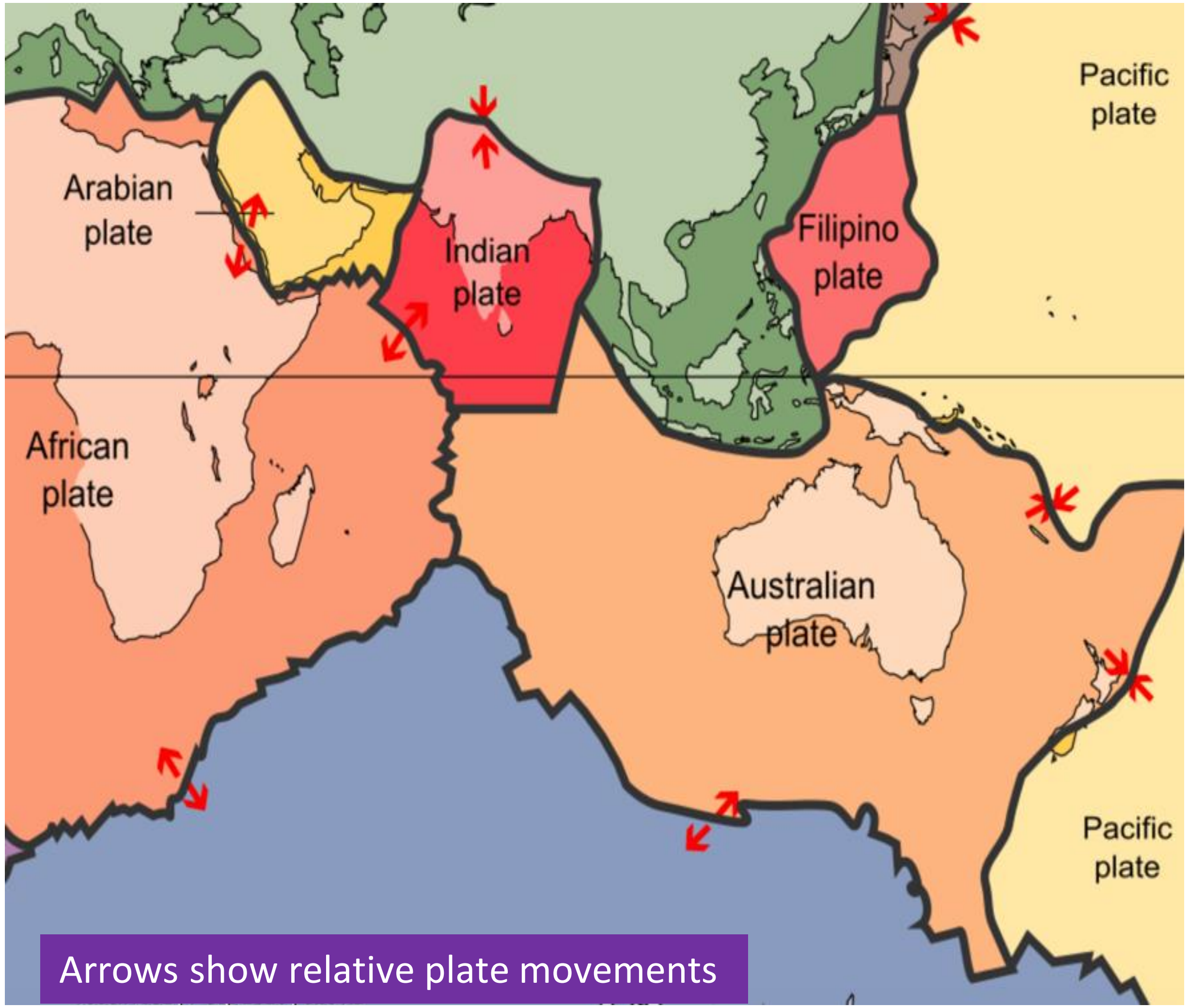
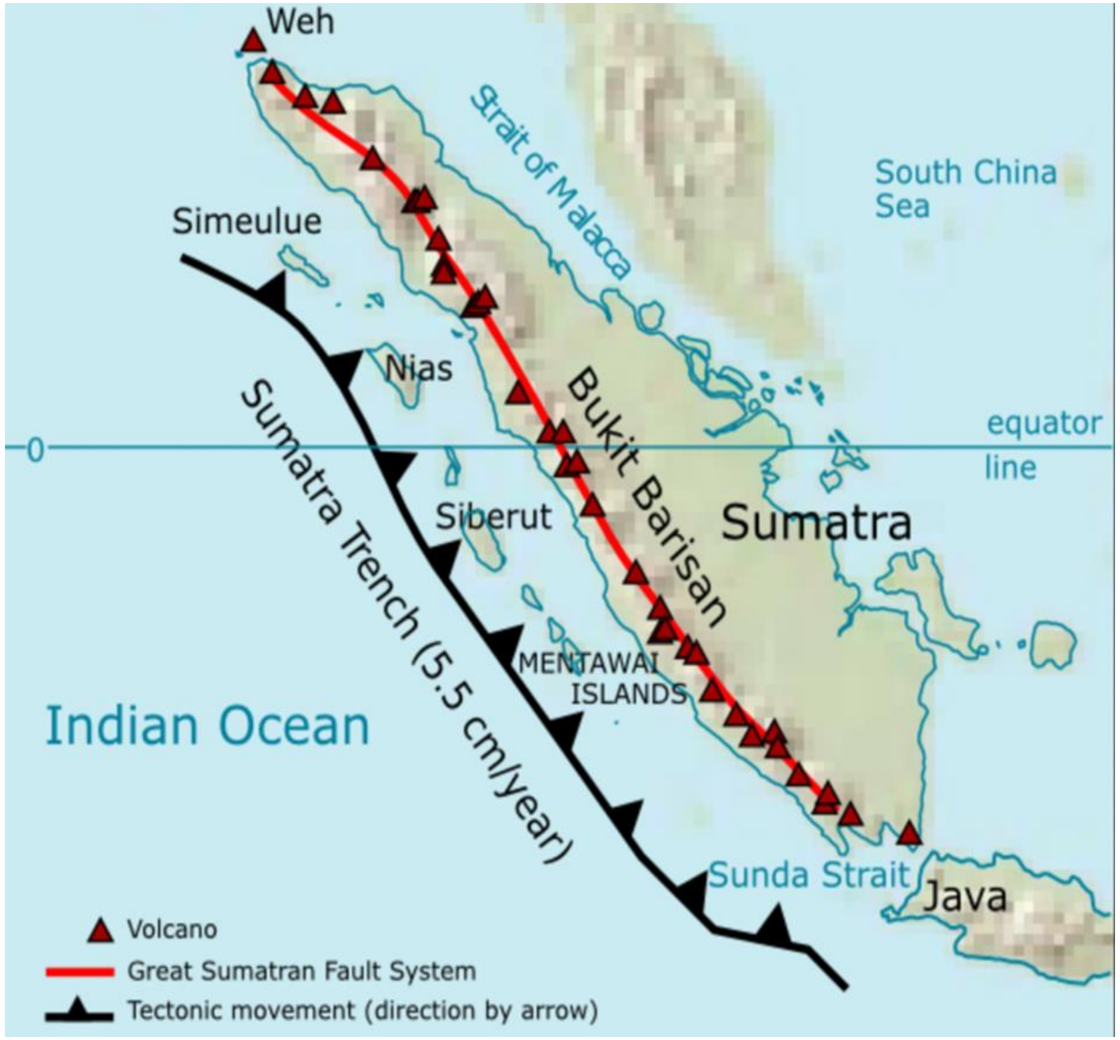
Effective management of geohazard threats in pipelines

