53	68000	389,449.28	57.58
500,006,500.00	67990	2,431.31	59.48	67990	389,389.71	59.57
500,006,600.00	67980	2,490.79	58.55	67980	389,330.15	59.56
500,006,700.00	67970	2,549.34	57.66	67970	389,271.60	58.55
500,006,800.00	67960	2,607.00	57.69	67960	389,213.86	57.74
500,006,900.00	67950	2,664.69	57.50	67950	389,156.12	57.74

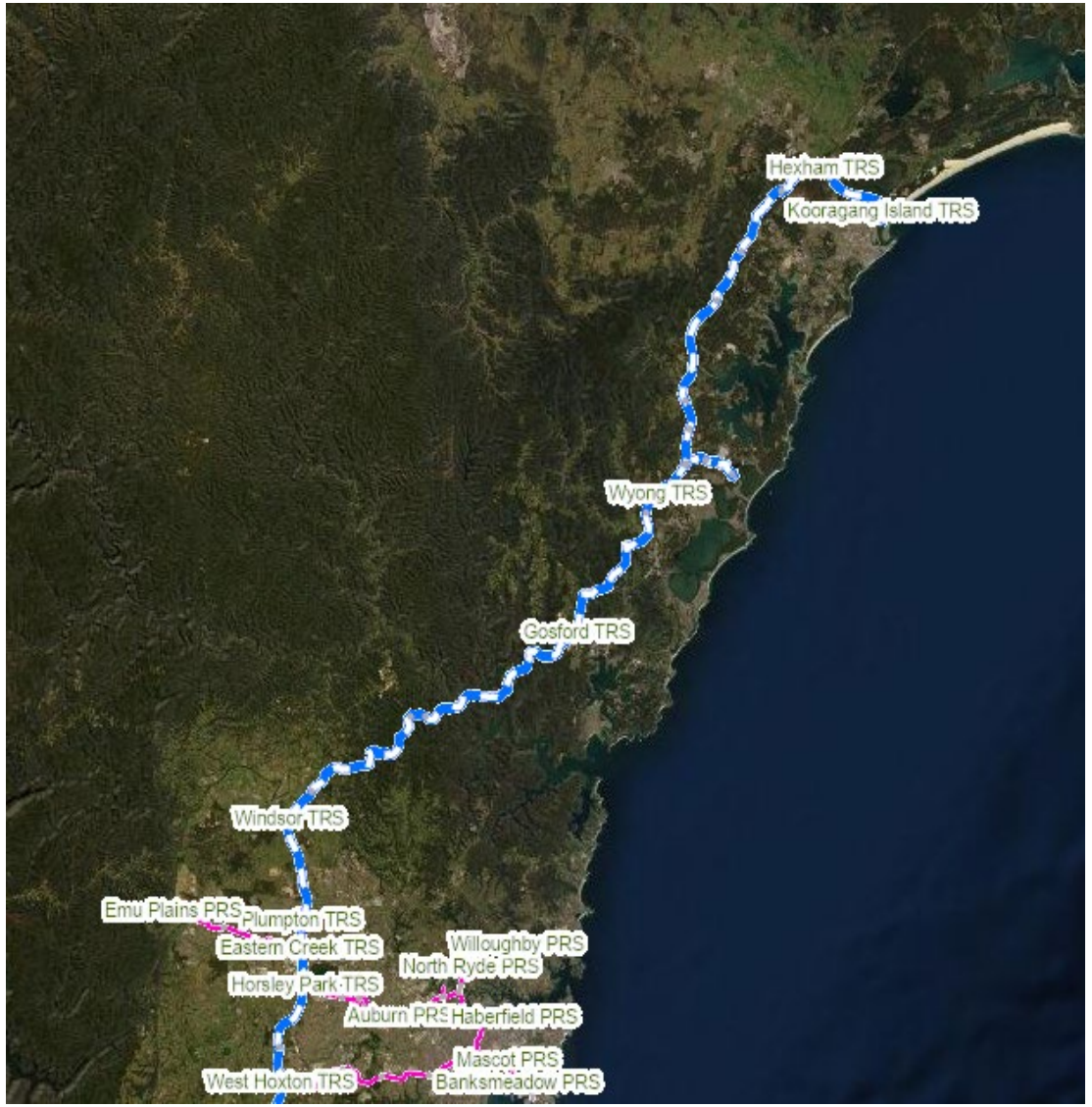
Identification of patterns in Spiral welded pipes



