

GEODETTIC PARAMETERS

Client RSK Environment Ltd

Job No. J387

Date 19/11/2016

Project: Environmental Survey

Location: Otranto

Vessel: RV Atlante

WGS-84 Geodetic Parameters			
Datum		WGS 84	
Spheroid		WGS 84	
Semi-major axis		6378137m	
Semi-minor axis			
First eccentricity squared			
Inverse flattening		298.2572235630	
Transformation Parameters from WGS 84 to Local System			
Bursa Wolf convention		<input type="checkbox"/> YES <input checked="" type="checkbox"/> NO	
Translation X	0.00	Rotation X	0.00
Translation Y	0.00	Rotation Y	0.00
Translation Z	0.00	Rotation Z	0.00
Scale factor		Scale in ppm	
Local Datum Geodetic Parameters			
Datum		WGS 84	
Spheroid		WGS 84	
Semi-major axis		6378137m	
Semi-minor axis			
First eccentricity squared			
Inverse flattening		298.2572235630	
Local Projection Parameters			
Projection name		Universal Transverse Mercator, Northern Hemisphere	
Projection type		UTM	
UTM zone		34 N	
Central meridian (CM)		21° E	
Latitude of origin		0° Equator	
False easting		500000m	
False northing		0m	
False height			
Scale factor on CM		0.9996	
Northern standard parallel			
Southern standard parallel			
Azimuth of central line projection			
Ellip. height of projection centre			
Units		Metres	



Local Datum Geodetic Parameters			
Datum		WGS 84	
Spheroid		WGS 84	
Semi-major axis		6378137m	
Semi-minor axis			
First eccentricity squared			
Inverse flattening		298.2572235630	
Transformation Parameters from WGS 84 to Local System			
Bursa Wolf convention		<input type="checkbox"/> YES <input checked="" type="checkbox"/> NO	
Translation X	0.00	Rotation X	0.00
Translation Y	0.00	Rotation Y	0.00
Translation Z	0.00	Rotation Z	0.00
Scale factor		Scale in ppm	
Geographical Co-ordinates of Point of Check in WGS-84			
Latitude		40° 18' 55.54710"N	
Longitude		018° 24' 02.51946"E	
Ellipsoidal height			
Height of geoid above ellipsoid			
Geoidal model used			
Geographical Co-ordinates of Point of Check in Local Datum			
Latitude		40° 18' 55.54710"N	
Longitude		018° 24' 02.51946"E	
Ellipsoidal height			
Height of geoid above ellipsoid			
Geoidal model used			
Projection Co-ordinates of Point of Check in Local Datum			
Easting		279136.32	
Northing		4466010.38	
Elevation			
Approval			
Project manager			
Client			
Party chief in the field			
Client representative in the field			



Co-ordinates of.....check in WGS-84	
Latitude	40° 18' 55.54710"N
Longitude	018° 24' 02.51946"E
Easting	
Northing	
Ellipsoidal height	
Height of geoid above ellipsoid	
Geoidal model used	
Co-ordinates of.....check in Local Datum	
Latitude	40° 18' 55.54710"N
Longitude	018° 24' 02.51946"E
Easting	
Northing	
Ellipsoidal height	
Height of geoid above ellipsoid	
Geoidal model used	

Co-ordinates of.....check in WGS-84	
Latitude	40° 18' 55.54710"N
Longitude	018° 24' 02.51946"E
Easting	
Northing	
Ellipsoidal height	
Height of geoid above ellipsoid	
Geoidal model used	
Co-ordinates of.....check in Local Datum	
Latitude	40° 18' 55.54710"N
Longitude	018° 24' 02.51946"E
Easting	
Northing	
Ellipsoidal height	
Height of geoid above ellipsoid	
Geoidal model used	
Approval	
Project manager	
Client	
Party chief in the field	
Client representative in the field	



OSD-FO-113.2 POSITIONING SYSTEM VERIFICATION

Vessel : Atlante CT 253
Location : Otranto
Positioning System : WGS 84 - UTM 34

Project no : 16-J387
Date : 19.11.2016

Fix No.	Time hh:mm:ss	From DGPS Logging		Control Co-ordinate		dE m	dN m
		Easting m	Northing m	Easting m	Northing m		
1	11:20:48	286544.57	4447339.75	286544.01	4447339.18	-0.56	-0.58
2	11:21:25	286544.58	4447339.74	286544.01	4447339.16	-0.57	-0.57
3	11:22:01	286544.58	4447339.78	286544.02	4447339.18	-0.57	-0.59
4	11:22:37	286544.59	4447339.77	286544.04	4447339.18	-0.54	-0.59
5	11:23:14	286544.61	4447339.76	286544.08	4447339.17	-0.53	-0.59
6	11:23:49	286544.57	4447339.72	286544.04	4447339.14	-0.53	-0.57
7	11:24:25	286544.56	4447339.66	286544.03	4447339.07	-0.54	-0.59
8	11:25:01	286544.57	4447339.80	286544.05	4447339.20	-0.52	-0.60
9	11:25:37	286544.59	4447339.80	286544.04	4447339.18	-0.55	-0.62
10	11:26:14	286544.61	4447339.79	286544.05	4447339.21	-0.56	-0.59
11	11:26:50	286544.61	4447339.78	286544.05	4447339.20	-0.56	-0.58
12	11:27:25	286544.60	4447339.76	286544.04	4447339.16	-0.56	-0.60
13	11:28:01	286544.61	4447339.81	286544.05	4447339.19	-0.56	-0.62
14	11:28:37	286544.58	4447339.77	286544.06	4447339.15	-0.52	-0.62
15	11:40:00	286544.52	4447339.67	286543.98	4447339.10	-0.54	-0.57
16	11:40:36	286544.57	4447339.79	286544.01	4447339.19	-0.56	-0.60
17	11:41:12	286544.54	4447339.69	286544.00	4447339.07	-0.54	-0.61
18	11:41:48	286544.55	4447339.76	286544.01	4447339.13	-0.54	-0.63
19	11:42:24	286544.53	4447339.72	286544.01	4447339.12	-0.52	-0.60
20	11:43:00	286544.55	4447339.71	286543.99	4447339.10	-0.56	-0.61
21	11:43:39	286544.57	4447339.76	286544.02	4447339.17	-0.55	-0.58
22	11:44:15	286544.55	4447339.74	286544.01	4447339.18	-0.54	-0.56
23	11:44:50	286544.55	4447339.74	286544.00	4447339.16	-0.55	-0.58
24	11:45:26	286544.57	4447339.74	286544.01	4447339.16	-0.55	-0.58
25	11:46:02	286544.57	4447339.76	286544.01	4447339.17	-0.56	-0.60
S.D.						0.02	0.02
Mean						-0.55	-0.59

Notes:

Datum WGS84
Projection UTM
CM 21
Hemisphere North

For Fugro OSD

For Client



GYRO CALIBRATION WITH TOTAL STATION

Project: 16-J387
Vessel: Atlante CT 253
Client: RSK

Location: Otranto
Date: 19.11.2016
Gyro Name: Meridian

Datum: WGS84
Hemisphere: North
Projection: UTM
Central Meridian: 21° E
False Easting: 500000
Convergence: -1.6783

Station 1:
Easting:
Northing:

Station 2:
Easting:
Northing:

Fix No.	UTC time (hh:mm:ss)	Co-ordinates				Observed vessel bearing Raw Gyro (deg)	Calculated vessel heading grid (deg)	Calculated vessel heading true (deg)	Difference (C-O) (deg)	Difference from mean C-O (deg)
		Bow		Stern						
		Easting	Northing	Easting	Northing					
1	10:45:01	286551.26	4447329.38	286528.08	4447362.11	142.90	144.69	143.02	0.12	0.13
2	10:45:37	286551.26	4447329.39	286528.05	4447362.11	143.00	144.65	142.97	-0.03	-0.02
3	10:46:13	286551.27	4447329.35	286528.11	4447362.08	143.00	144.71	143.03	0.03	0.05
4	10:46:49	286551.28	4447329.36	286528.11	4447362.09	143.00	144.70	143.02	0.02	0.03
5	10:47:26	286551.27	4447329.37	286528.09	4447362.10	143.00	144.68	143.01	0.01	0.02
6	10:48:02	286551.27	4447329.40	286528.07	4447362.11	142.90	144.66	142.98	0.08	0.09
7	10:48:38	286551.26	4447329.38	286528.07	4447362.12	143.10	144.69	143.01	-0.09	-0.08
8	10:49:15	286551.26	4447329.36	286528.08	4447362.09	143.00	144.68	143.00	0.00	0.02
9	10:49:50	286551.26	4447329.37	286528.10	4447362.11	143.10	144.72	143.05	-0.05	-0.04
10	10:50:27	286551.27	4447329.40	286528.05	4447362.08	143.00	144.62	142.94	-0.06	-0.05
11	10:51:01	286551.27	4447329.34	286528.09	4447362.07	143.00	144.69	143.02	0.02	0.03
12	10:51:37	286551.26	4447329.34	286528.10	4447362.08	143.10	144.72	143.04	-0.06	-0.04
13	10:52:13	286551.24	4447329.32	286528.11	4447362.09	143.10	144.78	143.11	0.01	0.02
14	10:52:50	286551.25	4447329.38	286528.08	4447362.09	143.10	144.69	143.01	-0.09	-0.08
15	10:53:30	286551.27	4447329.38	286528.08	4447362.09	143.10	144.67	142.99	-0.11	-0.10
16	10:54:06	286551.24	4447329.38	286528.07	4447362.10	143.00	144.70	143.02	0.02	0.03
17	10:54:42	286551.28	4447329.35	286528.10	4447362.07	142.90	144.68	143.00	0.10	0.11
18	10:55:19	286551.26	4447329.35	286528.10	4447362.09	143.10	144.72	143.04	-0.06	-0.05
19	10:55:55	286551.26	4447329.36	286528.09	4447362.11	143.00	144.72	143.04	0.04	0.05
20	10:56:31	286551.30	4447329.35	286528.10	4447362.07	143.10	144.67	142.99	-0.11	-0.10
								Average:	-0.01	
								St. dev.	0.07	

For Fugro OSD

For Client

Gyro is reading: **0.0** to high.

Project Details	
Project:	Job 16 J387
Vessel Name:	ATLANTE
Client:	TAP
Surveyors:	Davide P. Eduard T.
Project Description:	TAP Pre construction Survey
Calibration Description:	USBL Check
Method / Units:	Average Error / metres

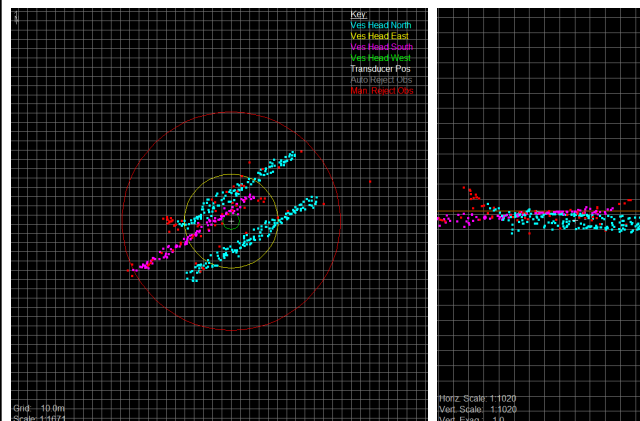
BEFORE (Initial Settings)

Beacon (estimate):		~SD:
Easting:	297,184.27 m (* **)
Northing:	4,481,547.75 m (* **)
Depth:	295.05 m (* **)
Transducer Offset:		
X:	-4.77 m (* **)
Y:	-8.00 m (* **)
Depth:	4.39 m (* **)
Sound Velocity:		
USBL:	1,530.00 m/s (* **)
Attitude Corrections:		
Starfix:	Pitch: 0.00 ° (* **)
	Roll: 0.00 ° (* **)
	Orientation: 0.00 ° (* **)
Sonardyne:	Pitch: 0.00 ° (* **)
	Roll: 0.00 ° (* **)
	Heading: 0.00 ° (* **)
APOS:	Pitch: 0.00 ° (* **)
	Roll: 0.00 ° (* **)
	Gear: 0.00 ° (* **)
<i>(Sonardyne and APOS corrections listed for convention)</i>		

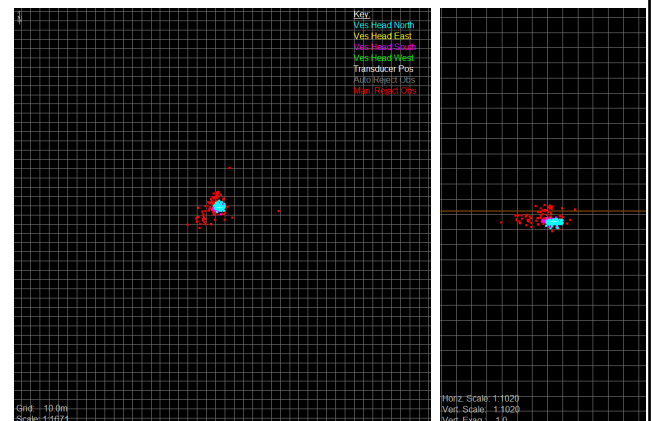
AFTER (Results of Calibration)

Beacon (mean):		SD:
Easting:	297,183.93 m (2.57 m)
Northing:	4,481,547.92 m (2.35 m)
Depth:	304.80 m (1.09 m)
Transducer Offset:		
X:	-4.77 m (* **)
Y:	-8.00 m (* **)
Depth:	4.39 m	
Sound Velocity:		
USBL:	1,548.68 m/s (* **)
ScaleFactor:	1.01221	
Attitude Corrections:		
Starfix:	Pitch: 1.14 ° (* **)
	Roll: -1.57 ° (* **)
	Orientation: 15.46 ° (* **)
Sonardyne:	Pitch: 1.14 ° (* **)
	Roll: -1.57 ° (* **)
	Heading: -15.46 ° (* **)
APOS:	Pitch: -1.14 ° (* **)
	Roll: 1.57 ° (* **)
	Gear: 15.46 ° (* **)
Iterations:	Obs Accepted:	Obs Rejected:
0	353	74

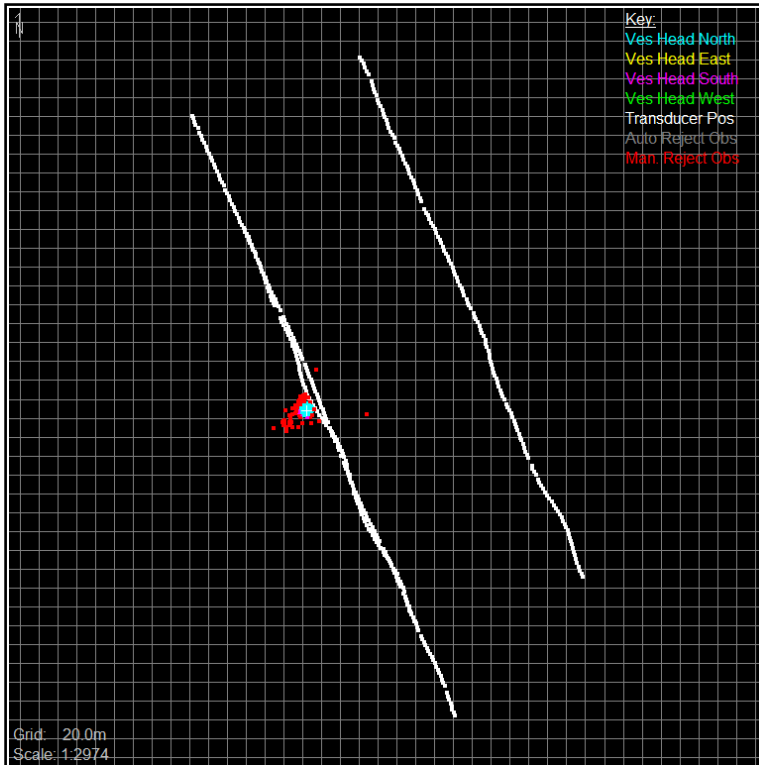
Scatter Before:



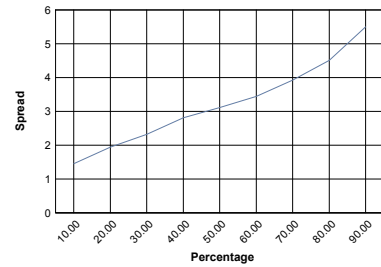
Scatter After:



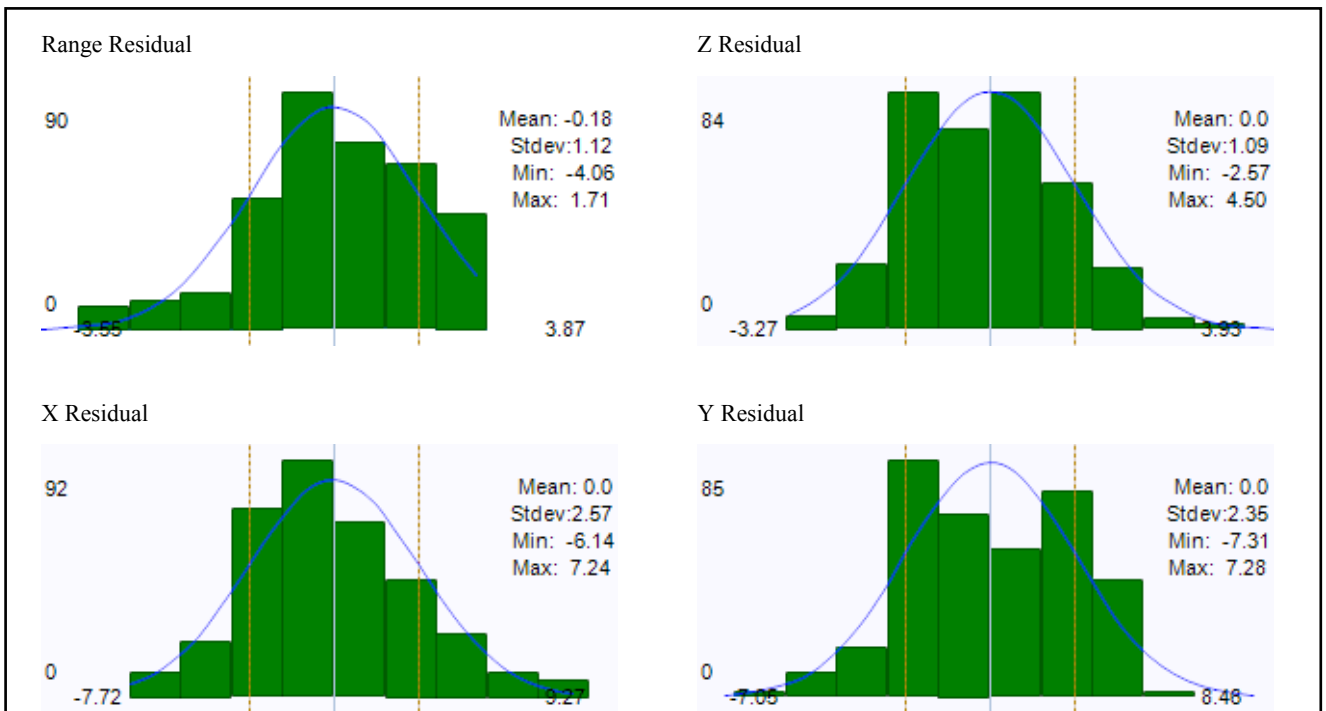
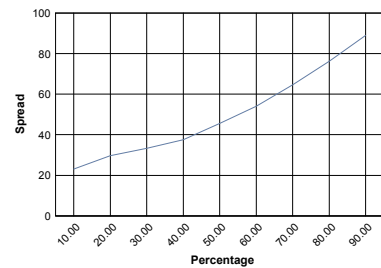
Vessel Track:



Position Spread After



Position Spread Before



Project Details	
Project:	Job 16 J387
Vessel Name:	ATLANTE
Client:	TAP
Surveyors:	Davide P. Eduard T.
Project Description:	TAP Pre construction Survey
Calibration Description:	USBL Calibration
Method / Units:	Average Error / metres

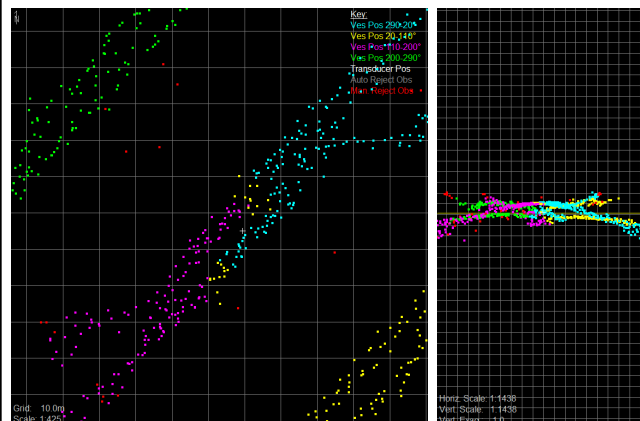
BEFORE (Initial Settings)

Beacon (estimate):		~SD:
Easting:	297,196.00 m (* **)
Northing:	4,481,561.00 m (* **)
Depth:	296.00 m (* **)
Transducer Offset:		
X:	-4.77 m (* **)
Y:	-8.00 m (* **)
Depth:	4.39 m (* **)
Sound Velocity:		
USBL:	1,530.00 m/s (* **)
Attitude Corrections:		
Starfix:	Pitch: 0.00 ° (* **)
	Roll: 0.00 ° (* **)
	Orientation: 0.00 ° (* **)
Sonardyne:	Pitch: 0.00 ° (* **)
	Roll: 0.00 ° (* **)
	Heading: 0.00 ° (* **)
APOS:	Pitch: 0.00 ° (* **)
	Roll: 0.00 ° (* **)
	Gear: 0.00 ° (* **)
<i>(Sonardyne and APOS corrections listed for convention)</i>		

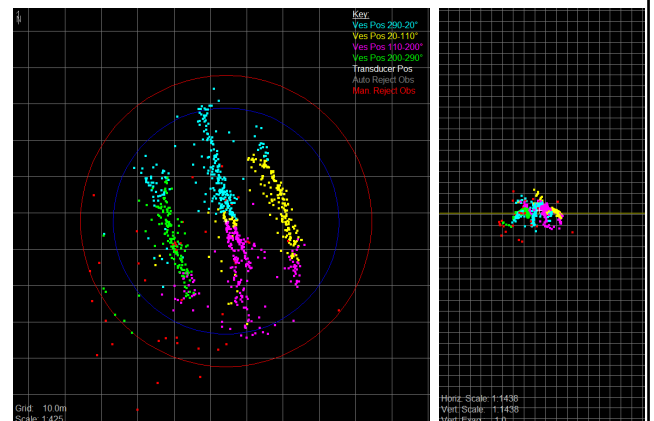
AFTER (Results of Calibration)

Beacon (mean):		SD:
Easting:	297,184.27 m (11.83 m)
Northing:	4,481,547.75 m (12.91 m)
Depth:	296.26 m (5.27 m)
Transducer Offset:		
X:	-4.77 m (* **)
Y:	-8.00 m (* **)
Depth:	4.39 m	
Sound Velocity:		
USBL:	1,530.00 m/s (* **)
ScaleFactor:	1.00000	
Attitude Corrections:		
Starfix:	Pitch: 1.72 ° (* **)
	Roll: -1.57 ° (* **)
	Orientation: 15.46 ° (* **)
Sonardyne:	Pitch: 1.72 ° (* **)
	Roll: -1.57 ° (* **)
	Heading: -15.46 ° (* **)
APOS:	Pitch: -1.72 ° (* **)
	Roll: 1.57 ° (* **)
	Gear: 15.46 ° (* **)
Iterations:	Obs Accepted:	Obs Rejected:
0	883	43

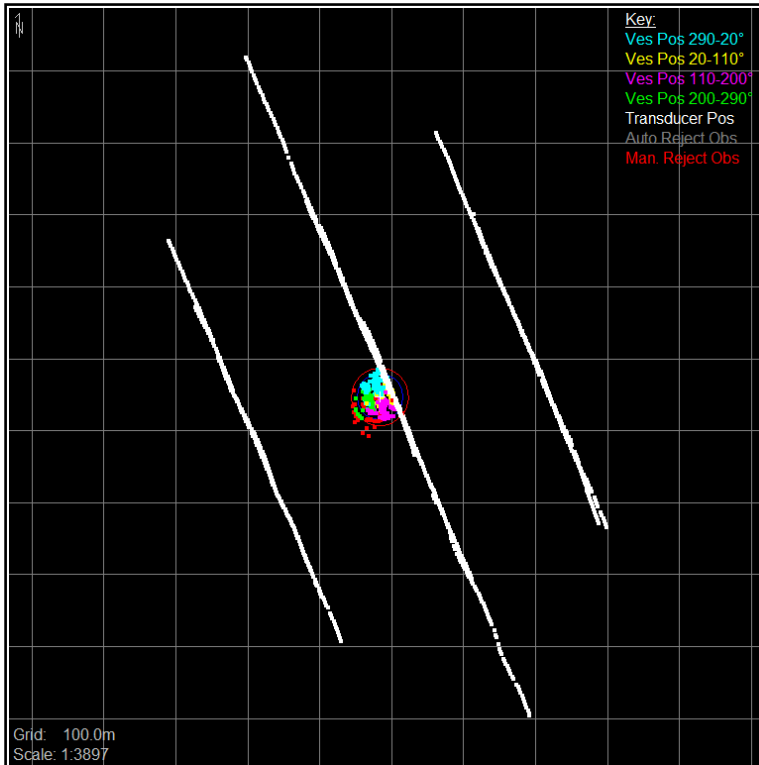
Scatter Before:



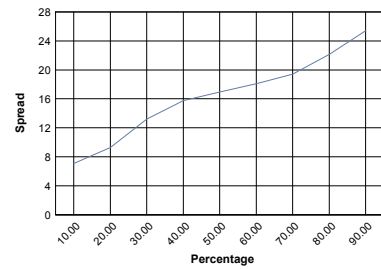
Scatter After:



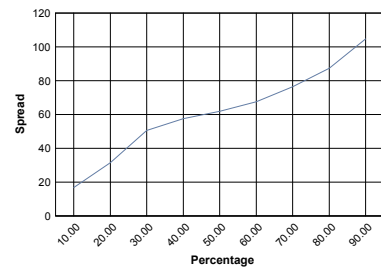
Vessel Track:



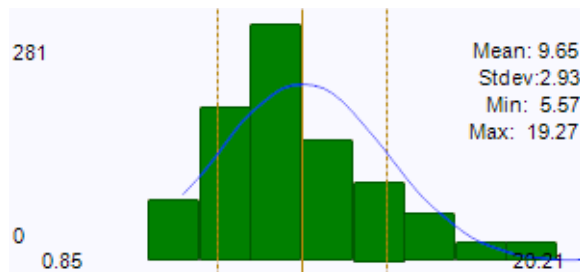
Position Spread After



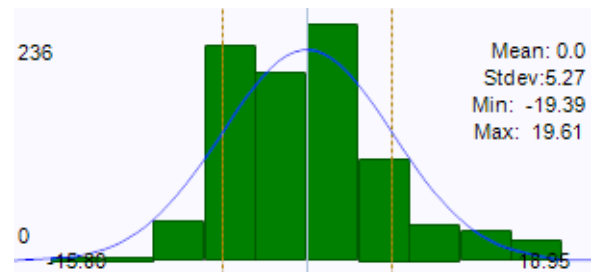
Position Spread Before



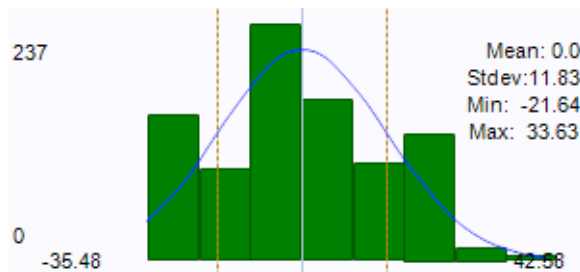
Range Residual



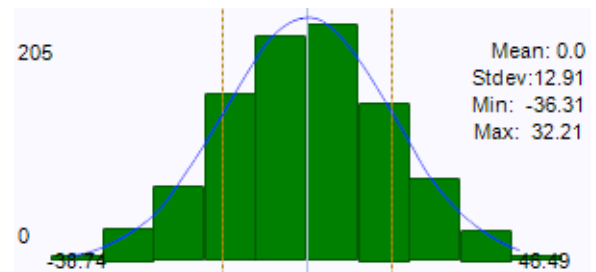
Z Residual



X Residual



Y Residual



Project Details	
Project:	Job 16 J387
Vessel Name:	ATLANTE
Client:	TAP
Surveyors:	Davide P. Eduard T.
Project Description:	TAP Pre construction Survey
Calibration Description:	USBL Calibration Pitch
Method / Units:	Average Error / metres

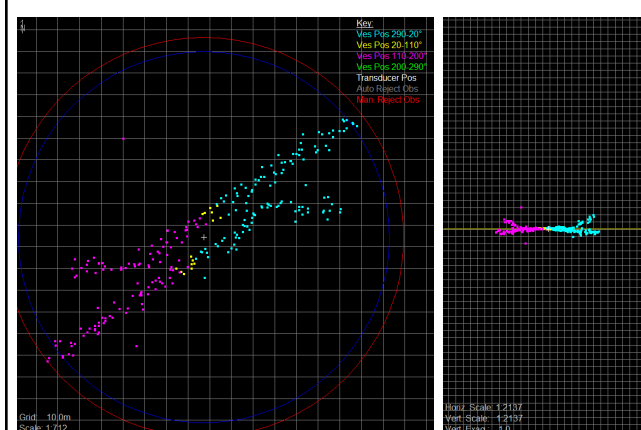
BEFORE (Initial Settings)

Beacon (estimate):		~SD:
Easting:	297,184.27 m (* **)
Northing:	4,481,547.75 m (* **)
Depth:	296.26 m (* **)
Transducer Offset:		
X:	-4.77 m (* **)
Y:	-8.00 m (* **)
Depth:	4.39 m (* **)
Sound Velocity:		
USBL:	1,530.00 m/s (* **)
Attitude Corrections:		
Starfix:	Pitch: 0.00 ° (* **)
	Roll: 0.00 ° (* **)
	Orientation: 0.00 ° (* **)
Sonardyne:	Pitch: 0.00 ° (* **)
	Roll: 0.00 ° (* **)
	Heading: 0.00 ° (* **)
APOS:	Pitch: 0.00 ° (* **)
	Roll: 0.00 ° (* **)
	Gear: 0.00 ° (* **)
<i>(Sonardyne and APOS corrections listed for convention)</i>		

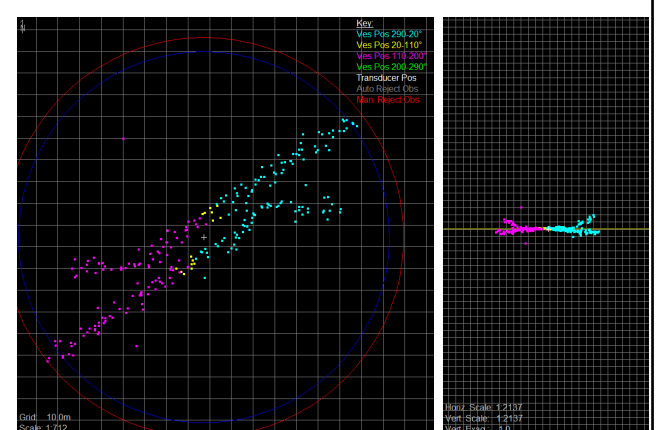
AFTER (Results of Calibration)

Beacon (mean):		SD:
Easting:	297,187.42 m (37.59 m)
Northing:	4,481,544.44 m (26.75 m)
Depth:	299.52 m (5.13 m)
Transducer Offset:		
X:	-4.77 m (* **)
Y:	-8.00 m (* **)
Depth:	4.39 m	
Sound Velocity:		
USBL:	1,530.00 m/s (* **)
ScaleFactor:	1.00000	
Attitude Corrections:		
Starfix:	Pitch: 0.00 ° (* **)
	Roll: 0.00 ° (* **)
	Orientation: 0.00 ° (* **)
Sonardyne:	Pitch: 0.00 ° (* **)
	Roll: 0.00 ° (* **)
	Heading: 0.00 ° (* **)
APOS:	Pitch: 0.00 ° (* **)
	Roll: 0.00 ° (* **)
	Gear: 0.00 ° (* **)
Iterations:	Obs Accepted:	Obs Rejected:
0	253	0

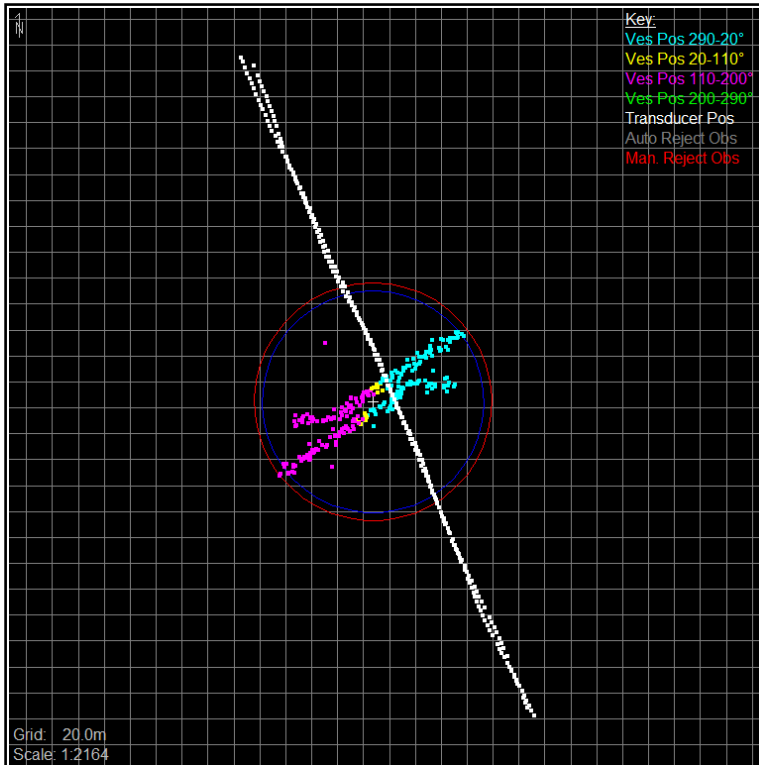
Scatter Before:



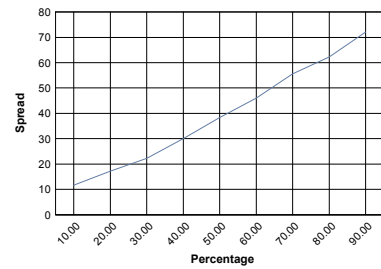
Scatter After:



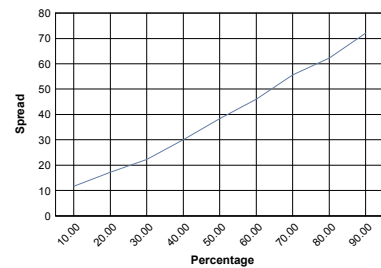
Vessel Track:



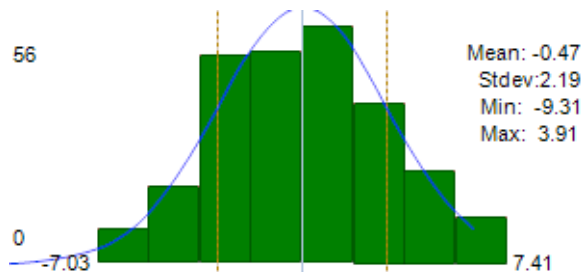
Position Spread After



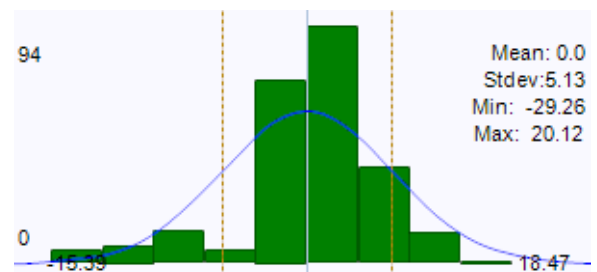
Position Spread Before



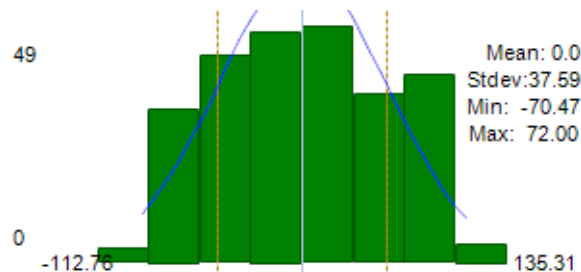
Range Residual



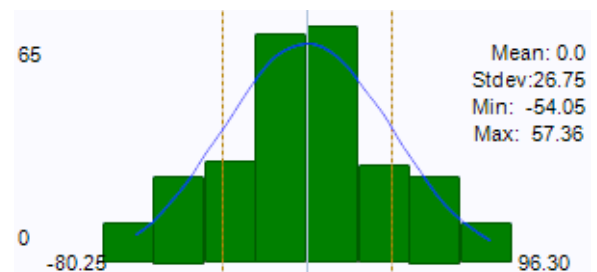
Z Residual



X Residual



Y Residual





MRU5 CALIBRATION

Project:	Nord Stream 2	Station 1:	P1	Datum:	WGS84	Time zone:	UTC+1	Roll Base (Lr):	4.800 m					
Vessel:	Otranto	Easting:		Hemisphere:	North			Pitch Base (Lp):	11.700 m					
Location:	Otranto	Northing:		Projection:	UTM zone 34									
Date:	19.11.2016	Station 2:	P2	Central Meridian:	21°									
Unit:	DMS3-05	Easting:		False Easting:	500000									
Serial No.:	039915	Northing:												
No.	Time observations of Roll	TRUE ROLL RTK DGNSS				Time observations of Pitch	True Pitch RTK DGNSS				Observed Roll, °	Observed Pitch, °	C-Or, °	C-Op, °
		H, m		ΔH, m	Δ Roll, °		H, m		ΔH, m	Δ Pitch, °				
		STBD	PORT				STERN	BOW						
1	10:29:52	39.93	39.90	-0.028	-0.334	10:35:27	39.90	39.92	0.016	0.078	-0.74	1.97	0.406	-1.892
2	10:29:58	39.91	39.89	-0.027	-0.322	10:35:34	39.90	39.93	0.031	0.152	-0.76	1.93	0.438	-1.778
3	10:30:04	39.92	39.89	-0.029	-0.346	10:35:41	39.90	39.93	0.033	0.162	-0.71	1.86	0.364	-1.698
4	10:30:10	39.91	39.89	-0.016	-0.191	10:35:48	39.89	39.93	0.040	0.196	-0.88	1.92	0.689	-1.724
5	10:30:16	39.92	39.90	-0.018	-0.215	10:35:55	39.90	39.93	0.034	0.167	-0.89	2.05	0.675	-1.883
6	10:30:22	39.92	39.89	-0.026	-0.310	10:36:02	39.90	39.92	0.029	0.142	-0.68	1.88	0.370	-1.738
7	10:30:31	39.91	39.89	-0.021	-0.251	10:36:09	39.90	39.92	0.025	0.122	-0.65	1.86	0.399	-1.738
8	10:30:42	39.91	39.89	-0.022	-0.263	10:36:16	39.88	39.92	0.035	0.171	-0.68	1.88	0.417	-1.709
9	10:30:48	39.91	39.89	-0.022	-0.263	10:36:23	39.88	39.90	0.025	0.122	-0.58	1.87	0.317	-1.748
10	10:30:55	39.92	39.90	-0.025	-0.298	10:36:30	39.88	39.89	0.009	0.044	-0.61	1.82	0.312	-1.776
11	10:31:01	39.91	39.89	-0.026	-0.310	10:36:37	39.88	39.90	0.021	0.103	-0.65	1.89	0.340	-1.787
12	10:31:07	39.91	39.89	-0.025	-0.298	10:36:43	39.88	39.90	0.019	0.093	-0.68	1.92	0.382	-1.827
13	10:31:15	39.91	39.89	-0.018	-0.215	10:36:50	39.88	39.89	0.016	0.078	-0.73	1.84	0.515	-1.762
14	10:31:22	39.91	39.89	-0.018	-0.215	10:36:57	39.88	39.90	0.024	0.118	-0.77	1.93	0.555	-1.812
15	10:31:29	39.92	39.90	-0.019	-0.227	10:37:03	39.87	39.90	0.025	0.122	-0.73	1.96	0.503	-1.838
16	10:31:37	39.92	39.90	-0.024	-0.286	10:37:10	39.88	39.89	0.012	0.059	-0.60	1.94	0.314	-1.881
	Average:	39.916	39.893	-0.023	-0.272		39.887	39.911	0.025	0.121	-0.709	1.908	0.437	-1.787
	St. dev.	0.005	0.004	0.004	0.049		0.010	0.016	0.009	0.043	0.089	0.057	0.120	0.063