Derek Storey, Bipin Thomas, Suji Kurungodan,
Inspipe Integrity Ltd, UK
(www.inspipe.net)

Pranav Pasari, Satsense Solutions Ltd, UK
(www.satsense.co)

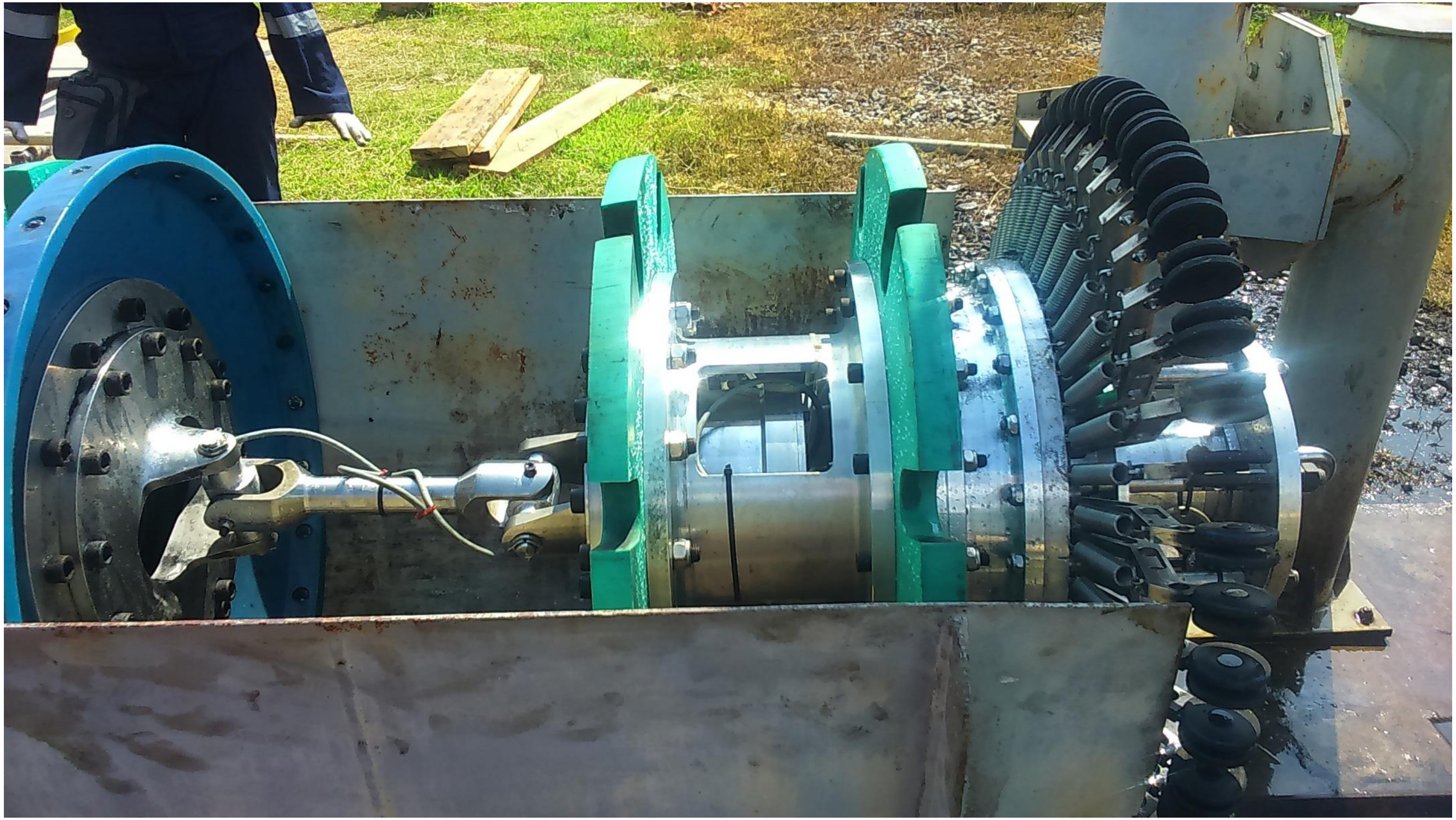


Indo-Australian Tectonic Plates



Major Tectonic Features of Sumatra

Receiving the 28” High Resolution Geometry + IMU Survey Tool



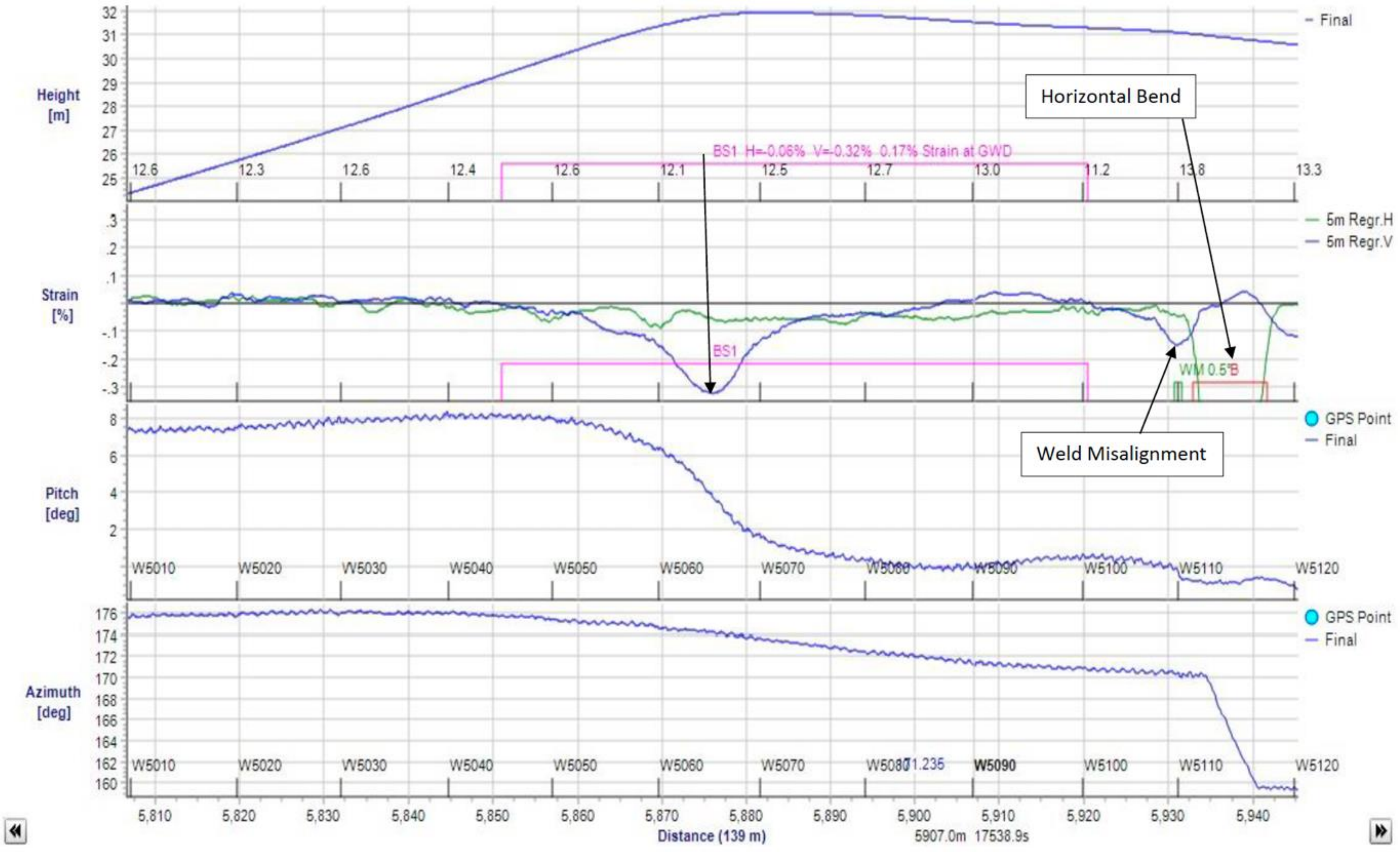
28” High Resolution Geometry + IMU Survey Tool

Feature No.	Distance, m	Reduction		Remaining ID, mm	Velocity, ms^{-1}	Remarks
		mm	%			
6	2.69	7.78	1.16	661.42	1.26	Valve
11	5.33	3.71	0.55	665.49	3.77	Tee
13	7.38	9.12	1.36	660.08	3.75	Tee
22	29.57	8.11	1.21	661.09	3.43	Tee
1923	22,393.86	4.52	0.68	664.68	1.21	Tee
1935	22,413.72	10.45	1.56	658.76	1.92	Tee
1938	22,415.86	4.96	0.74	664.24	1.44	Valve

