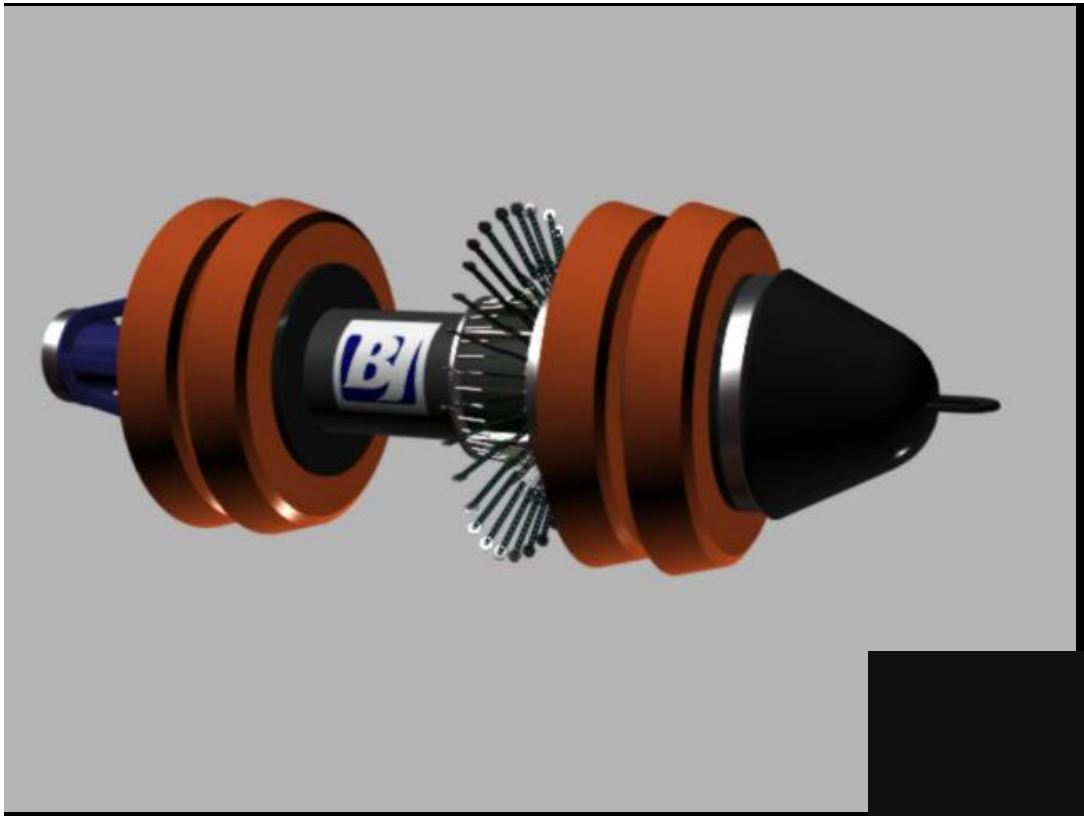
PIPELINE OUT- of - STRAIGNTNESS ASSESSMENT

USING

PIPELINE INERTIAL GEOMETRY SURVEY (GEOPIG®) TECHNOLOGY

Alaska Pipeline Workshop
Anchorage, Alaska
November 08, 1999

David Hektner
BJ Pipeline Inspection Services

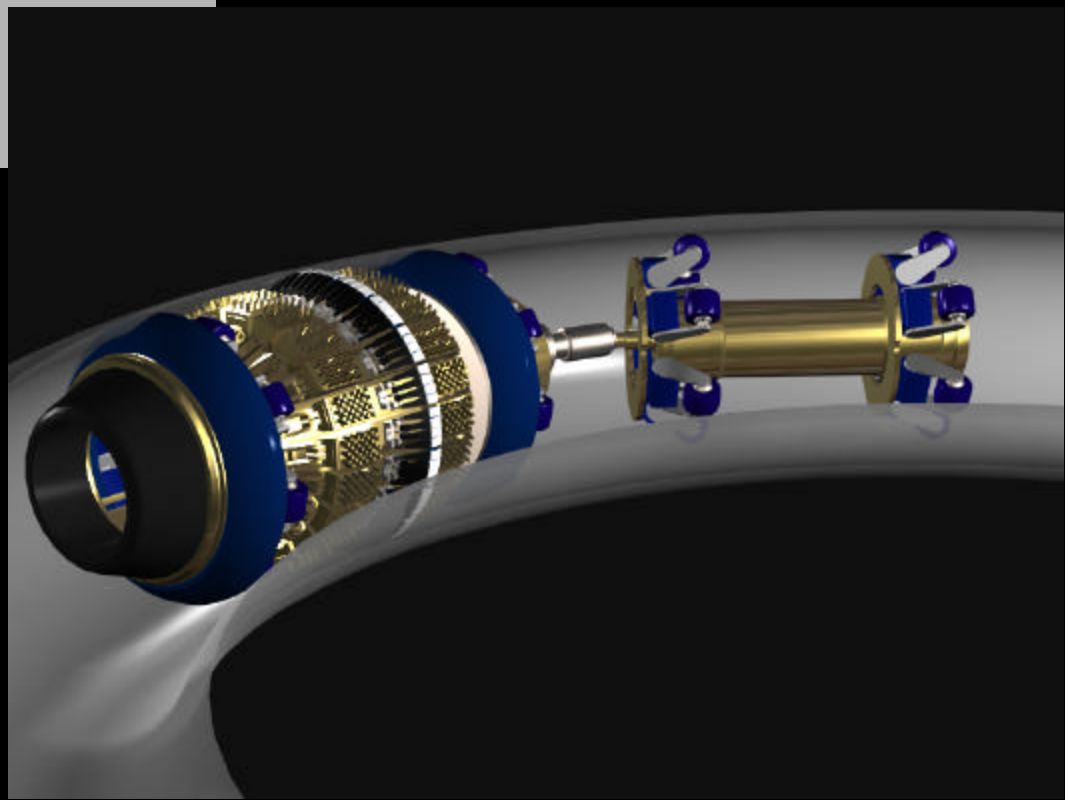


GEOPIG®

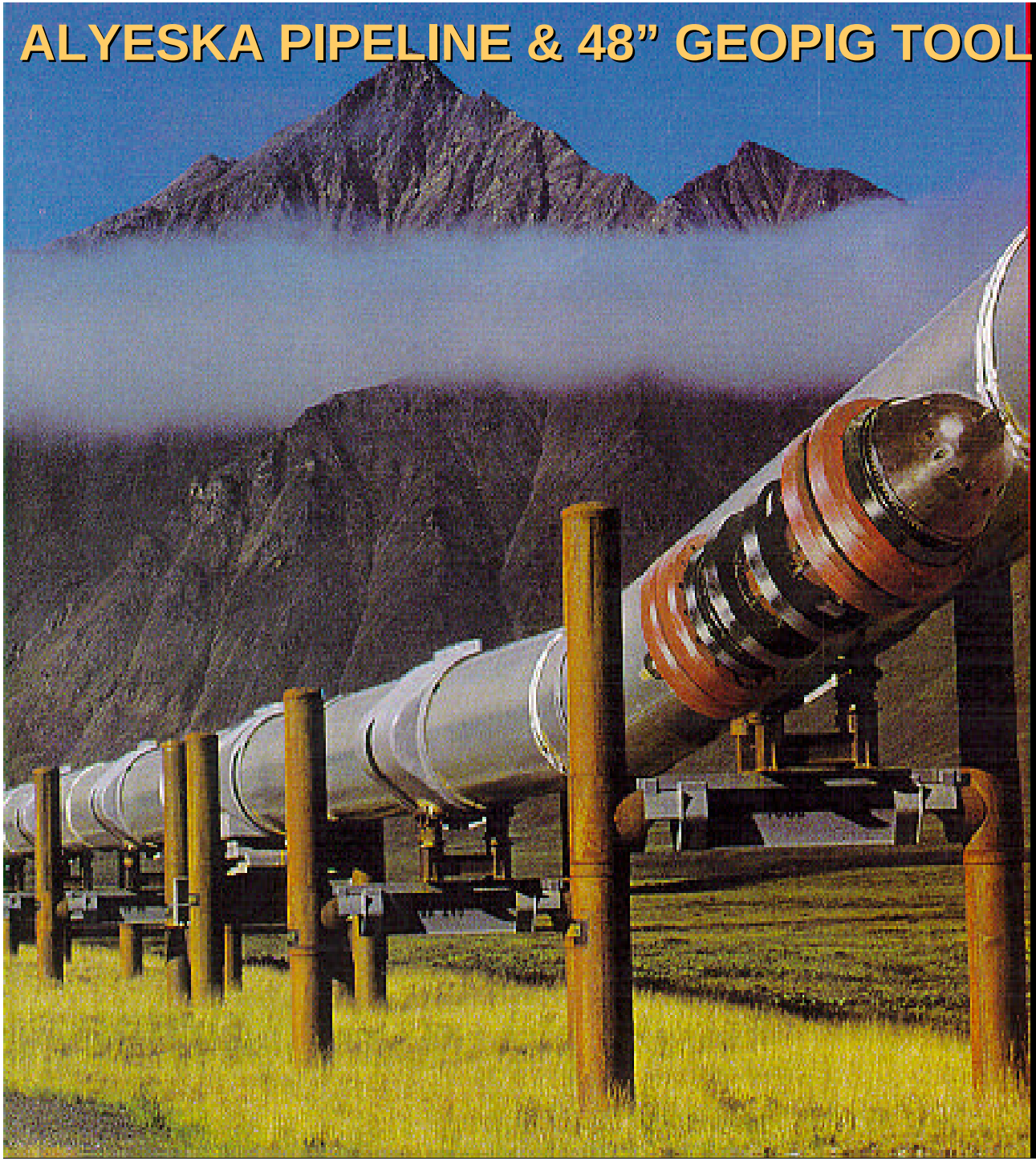
The Advanced Pipeline Inertial Geometry Inspection Tool