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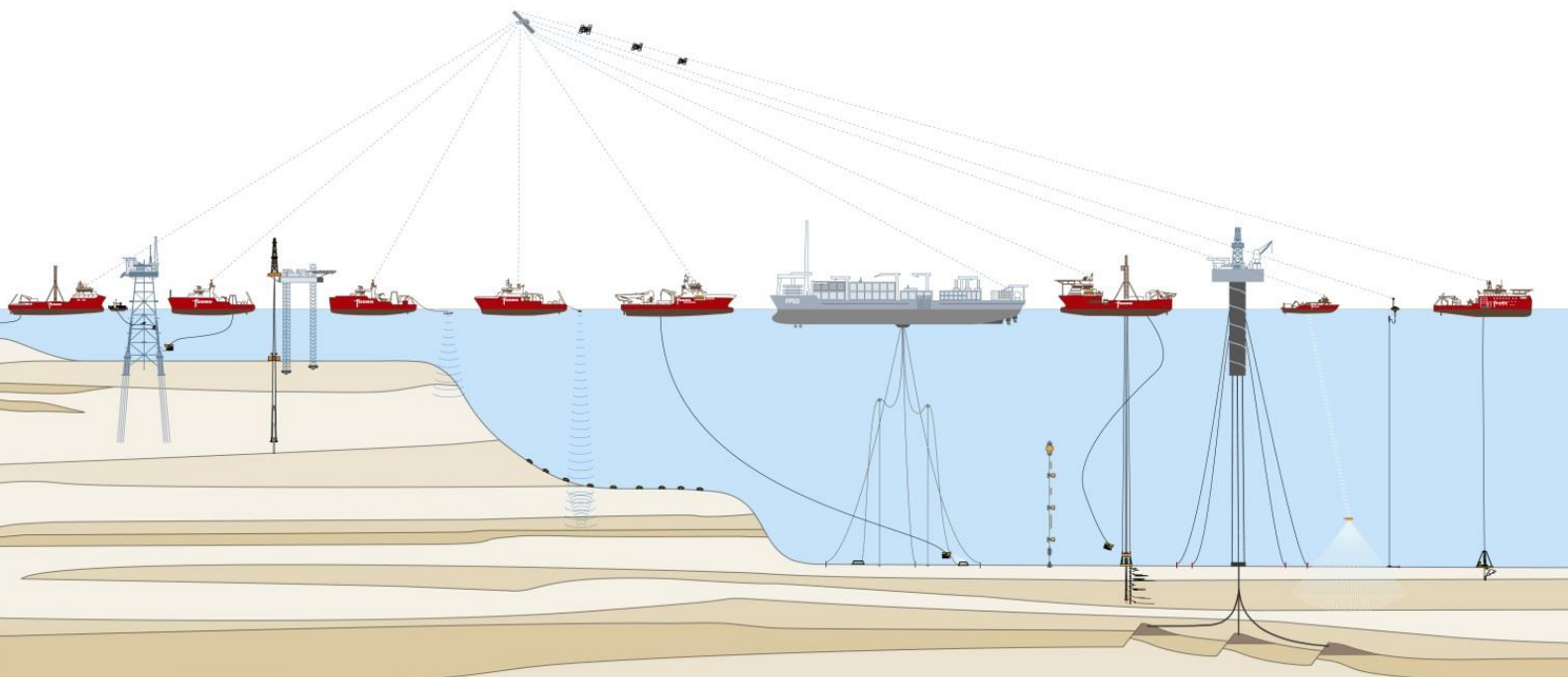
**TAP Pre-construction Survey-Installation of
Monitoring Station, Environmental and
Geophysical Survey
Adriatic Sea**

**MBES calibration Report
Reson Seabat 7101**

Trans Adriatic Pipeline AG



RSK Environment Ltd.



FUGRO

TAP Pre-construction Survey-Installation of Monitoring Station, Environmental and Geophysical Survey Adriatic Sea

MBES calibration Report Reson Seabat 7101

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00	Multibeam Calibration Report	Paolo Cosmo Santoro
Rev	Descrizione	Prepared

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1. INTRODUCTION

1.1 General

The Reson Seabat 7101 multibeam echo sounder on board the MN ATLANTE was calibrated on 02 December 2016. The calibration was undertaken over an area with several targets inside the survey area. The purpose of calibrating the system was to determine the angular difference between the pitch, roll and heading sensors with the multibeam head installation.

1.2 Background

When the multibeam transducer, motion sensor and gyro are installed on a vessel, there is always going to be some residual misalignment between the sensors. During survey operations the multibeam data, with appropriate offset corrections, needs to be derived relative to true vertical. Any deviations in roll will translate to depth measurement errors in the outer beams, increasing with beam angle. Deviations in pitch will result in along track position errors. Similarly, heading (or yaw) offsets between the planes of the multibeam transmit beam and the alignment of the vessel reported by the gyro will result in position errors on the soundings from the outer beams. These errors will increase both with beam angle off nadir and water depth.

It is also necessary to determine any latency within the positioning system to ensure that the data collection system is synchronized to GPS time. The difference in time from the moment when a position is valid until the position message is sent to the data collection system must be determined. Commonly used DGPS receivers have latencies ranging from 200 milliseconds to over one second. If the data collection system does not correct for this latency, the result is a speed dependent position error in the data. The positioning system used in the current survey has no latency, so the lines have not been run.

1.3 Pre Calibration

The following operations were carried out prior to calibration:

- Location of appropriate calibration feature
- Draft measurement of echo sounders
- Gyro calibration
- Sound velocity Profile
- Check time offset of positioning system, motion sensors and echo sounders
- Check operation of motion sensors

1.4 Settings

Local Geodetic Parameters

Datum WGS84
 Spheroid WGS84
 Semi-Major Axis a=6 378 137.000m
 Inverse Flattening 1/f=298.257223563

Projection parameters:

Projection Universal Transverse Mercator, Northern Hemisphere
 Zone 34 N
 Central Meridian 21° 00' 00" E
 False Easting 500 000 m
 False Northing 0.00000 m
 Scale Factor 0.9996 on Central Meridian
 Units Meters

Multibeam Echo Sounder

MBE Device Type HULL MOUNTED
 Cast Reference SVP 02/12/2016
 Transducer SV 1514 m/s
 MBE Device Reson SEABAT 7101
 Position Device Starfix STAR PACK
 Heading Device Teledyne Meridian gyro
 Heave Device Teledyne DMS 505
 Pitch Roll Device Teledyne DMS 505 Pos Offset from CRP MBES (installation position)

Calibration Location

Centred about the following coordinates:
 Easting 286650.95 m
 Northing 4447962.90 m
 Depth -120 m

Table 1.1: Loaded Calibration Lines (P= pitch – R=roll – Y=Yaw)

RESON 8111 MULTIBEAM CALIBRATION LINE SUMMARY			
Calibration Line used For	Logging Session	Average Heading (deg)	Average Speed m/s(knots)
PRH	201612020829	235°	4 knots
	201612020842	42°	
H	201612020902	235°	4 knots
	201612021138	42°	

Calibration Conditions

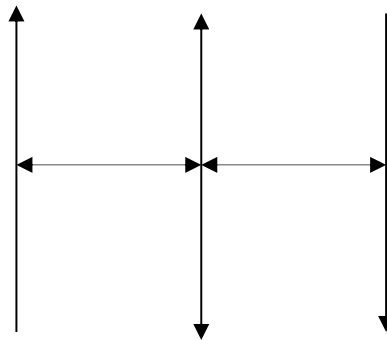
Weather: Good

Sea: Calm

1.5 Calibration Method

4 lines were run, 2 over the same location, two for yaw and two in opposite direction for roll, pitch, yaw and latency calibration. Calibration lines were processed using the Multibeam calibration software program within Fugro's Starfix suite to find correction values in the following order:

1. Roll
2. Pitch
3. Heading (or Yaw)
4. Latency



Pitch Calibration

A latency correction 0 s was applied before deriving the Pitch offset error.

Pitch offset error was measured from reciprocal lines that were run over the established point at a speed of 4 knots.

The pitch offset correction of -2° was derived by iteratively reducing the differences in vertical angle through nadir along the track calibration line until the two data sets aligned.

Roll Calibration

A pitch correction of -2° was applied before deriving the Roll offset error.

The roll offset error was measured by running reciprocal survey lines over a flat area of seabed then comparing the across track profiles against one another.

The roll offset correction of 1.26° was derived by iteratively reducing the differences in horizontal angle along an across track calibration line until the two data sets aligned.



Heading (or Yaw) Calibration

A Roll offset correction of 1.26 ° was applied before deriving the Orientation offset error.

The heading offset error was derived by iteratively reducing the difference in orientation angle to a target resolved in 2 lines run in the same direction and apart.

A heading offset correction of 0.6 ° was derived by iteratively reducing the differences in orientation angle of each swathe until the target aligned within the overlapping central region.

1.6 Results

A summary of calibration results is given below:

Table 1.2: Calibrations results

Motion Sensor	Calibration Date	Latency (s)	Pitch Error (°)	Roll Error (°)	Heading Error (°)
Teledyne DMS 505	02/12/2016	0	-2	1.26	0.6

A good correlation of features was observed on overlapping lines after the application of calibration corrections.

The following data examples show screen dumps after the application of calibration corrections and an image showing the final corrected data set.