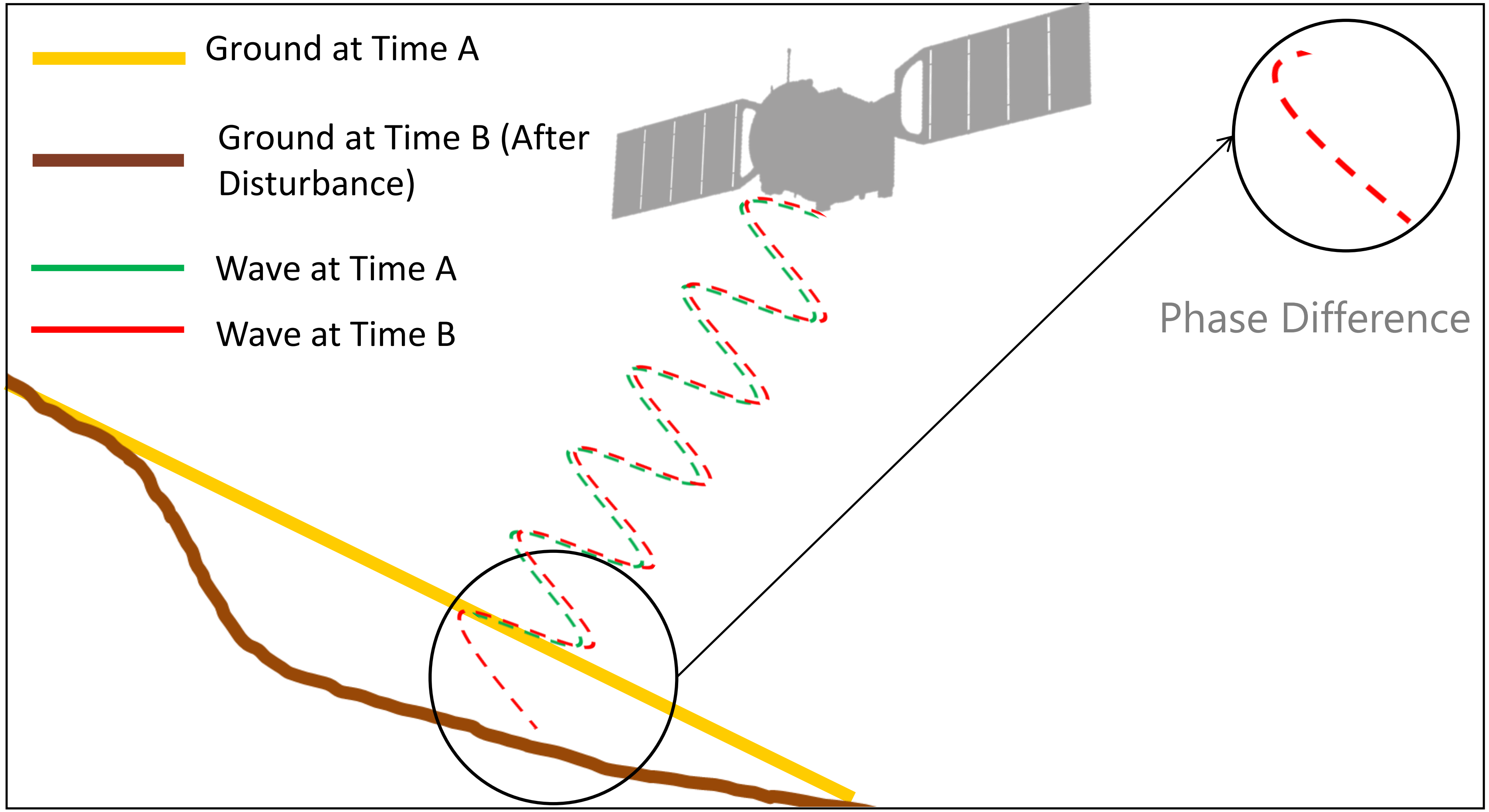
Most significant geometric features found in the pipeline

Feature ID	Distance (m)	Peak Strain			Main Orientation	Start Distance (m)	End Distance (m)	Length (m)	UTM Zone 48 (CM 105)			Comments
		Vertical (%)	Horizontal (%)	Total (%)					Latitude (deg)	Longitude (deg)	Height (m)	
BS1	5875.996	-0.32	-0.06	0.33	Vertical	5850.981	5920.332	69.351	-3.38429424	104.08386910	31.808	0.17% Strain at GWD
BS2	9568.113	-0.20	-0.03	0.20	Vertical	9536.697	9576.321	39.624	-3.40005962	104.10993357	32.814	0.19% Strain at GWD
BS3	11353.440	-0.25	-0.01	0.25	Vertical	11317.710	11380.690	62.980	-3.40921303	104.12276949	47.940	0.24% Strain at GWD
BS4	14938.750	-0.20	0.02	0.20	Vertical	14916.950	14953.240	36.290	-3.41608719	104.15379112	43.705	At GWD
BS5	15314.910	-0.17	-0.01	0.22	Vertical	15283.650	15322.570	38.920	-3.41707100	104.15699527	53.160	