VECTRA®

The Integrated MFL Inspection System



ALYESKA PIPELINE & 48” GEOPIG TOOL



ACKNOLOGEMENTS

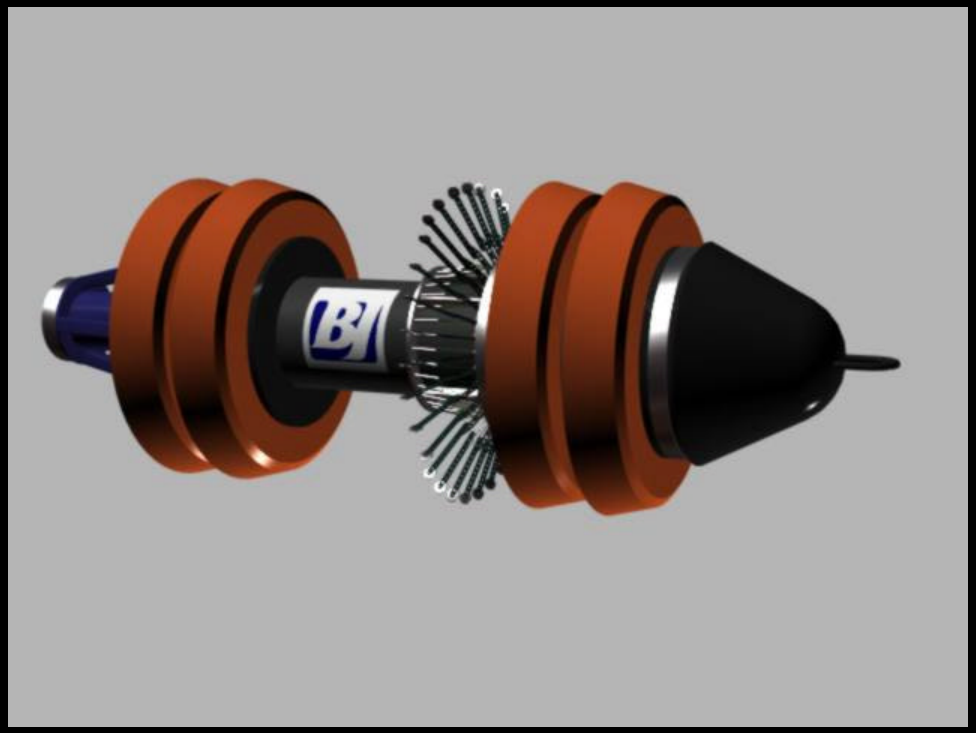
ALYESKA PIPELINE
NPS 48

May , 1993	800	Miles;
Sept, 1993	200	Miles;
May, 1994	800	Miles;
May, 1995	200	Miles;
April, 1997	800	Miles.

BP EXPLORATION &
COLT ENGINEERING
NPS 12
BADAMI PROJECT

June, 1998	25	Miles.

GEOPIG® APPLICATIONS:



- > High Speed and High Accuracy Pipeline Caliper,
- > GPS Location of Features and Anomalies,
- > Pipeline Mapping and GIS Integration,
- > Bending Strain (Structural Analysis).

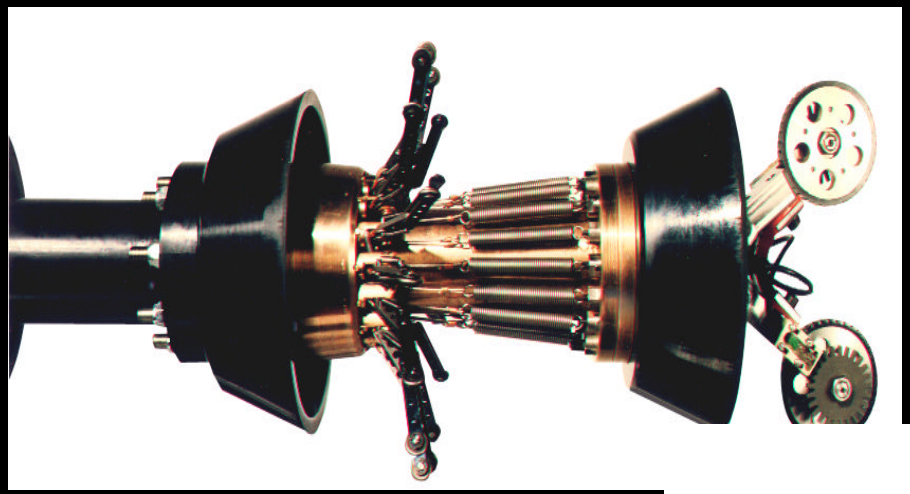
GEOPIG® SYSTEM ACCURACIES

- **DENT :** +/- 1/10 inch
- **OVALITY :** +/- 1/10 inch
- **JOINT LENGTH :** +/- 1/2 inch
- **CURVATURE :** 2500 D, Radius Bend
- **BENDING STRAIN:** +/- 0.02% Strain
- **INERTIAL DEVIATION :** 1:2,000