A case Study
Northern Trunk Line

Pipeline Details

Pilot Study	
Pipeline Length	171 Km
Pipeline Nominal Diameter	20”
Pipeline Segments	L3, L7 and L8
Pipeline Total Length (Km)	171
Pipeline ILI History	1998 ROSEN 2008 ROSEN 2018 BHGE



Summary of Anomalies in One Snapshot – Traditional

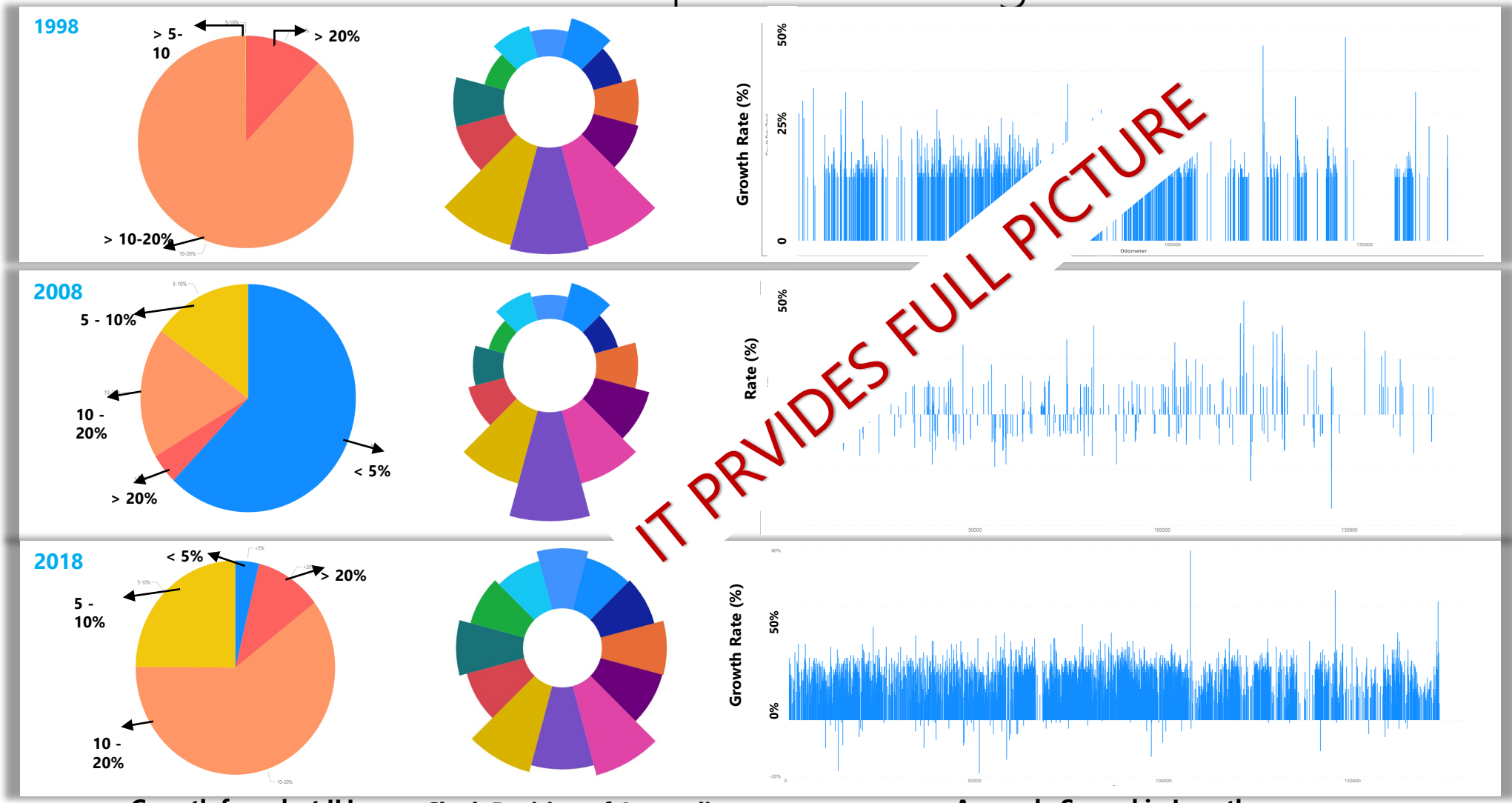
What Does it tell us?