MULTIBEAM CALIBRATION DATA EXAMPLE

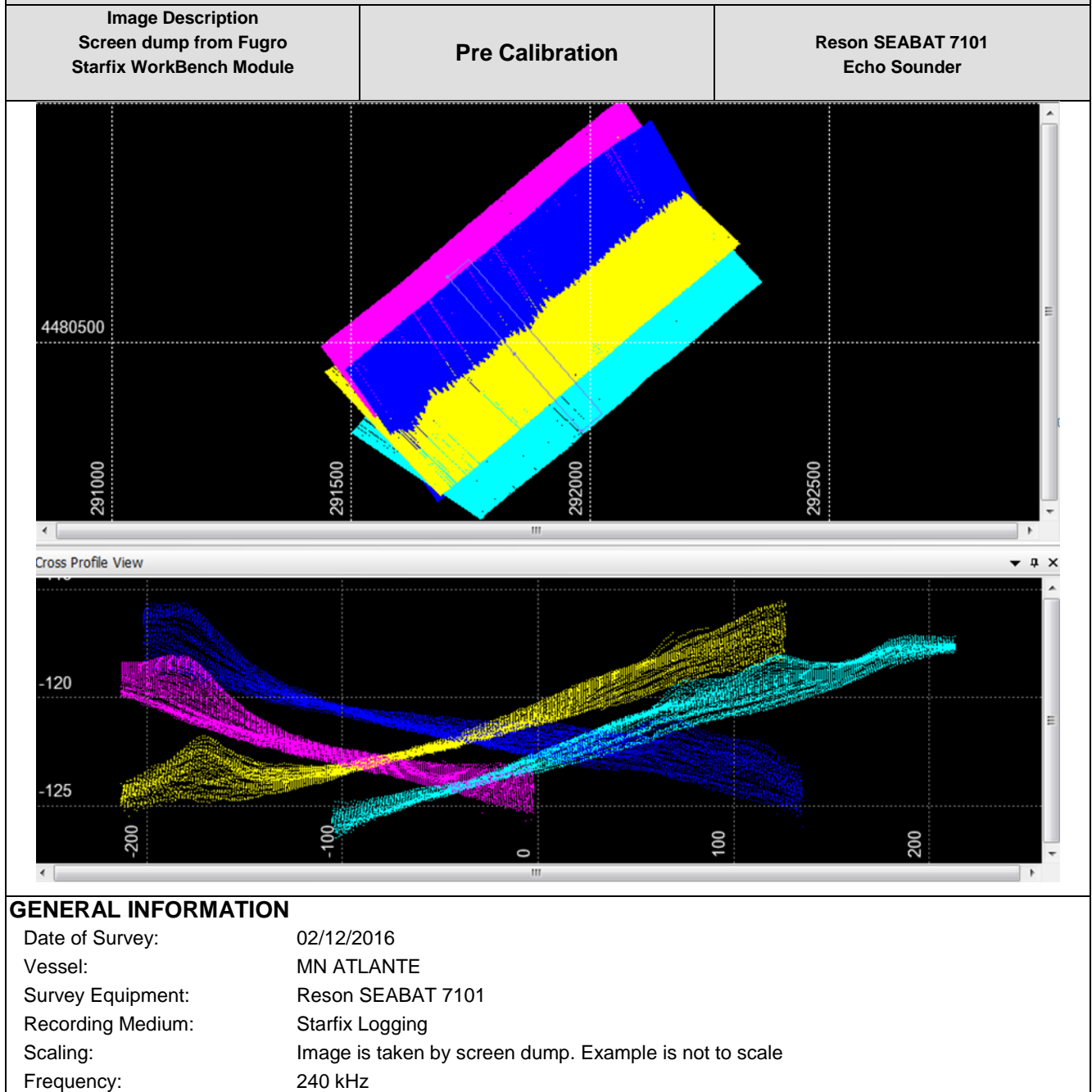


Figure 1.1: MBES data example (pre calibration)

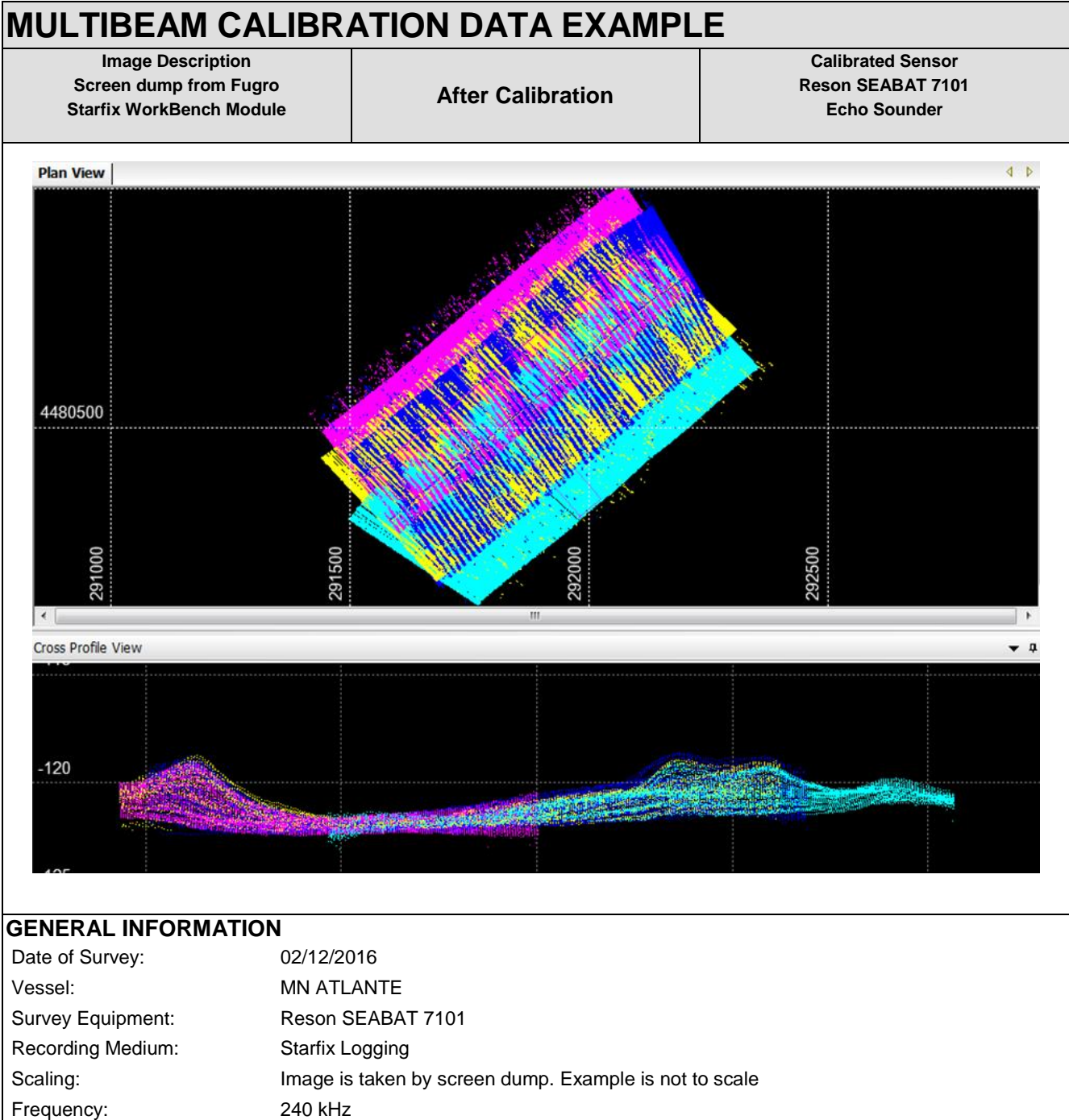


Figure 1.2: MBES data example (after calibration)