List of Bending Strain Areas Identified from IMU Analysis



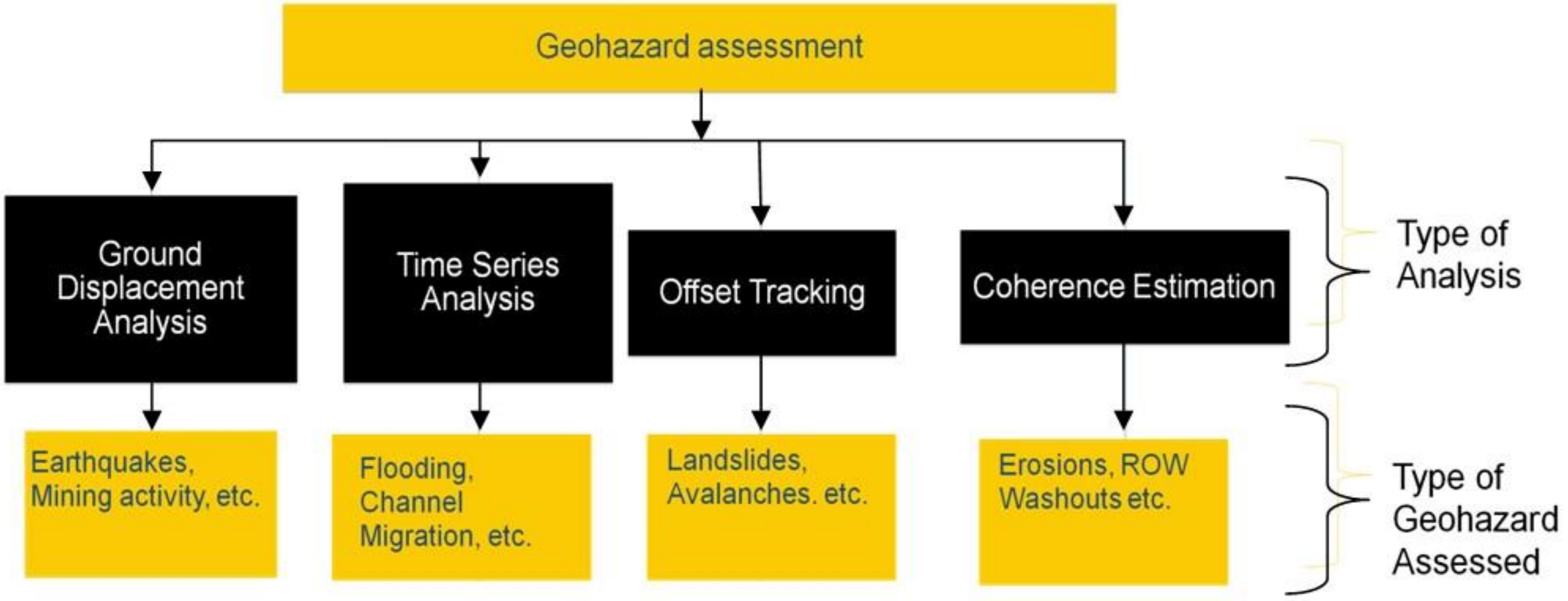
Plots of Bending Strain for Feature BS1 (Max. Bending Strain 0.33%)



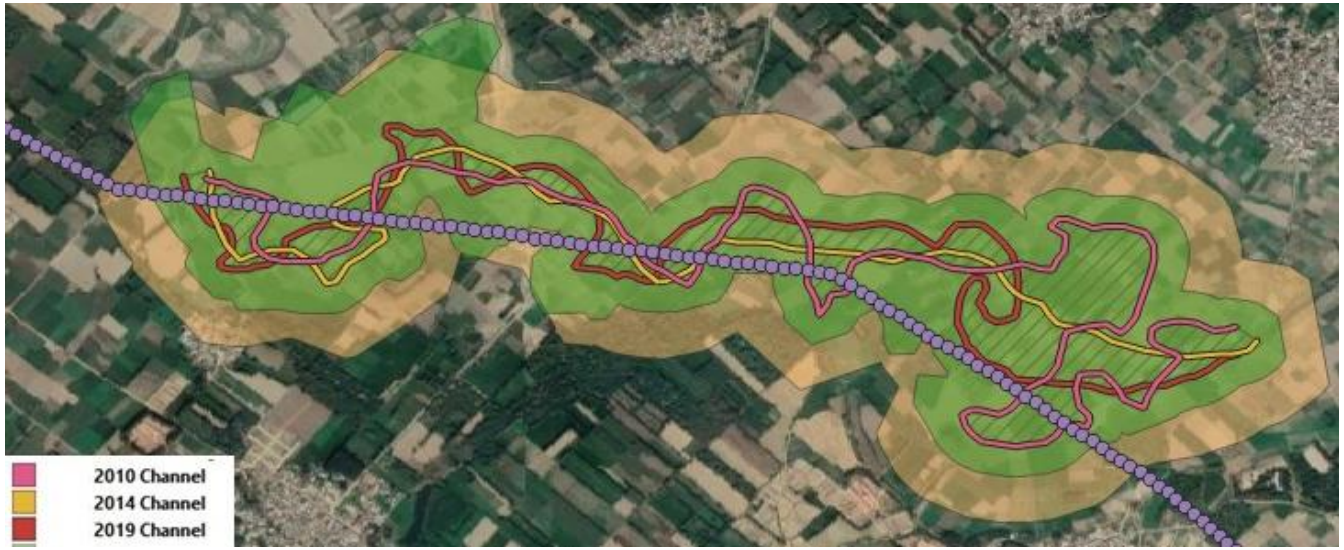
Visual Representation of the Phase Difference in Interferometric SAR processing