Caliper Surveying

Pipe-wall Deformations

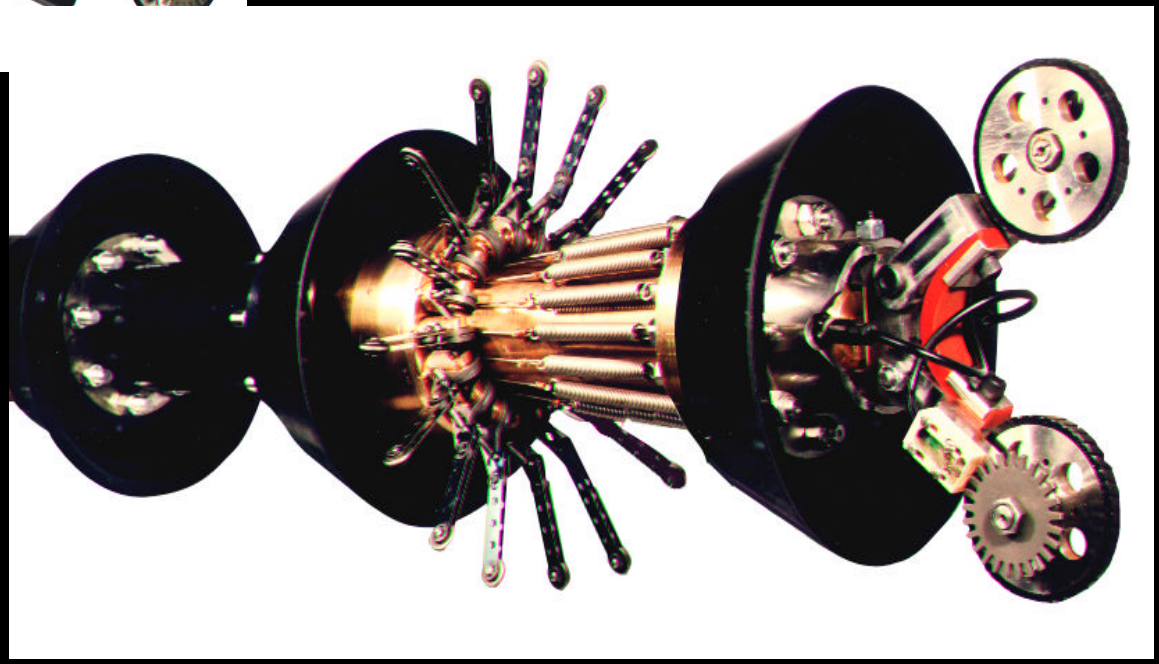
HIGH RESOLUTION CALIPER TECHNOLOGY

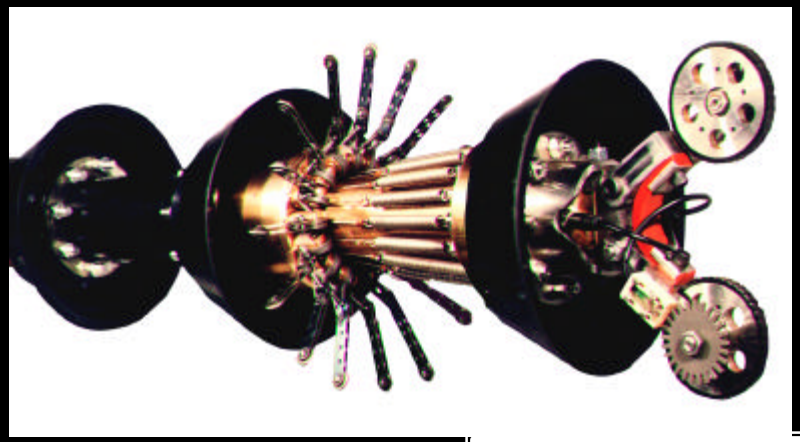


Individual, pre-tensioned mechanical caliper arms for constant internal pipe-wall mapping.

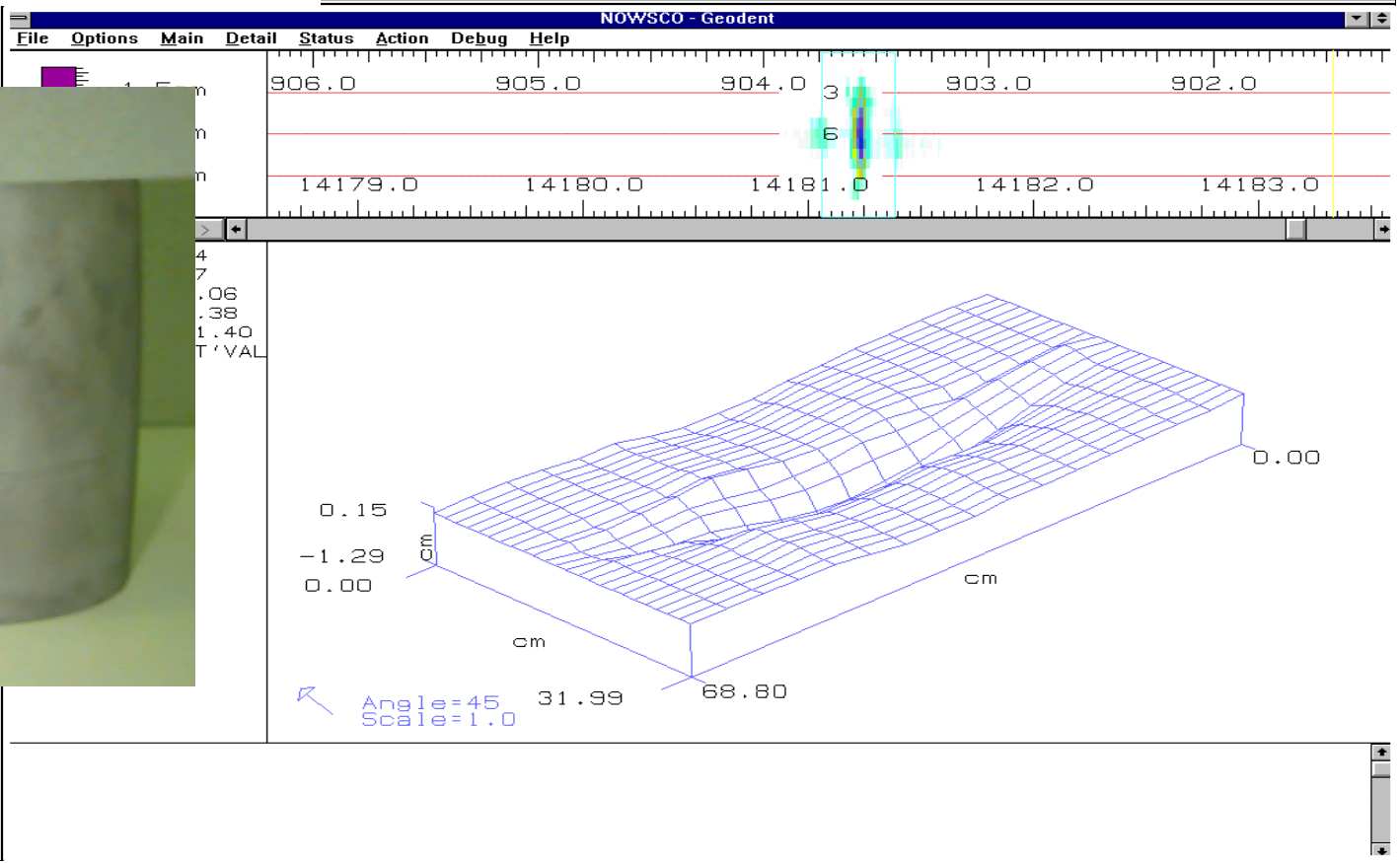
Solid state ‘hall’ sensors record digital caliper arm measurement data.