- Statistical distribution of anomalies.
- Confusing
- Doesn't relate to physics
- Doesn't correlate the data and anomaly growth

Summary of Anomalies in One Snapshot – Using ML

what Does it tell u?

- Clear
- Data is presented with respect to Physical properties – Location, Position, mechanism/pattern
- Data are correlated and growth can be tracked.



Growth from last ILI

There has been size growth between ILIs however it is less than 20% (mostly tool tolerance)

Clock Position of Anomalies

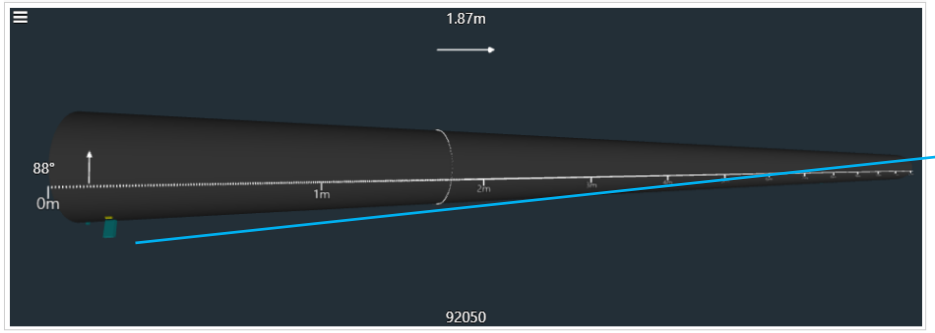
The anomaly were concentrated at the bottom of line in 2008 however the 2018 shows they are evenly distributed circumferentially.

Anomaly Spread in Length

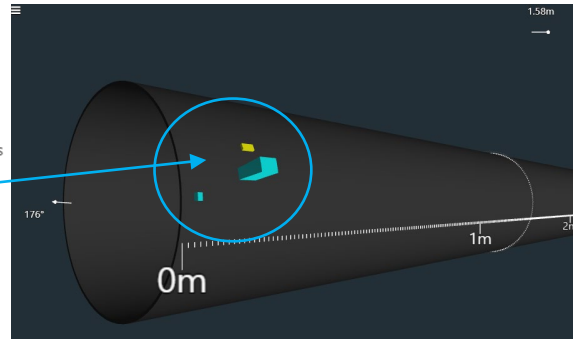
- There is a significant growth on number of anomalies along the pipeline however the growth is not significant.
- There are handful of areas that needs to be investigated

How does it look like at anomaly level?

An anomaly with multiple ILIs

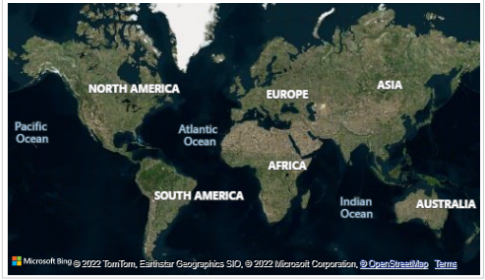


Corrosion cluster
Feature ID
107196.158
Odometer
Corrosion Wall Loss
Alias Type
0.102
U/S Weld Distance
60.0%
Curr. Max Depth %
(Blank)
Ref. Max Depth %



Anomalies on Selected Joint

Feature ID	Aligned to Feature	Max Depth %	U/S Weld Distance	Length	Width	Orientation	Assessment
Corrosion		15.0%	0.020	8.001	15.603	174	2018/11/14
Corrosion cluster		60.0%	0.102	32.931	24.293	163	2018/11/14
		11.0%	0.119	23.000	14.000	149	2008/11/29
Metal Object			8.365	79.809	178.532	194	2018/11/14



- Dig Up confirmed prediction.