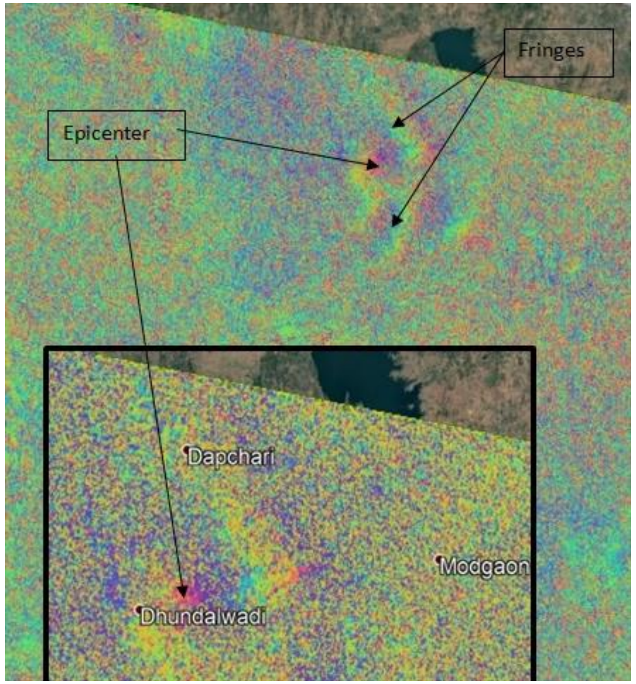
Geological Category	Specific Geohazards
Seismic	Faults, Liquefaction, Lateral Spreading, Tsunami.
Geotechnical	Landslides, Slope Creep, Karst, Subsidence, Mining.
Hydrotechnical	Channel Migration, Flooding, Vertical Scour, Lateral Scour.
Erosional	Headcuts, Downcutting, ROW Washouts, Erodible Soils.

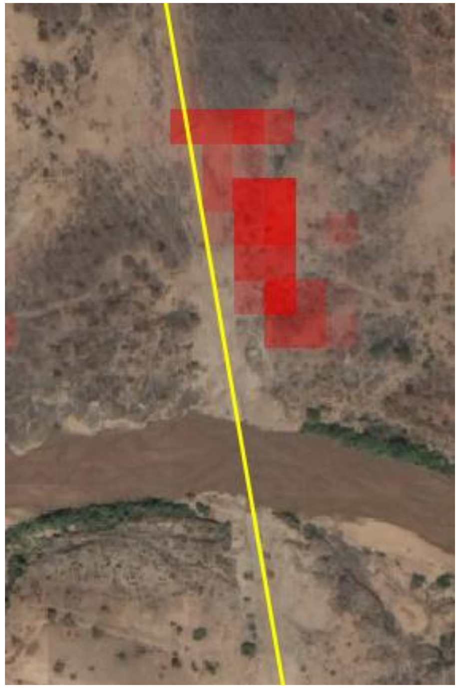
Categories and examples of Geohazards that typically pose risks to Pipelines