Data Collection at 128 Hz

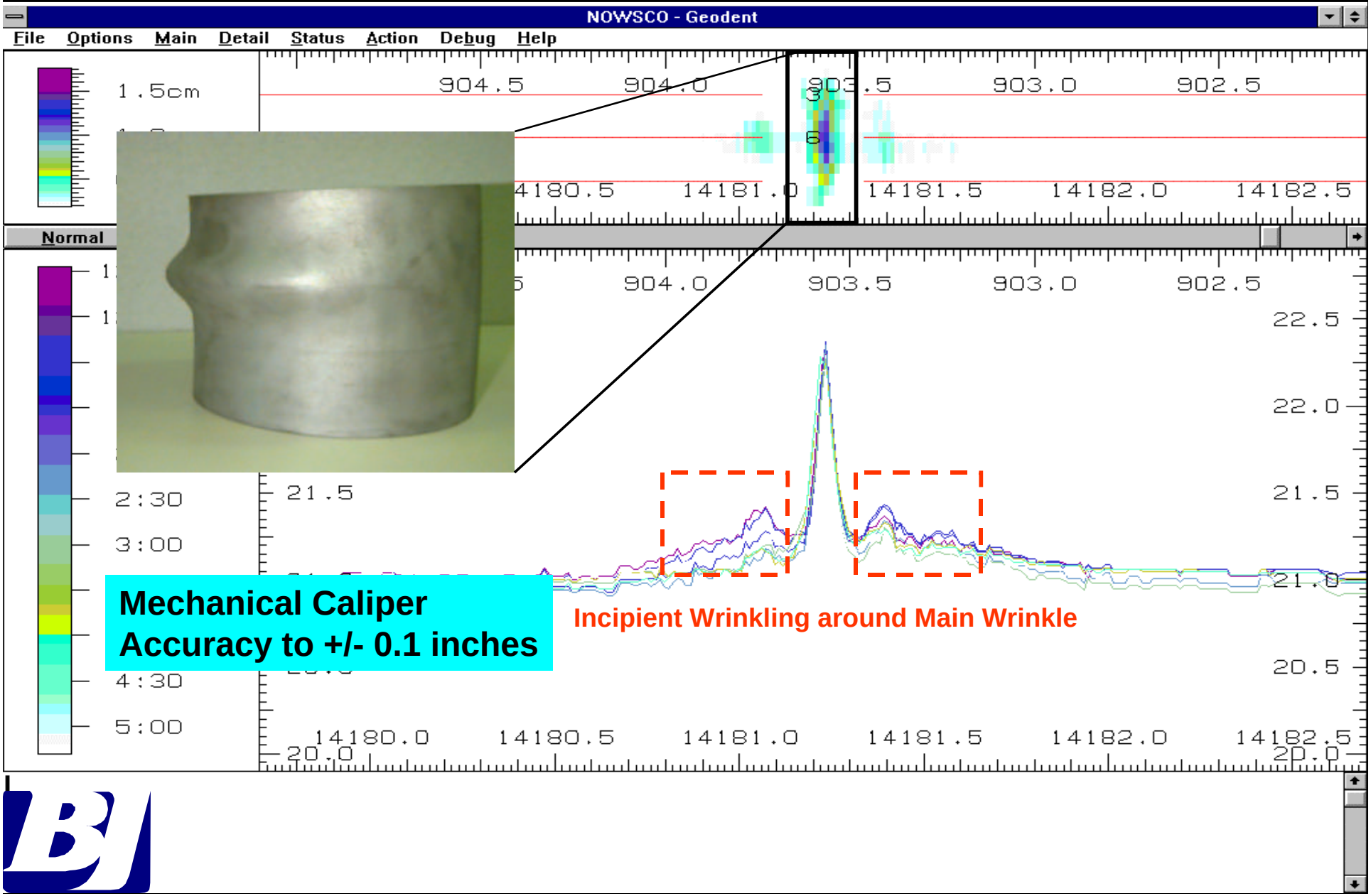


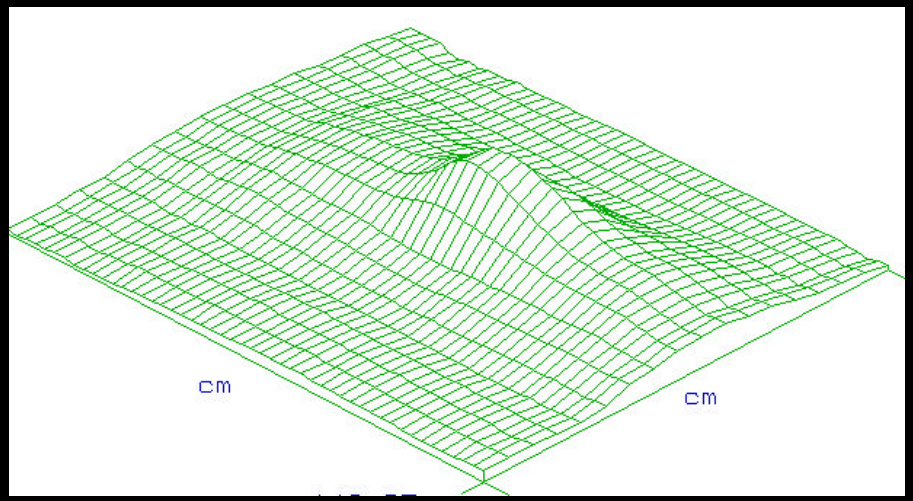


Pre-calibrated caliper arms to map the most complex wrinkle and/or buckle features.



Wrinkle and Incipient Wrinkle Definition

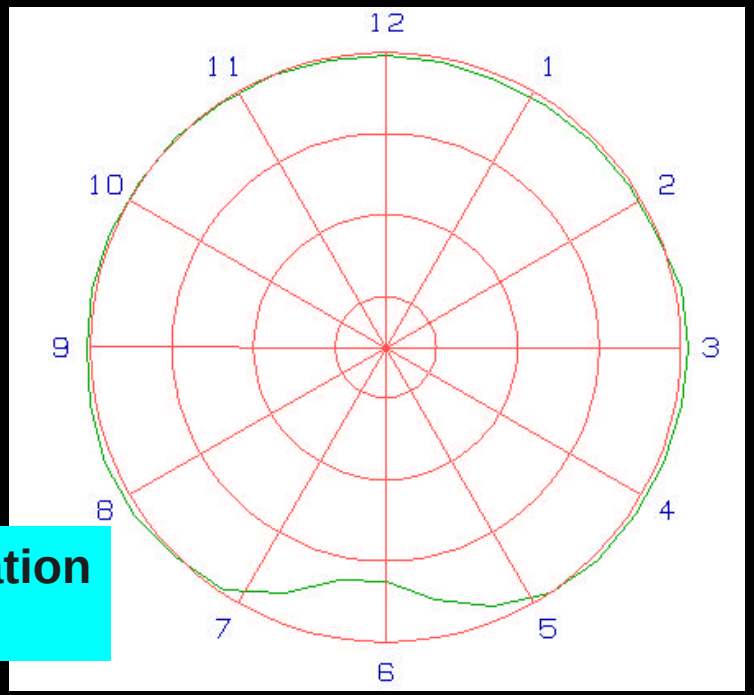




High Resolution Caliper Technology

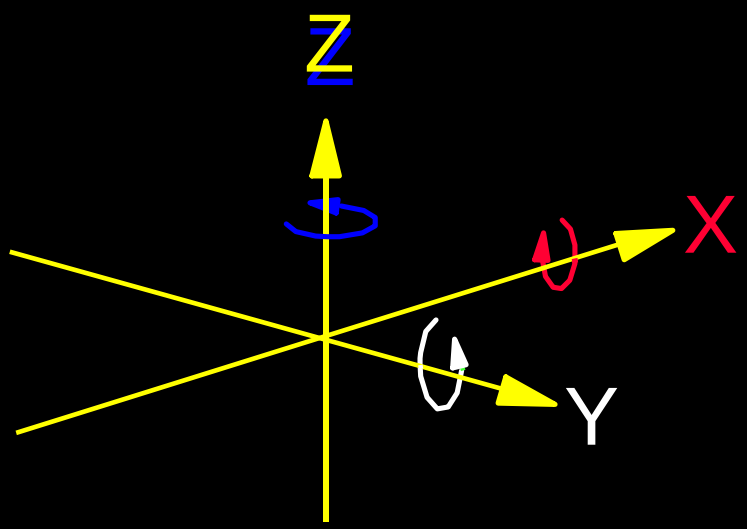
The 128 Hz (minimum) data acquisition rate provides higher feature resolution at faster tool velocities.

Dent & Feature Orientation to +/- 2 degree arc



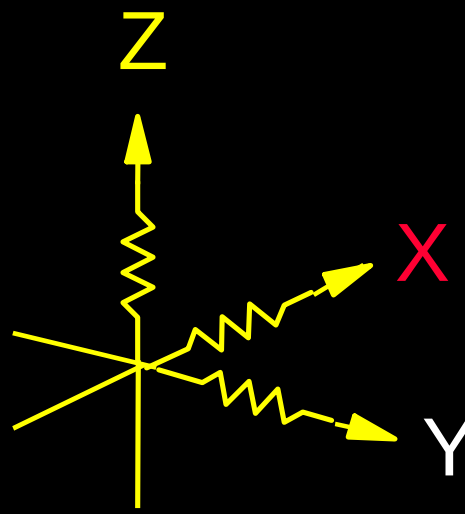
Pipeline Mapping and GIS Integration

GEOPIG Inertial Measurement Unit



Gyroscopes

Angular Rate (Degrees/sec)