Results Comparison of Cost – Machine vs Traditional Method

Machine

Results – 4.1MPa Growth vs 5MPa Growth

	3 years		5 years		7 years		10 Years	
	CIM	Repaired/Inspected	CIM	Repaired/Inspected	CIM	Repaired/Inspected	CIM	Repaired/Inspected
MOP = 5MPa								
# of Digs	4	1	6	3	8	3	12	3
Threat type	HSS 4 Ext 0 Int 0		HSS 5 Ext 0 Int 1		HSS 5 Ext 2 Int 1		HSS 6 Ext 1 Int 5	
Total Dig Cost 300k per dig	**900K**		**900K**		**1500K**		**2700K**	
MOP = 4.1 MPa								
# of Digs	4	1	6	3	8	3	12	3
Threat type	HSS 4 Ext 0 Int 0		HSS 5 Ext 0 Int 1		HSS 5 Ext 2 Int 1		HSS 6 Ext 2 Int 4	
Total Dig Cost 300k per dig	**900K**		**900K**		**1500K**		**2700K**	

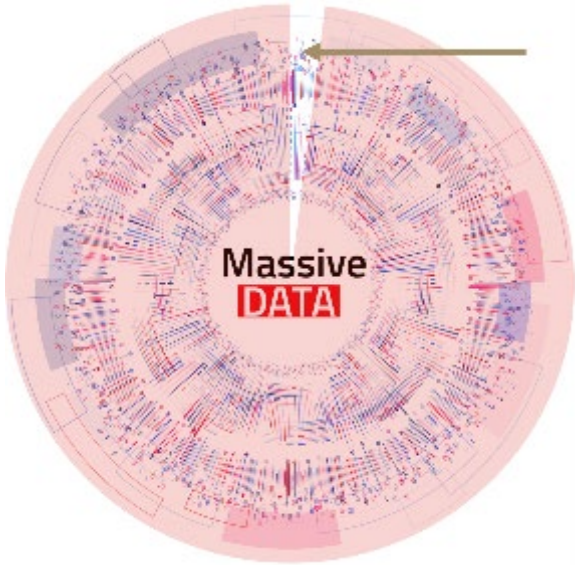
Traditional Method

MOP	Anomaly Type	Quantity	Assumed % requiring dig up	Cost of Dig ($300k/dig)	Total Cost
4.1	HSS	6	95%	$ 1.71 M	$ 2.41 M
	Ext Body	4	50%	$ 0.6 M	
	Internal	16	2%	$ 0.02 M	
5.0	HSS	8	95%	$ 2.28 M	$ 4.71 M
	Ext Body	15	50%	$ 2.25 M	
	Internal	30	2%	$ 0.18 M	

- Using machine, the estimated cost of maintenance in 5 years is reduced by a factor of 5.
- It reduced the ILI frequency.

Why a large difference?
Data alignments allows pit to pit growth rate calc.

- **Pit to Pit Measurement**
  - The best method for determining corrosion rates is by directly comparing measured wall thickness changes after a known time interval.
- **Half Life calculation**
  - Measuring the corrosion rate of the material and manage future inspection based on the worst case half life established at each location.
- **One Size fit all – Flat/default rate**
  - The least accurate method is by using a default rate

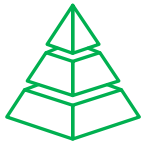


Conclusion

- In 20th Century, we invented machine to collect the data, in 21st Century we certainly can train new generation to analyse the data.
- Using machine to analyse a large amount of data Jemena was able to significantly decrease
  - Assessment time by a factor of 10 (2 weeks vs 6 Months),
  - Cost by a factor of 5.

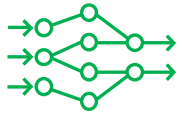
Save time

Save costs



Reduce risk

Improve accuracy



Increase certainty

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