Schematic of types of Analyses used for different Geohazard assessments







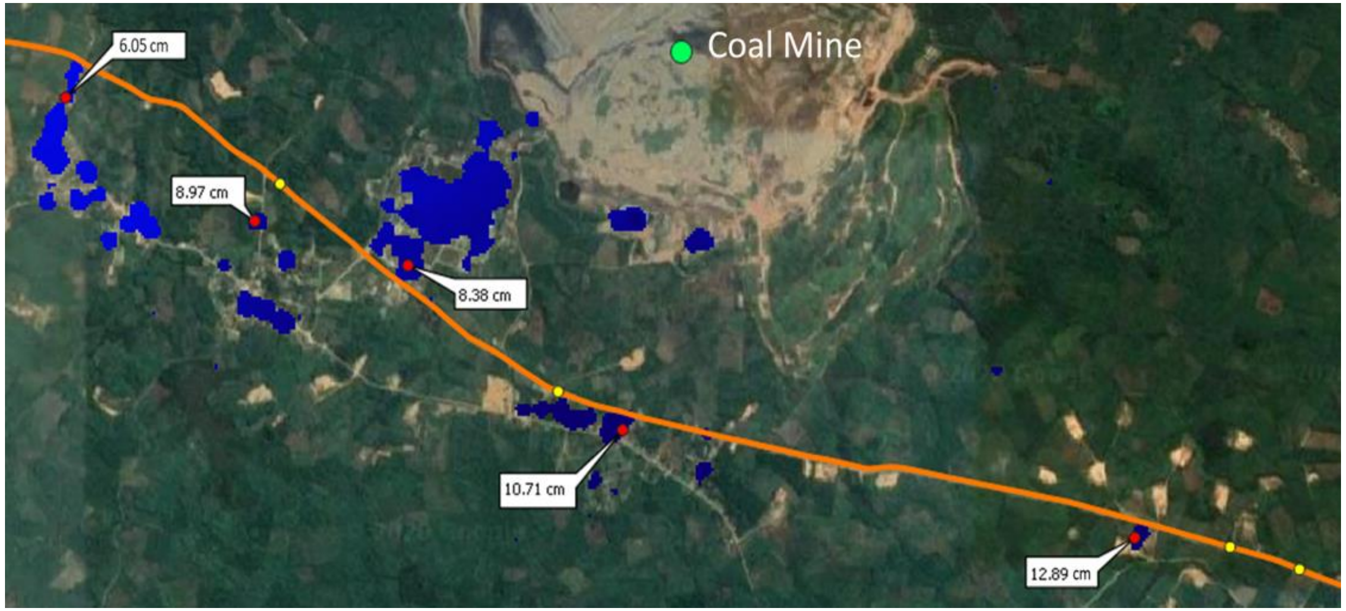
Clockwise from Top, Hydro-technical (Channel Migration), Erosional (ROW Washout) & Seismic (Faults).

Location of Bending Strain Areas identified from IMU Analysis

Sr. No.	Distance (m)	Height[m]	Latitude[deg]	Longitude[deg] - UTM Zone 48	Displacement measured using SAR (in cm)	Displacement measured using SAR (in cm)- High Coherence Values
946	11613.488	44.827	-3.4099322	104.124954	10.2469	
947	11629.088	44.457	-3.40996216	104.1250889	10.2312	
948	11644.688	44.285	-3.40999213	104.1252237	10.2616	
949	11650.288	44.218	-3.410003	104.1252721	10.306	
950	11660.288	44.156	-3.41002266	104.1253585	10.3454	10.3454
951	11691.488	44.692	-3.4100878	104.1256271	10.3326	10.3326
952	11707.288	45.203	-3.4101229	104.1257626	10.2679	10.2679
953	11713.888	45.443	-3.41013802	104.1258191	10.363	10.363
954	11723.088	45.643	-3.41015992	104.1258976	10.2893	10.2893
955	11738.888	45.802	-3.41019867	104.1260321	10.3581	10.3581
956	11754.688	45.726	-3.41023811	104.1261664	10.4471	10.4471
957	11768.288	45.592	-3.41027268	104.1262819	10.52	10.52

Tabulated Ground Displacement data along pipeline section obtained from Differential InSAR processing

Visual representation of Ground Displacement data near Coal Mine



CONCLUSIONS

- This project successfully evaluated an integrated, two-method approach to the measurement of ground movements and other geohazards near a pipeline
- Based on a combination of IMU and SAR data, small ground movements were used to calculate bending strains in ground-disturbed areas
- While no structurally significant pipeline strains were found, the project clearly confirmed the value of integrating IMU and SAR data to increase the confidence of the data analysis
- As anticipated, dense forest cover led to signal coherence loss in some areas due to dispersal of the radar signal by the forest canopy. Despite this, results were highly encouraging
- Further development of the combined IMU/SAR methodology is already underway in a partnership between Inspipe Integrity Ltd. and Satsense Solutions Ltd.
- Future work will refine the technologies and methods involved, including analysis of historical data for each method to enhance the predictive capabilities of the integrated analysis

Effective management of geohazard threats in pipelines

Thank You