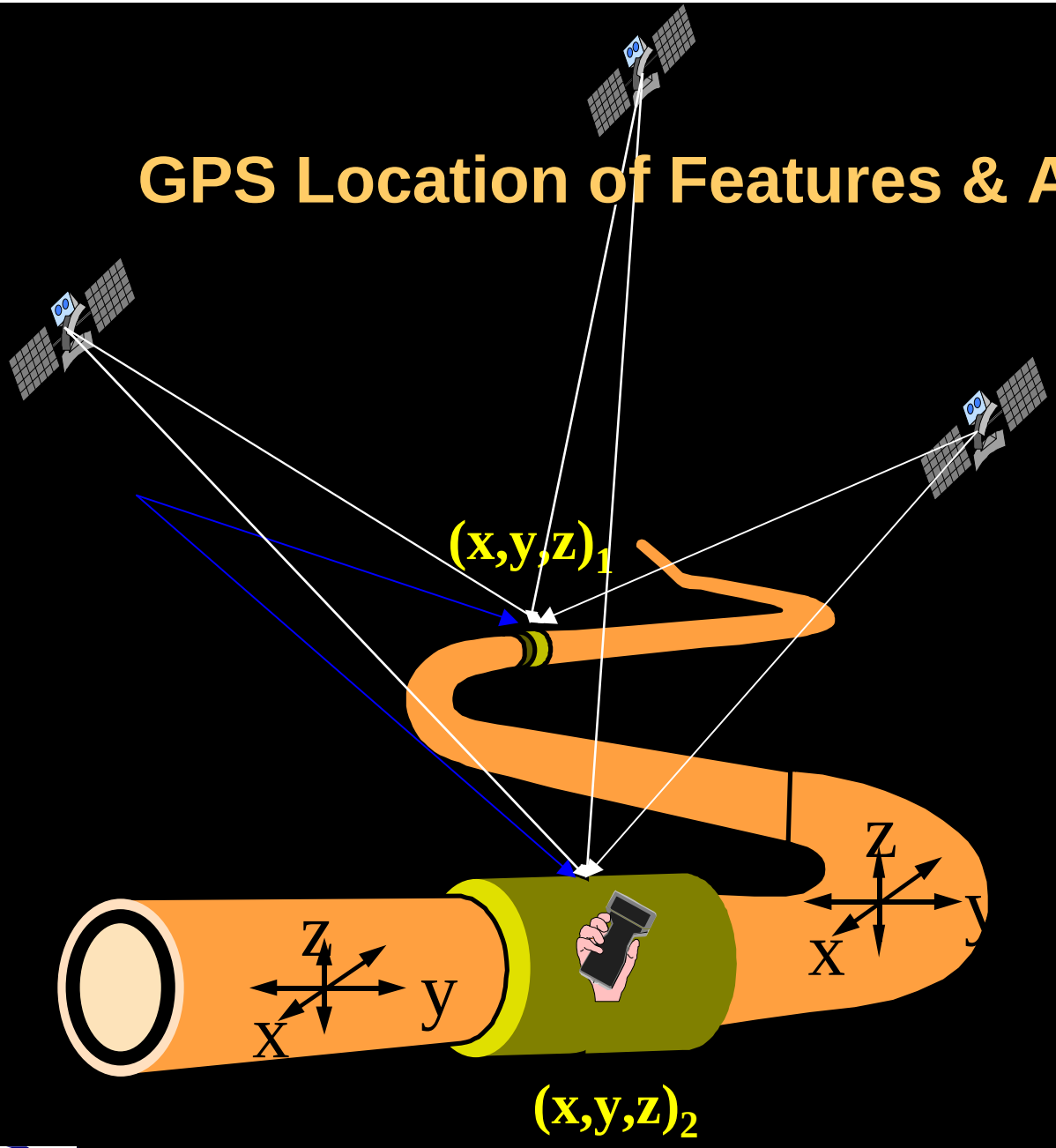


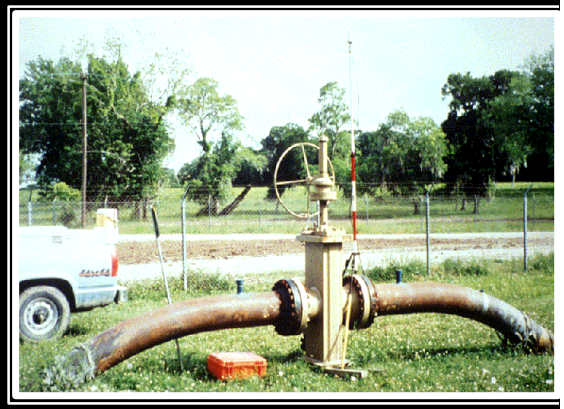
Accelerometers

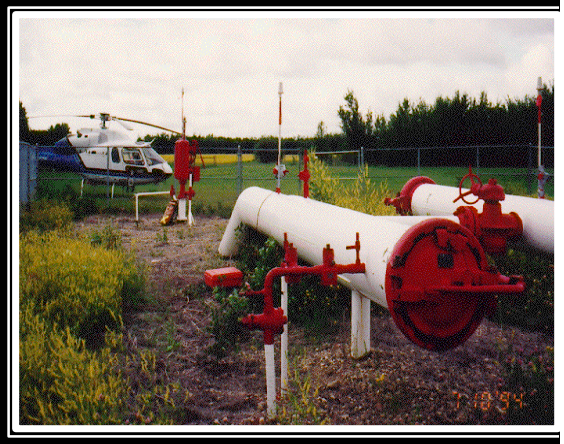
Linear Acceleration (m/sec^2)

Inertial Sampling Rate : 50 Hz

GPS Location of Features & Anomalies





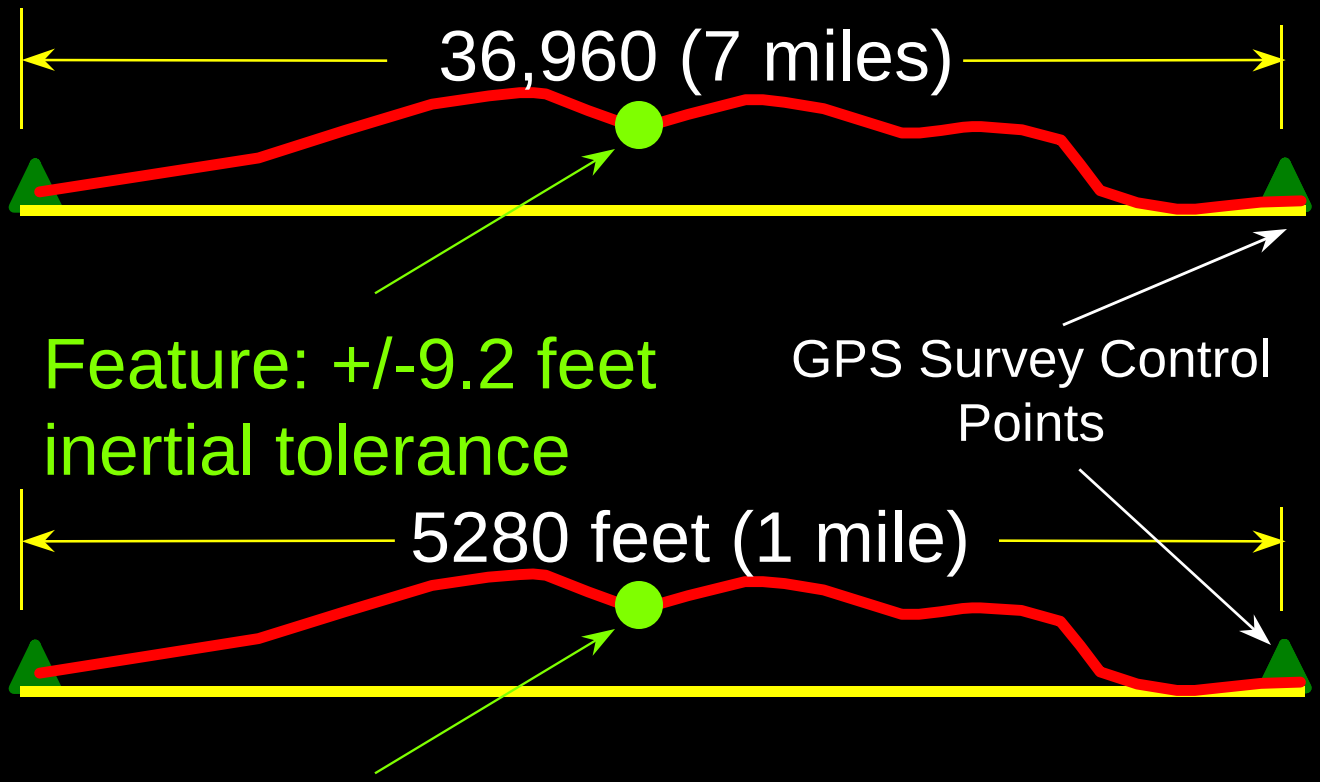


Inertial Drift Control

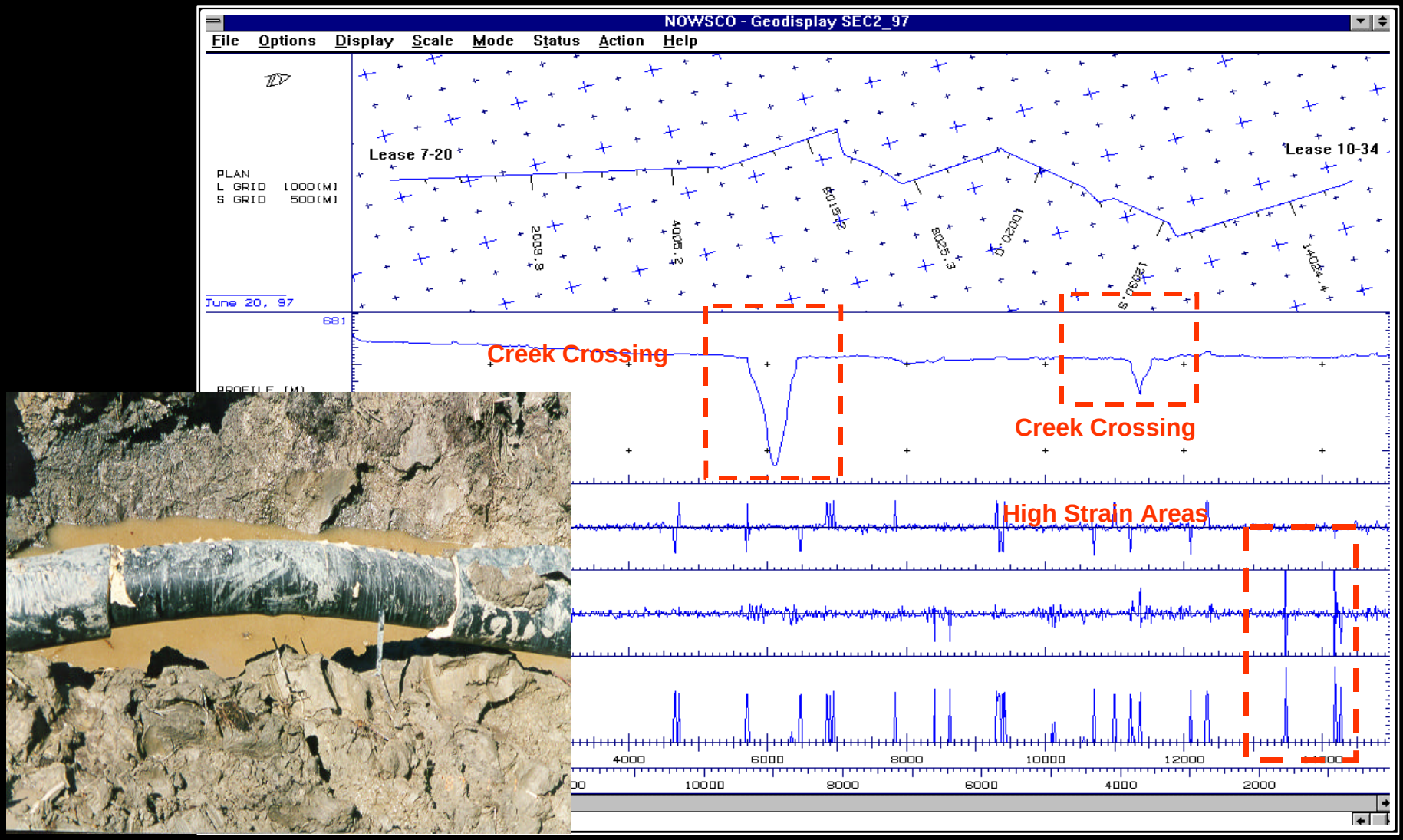
Scale & Rotate Inertial Deflection Vectors

Location Accuracy

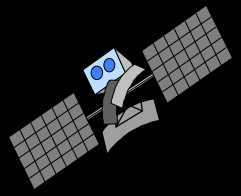
1 : 2,000



Feature Location Using GEODISPLAY

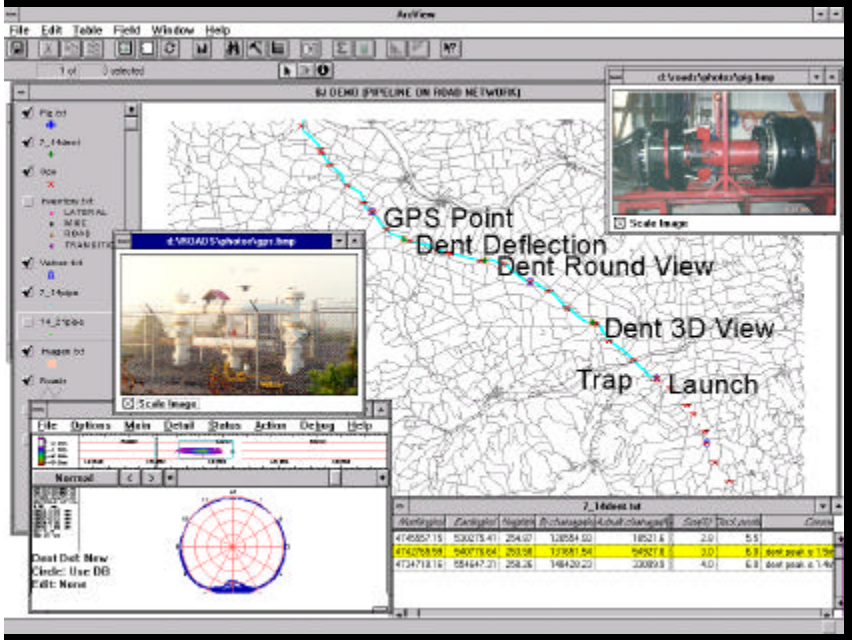


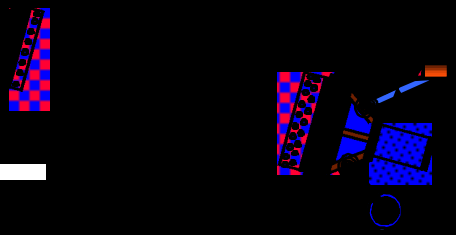
Pipeline Mapping and GIS Integration uses Three ‘Space Age’ Technologies



GPS
Global Positioning System Technology

GIS
Geographic Information System

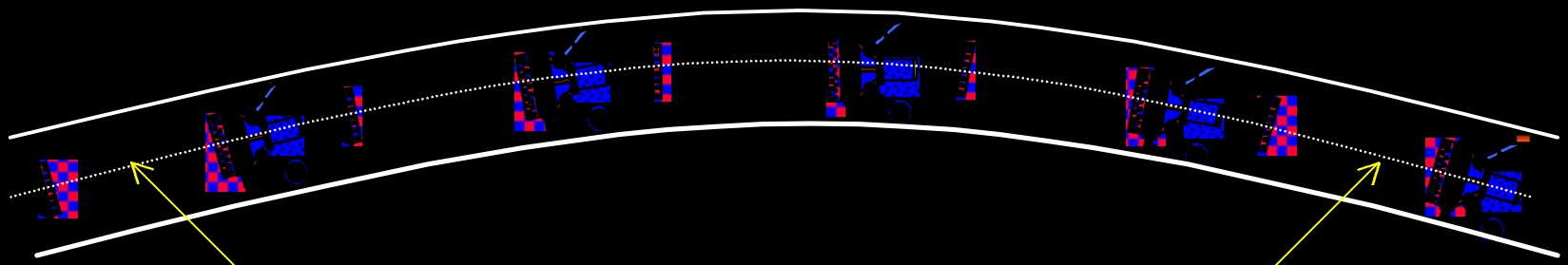




GEOPIG
Inertial Technology

BENDING STRAIN and STRUCTURAL ANALYSIS

Bending Strain and Structural Analysis



$P_2 (X_2, Y_2, Z_2)$

$P_1 (X_1, Y_1, Z_1)$

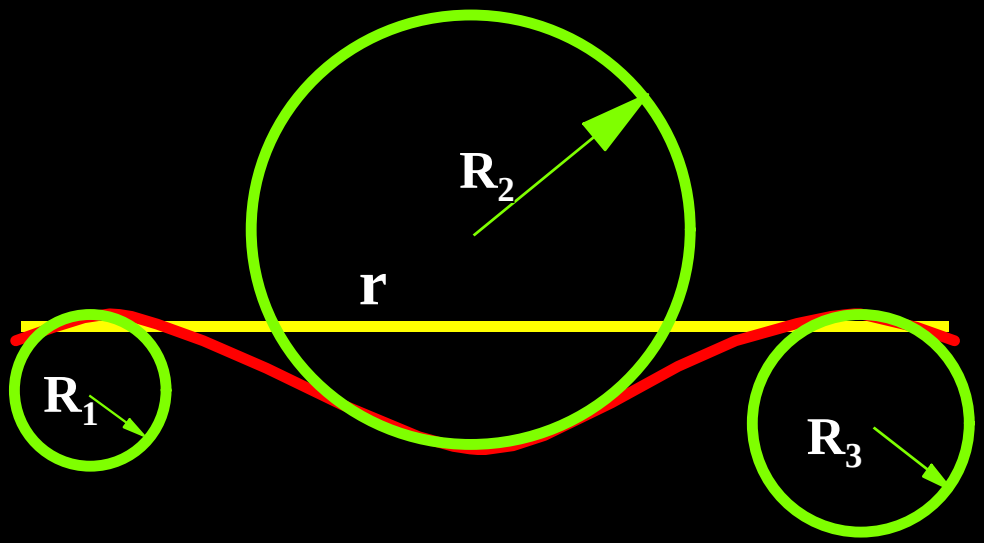
Angle = $P_1 - P_2$

INERTIAL INSTRUMENT
SENSITIVITY
2500 D BEND RADIUS

Radius of Curvature

$$R = \frac{\text{Arc Length}}{\text{Angle}}$$

Curvature Strain Calculation



Original Straight Pipe

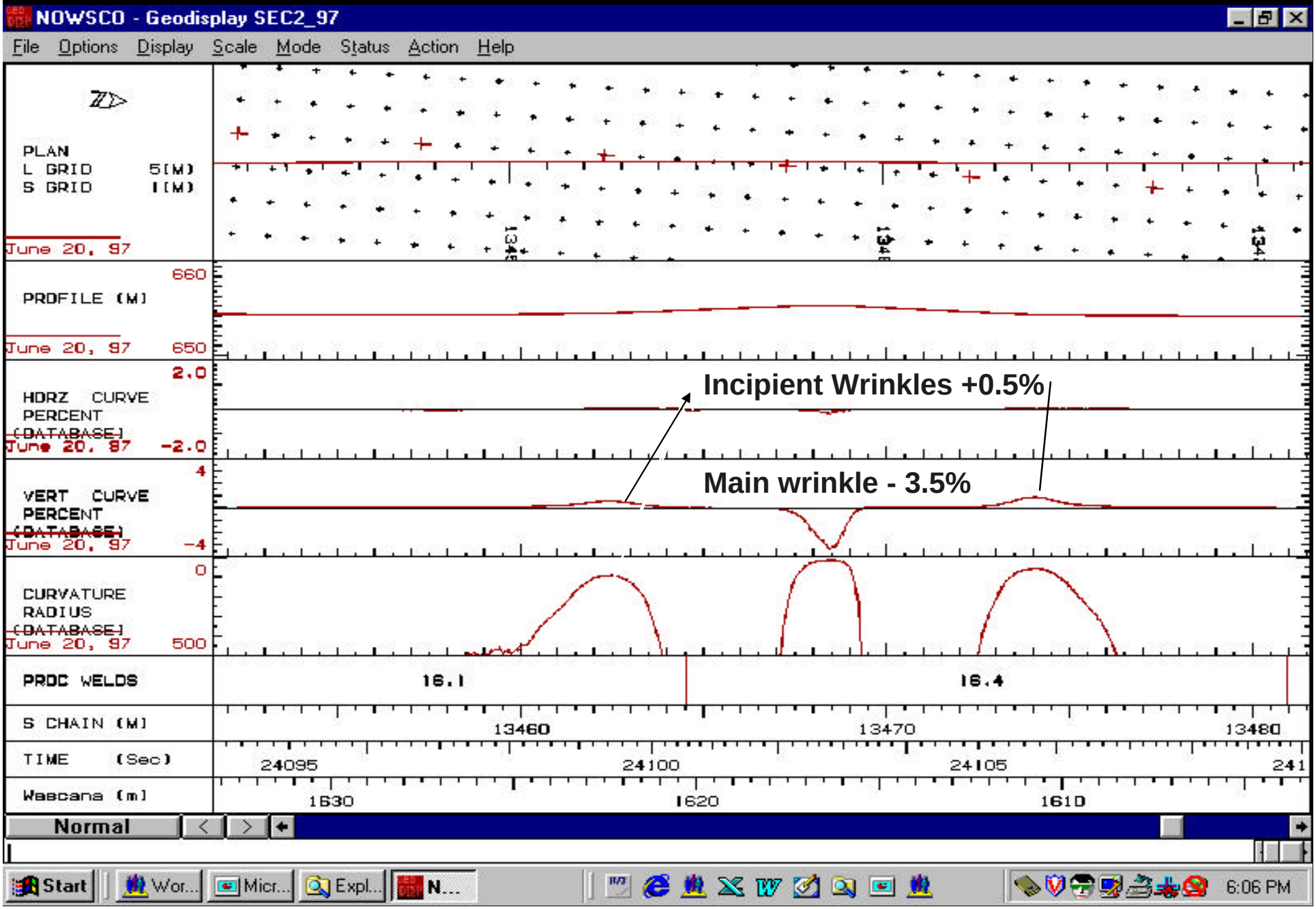
Deformed Pipe

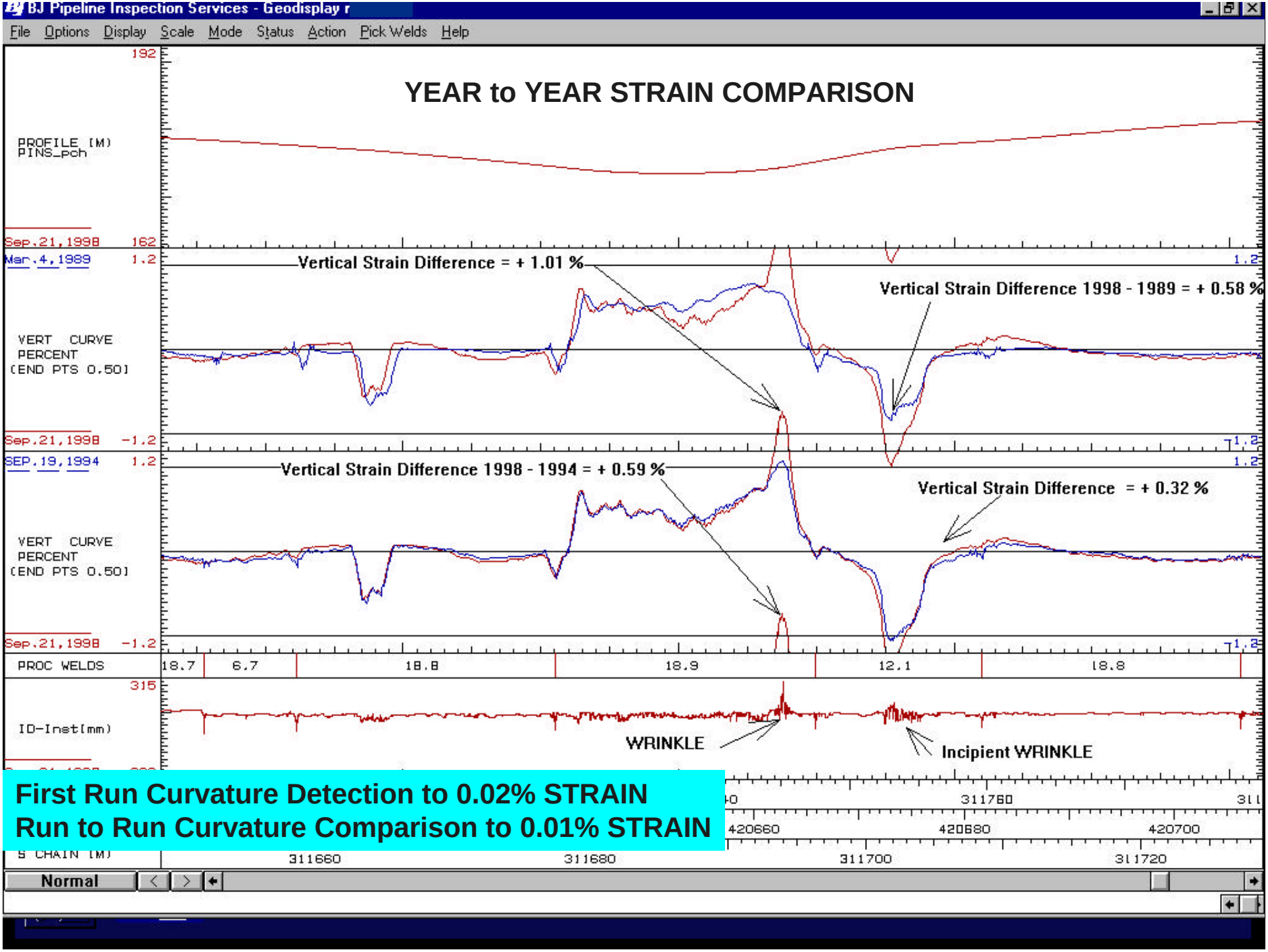
Bending Radius

$$\text{Strain} = \frac{\text{Radius Pipe (r)}}{\text{Radius of Curvature}} \times 100$$

(i.e. R_1, R_2 or R_3)

NPS 8 VERTICLE WRINKLE and INCIPIENT WRINKLES




BJ Pipeline Inspection Services - Geodisplay r
File Options Display Scale Mode Status Action Pick Welds Help
YEAR to YEAR STRAIN COMPARISON
PROFILE [M]
PINS_pch
192
162
Sep.21,1998
Mar.4,1989
1.2
VERT CURVE
PERCENT
(END PTS 0.50)
-1.2
Vertical Strain Difference = + 1.01 %
Vertical Strain Difference 1998 - 1989 = + 0.58 %
SEP.19,1994
Vertical Strain Difference 1998 - 1994 = + 0.59 %
Vertical Strain Difference = + 0.32 %
PROC WELDS
18.7
6.7
18.8
18.9
12.1
18.8
315
ID-Inst[mm]
WRINKLE
Incipient WRINKLE
First Run Curvature Detection to 0.02% STRAIN
Run to Run Curvature Comparison to 0.01% STRAIN
311660
311680
311700
311720
311760
420660
420680
420700
Normal

MAJOR GEOPIG BENEFITS

> High Resolution CALIPER technology for accurate measurement of all anomalies and features, even in ‘dirtier’ pipelines,

> PIPELINE MAPPING and the integration of GPS coordinates to for direct integration into a Geographic Information System,

> STRUCTURAL ANALYSIS and FITNESS For PURPOSE using extremely precise radius of curvature detection.

PIPELINE OUT- of - STRAIGNTNESS ASSESSMENT

USING

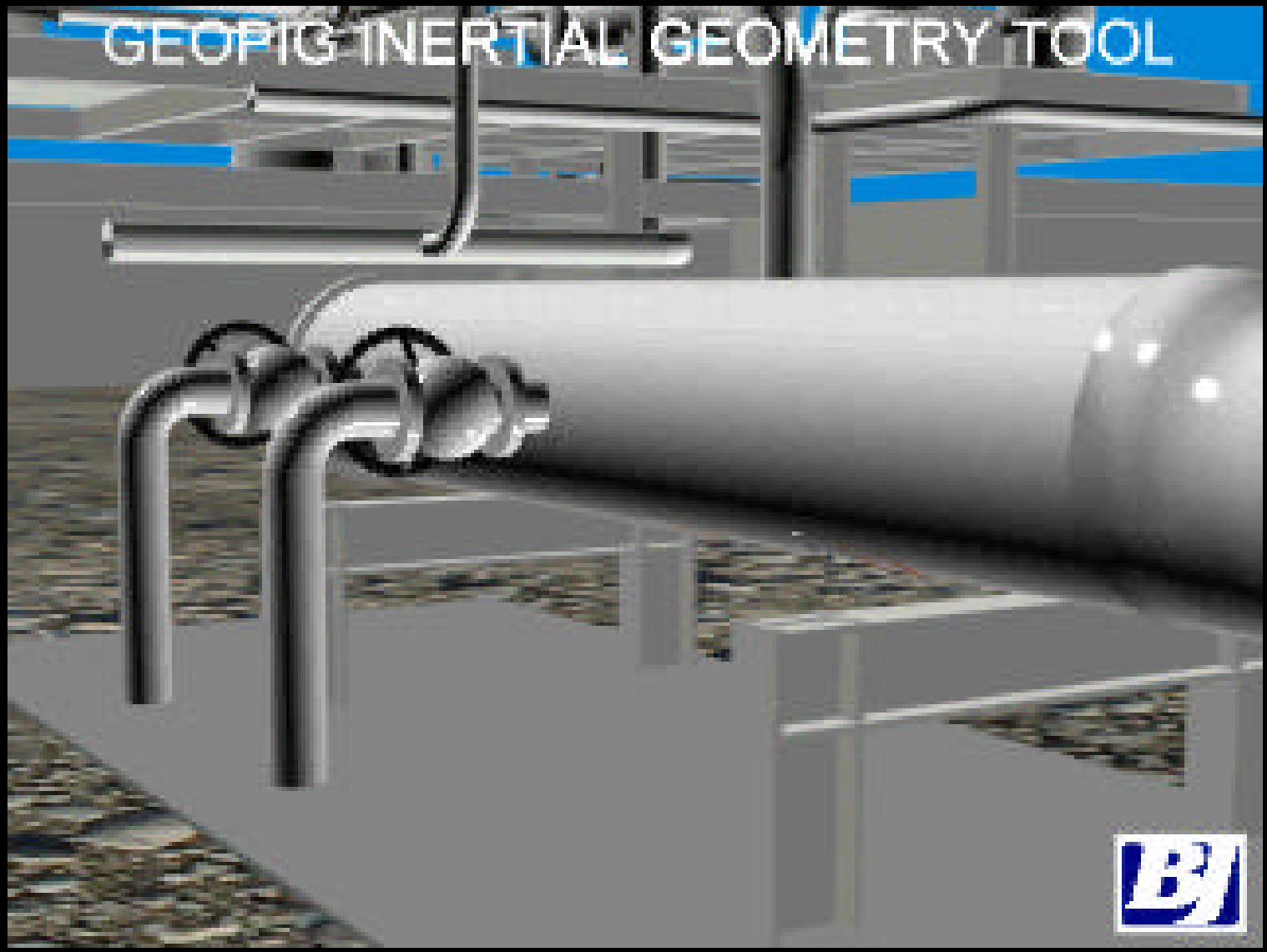
GEOPIG® TECHNOLOGY

Major GEOPIG Out-of-Straightness Surveys

Norske Hydro North Sea	January 1999	17	10” Gas	High accuracy caliper and straightness survey, geometry monitoring and structural analysis
Amerada Hess North Sea	November 1998	22	10” Oil	High accuracy caliper and straightness survey, geometry monitoring and structural analysis
Hudson North Sea	Oct 1998		8 and 10 Water	High accuracy caliper and straightness survey, geometry monitoring and structural analysis
Great Lakes Gas, Michigan, USA	Oct. 1998	12	24 Gas	Movement Monitoring, Caliper and Structural Analysis
Subsea Engineering/Mobil Mallory North Sea	Aug. 1998	8.4	10.75 Water	High accuracy out of straightness survey, geometry monitoring and structural analysis
Colt Stomex Seaway/ETAP North Sea	Jul. 1998	16	10 Oil	High accuracy out of straightness survey, geometry monitoring and structural analysis
Colt Engineering/BP Alaska	Jul. 1998	60	12 Oil	High accuracy caliper and straightness survey, geometry monitoring and structural analysis
Phillips Petroleum Norway	Jun. 1998	3	22 Condensate	High accuracy caliper and straightness survey, geometry monitoring and structural analysis
Statoil Norway	Dec. 1997	40	30 Gas	High accuracy straightness survey, geometry monitoring and structural analysis

"The World's Most Advanced Pipeline Inspection Technology"

BJ PIPELINE INSPECTION SERVICES


GEOPIG INERTIAL GEOMETRY TOOL