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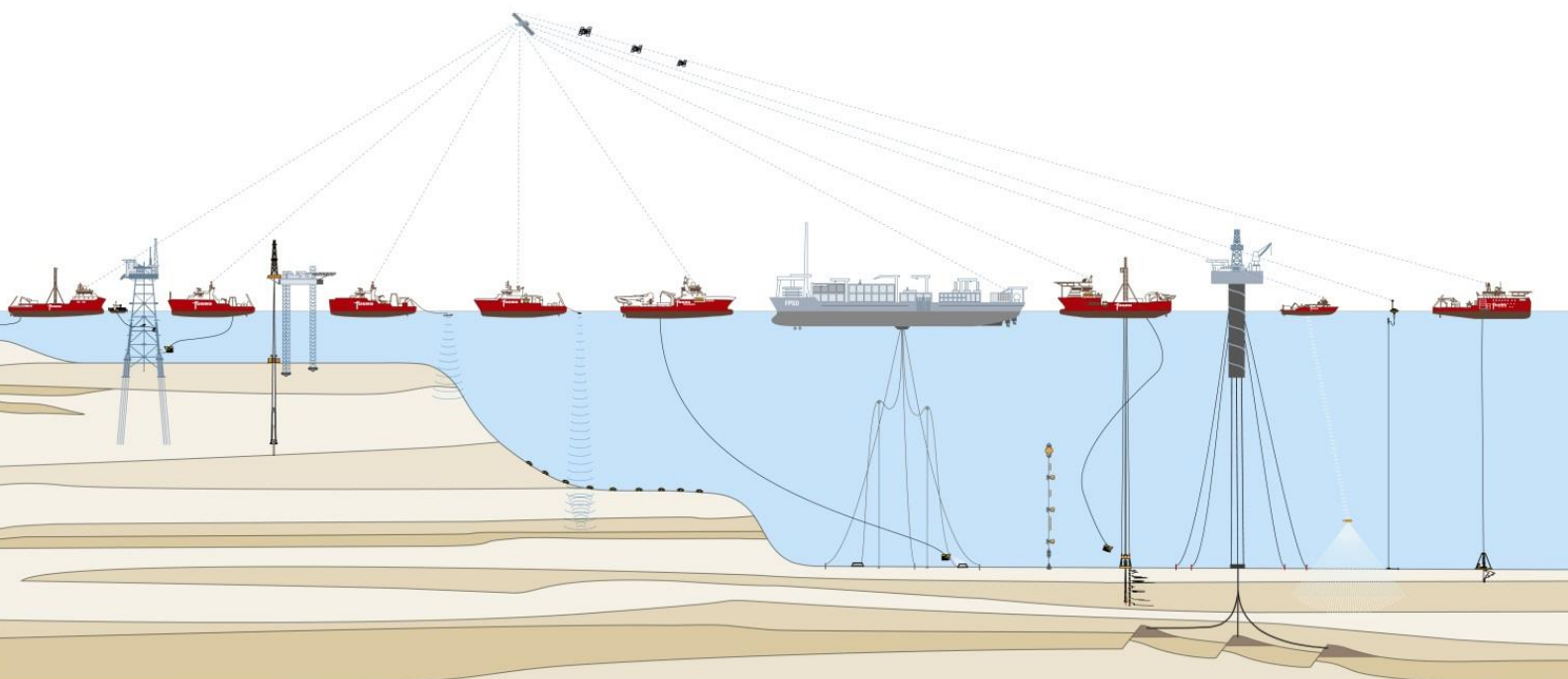
**TAP Pre-construction Survey-Installation of
Monitoring Station, Environmental and
Geophysical Survey
Adriatic Sea**

**MBES calibration Report
Reson Seabat 7160**

Trans Adriatic Pipeline AG



RSK Environment Ltd.



FUGRO

TAP Pre-construction Survey-Installation of Monitoring Station, Environmental and Geophysical Survey Adriatic Sea

MBES calibration Report Reson Seabat 7160

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Rev	Descrizione	Prepared
00	Multibeam Calibration Report	Paolo Cosmo Santoro

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1. INTRODUCTION

1.1 General

The Reson Seabat 7160 multibeam echo sounder on board the MN ATLANTE was calibrated on 07 December 2016. The calibration was undertaken over an area with several targets inside the survey area. The purpose of calibrating the system was to determine the angular difference between the pitch, roll and heading sensors with the multibeam head installation.

1.2 Background

When the multibeam transducer, motion sensor and gyro are installed on a vessel, there is always going to be some residual misalignment between the sensors. During survey operations the multibeam data, with appropriate offset corrections, needs to be derived relative to true vertical. Any deviations in roll will translate to depth measurement errors in the outer beams, increasing with beam angle. Deviations in pitch will result in along track position errors. Similarly, heading (or yaw) offsets between the planes of the multibeam transmit beam and the alignment of the vessel reported by the gyro will result in position errors on the soundings from the outer beams. These errors will increase both with beam angle off nadir and water depth.

It is also necessary to determine any latency within the positioning system to ensure that the data collection system is synchronized to GPS time. The difference in time from the moment when a position is valid until the position message is sent to the data collection system must be determined. Commonly used DGPS receivers have latencies ranging from 200 milliseconds to over one second. If the data collection system does not correct for this latency, the result is a speed dependent position error in the data. The positioning system used in the current survey has no latency, so the lines have not been run.

1.3 Pre Calibration

The following operations were carried out prior to calibration:

- Location of appropriate calibration feature
- Draft measurement of echo sounders
- Gyro calibration
- Sound velocity Profile
- Check time offset of positioning system, motion sensors and echo sounders
- Check operation of motion sensors



1.4 Settings

Local Geodetic Parameters

Datum WGS84
 Spheroid WGS84
 Semi-Major Axis a=6 378 137.000m
 Inverse Flattening 1/f=298.257223563

Projection parameters:

Projection Universal Transverse Mercator, Northern Hemisphere
 Zone 34 N
 Central Meridian 21° 00' 00" E
 False Easting 500 000 m
 False Northing 0.00000 m
 Scale Factor 0.9996 on Central Meridian
 Units Meters

Multibeam Echo Sounder

MBE Device Type HULL MOUNTED
 Cast Reference SVP 07/12/2016
 Transducer SV 1514 m/s
 MBE Device Reson SEABAT 7160

Position Device Starfix STAR PACK
 Heading Device Teledyne Meridian gyro
 Heave Device Teledyne DMS 505
 Pitch Roll Device Teledyne DMS 505 Pos Offset from CRP MBES (installation position)

Calibration Location

Centred about the following coordinates:

Easting 299625 m
 Northing 4481868 m
 Depth -591 m

Table 1.1: Loaded Calibration Lines (P= pitch – R=roll – Y=Yaw)

RESON 7160 MULTIBEAM CALIBRATION LINE SUMMARY			
Calibration Line used For	Logging Session	Average Heading (deg)	Average Speed m/s(knots)
PRH	201612071107	149°	4 knots
	201612071126	329°	
H	201612071142	149°	4 knots
	201612071201	329°	

Calibration Conditions

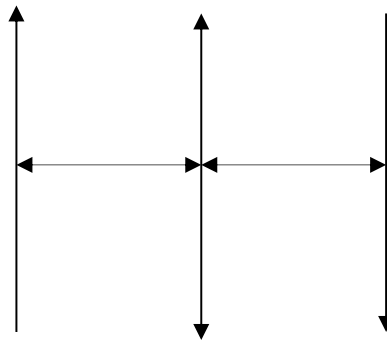
Weather: Good

Sea: Calm

1.5 Calibration Method

4 lines were run, 2 over the same location, two for yaw and two in opposite direction for roll, pitch, yaw and latency calibration. Calibration lines were processed using the Multibeam calibration software program within Fugro's Starfix suite to find correction values in the following order:

1. Roll
2. Pitch
3. Heading (or Yaw)
4. Latency



Pitch Calibration

A latency correction 0 s was applied before deriving the Pitch offset error.

Pitch offset error was measured from reciprocal lines that were run over the established point at a speed of 4 knots.

The pitch offset correction of -0.8° was derived by iteratively reducing the differences in vertical angle through nadir along the track calibration line until the two data sets aligned.

Roll Calibration

A pitch correction of -0.8° was applied before deriving the Roll offset error.

The roll offset error was measured by running reciprocal survey lines over a flat area of seabed then comparing the across track profiles against one another.

The roll offset correction of 1.6° was derived by iteratively reducing the differences in horizontal angle along an across track calibration line until the two data sets aligned.



Heading (or Yaw) Calibration

A Roll offset correction of 1.6 ° was applied before deriving the Orientation offset error.

The heading offset error was derived by iteratively reducing the difference in orientation angle to a target resolved in 2 lines run in the same direction and apart.

A heading offset correction of -0.25° was derived by iteratively reducing the differences in orientation angle of each swathe until the target aligned within the overlapping central region.

1.6 Results

A summary of calibration results is given below:

Table 1.2: Calibrations results

Motion Sensor	Calibration Date	Latency (s)	Pitch Error (°)	Roll Error (°)	Heading Error (°)
Teledyne DMS 505	07/12/2016	0	-0.8	1.6	-0.25

A good correlation of features was observed on overlapping lines after the application of calibration corrections.

The following data examples show screen dumps after the application of calibration corrections and an image showing the final corrected data set.

MULTIBEAM CALIBRATION DATA EXAMPLE

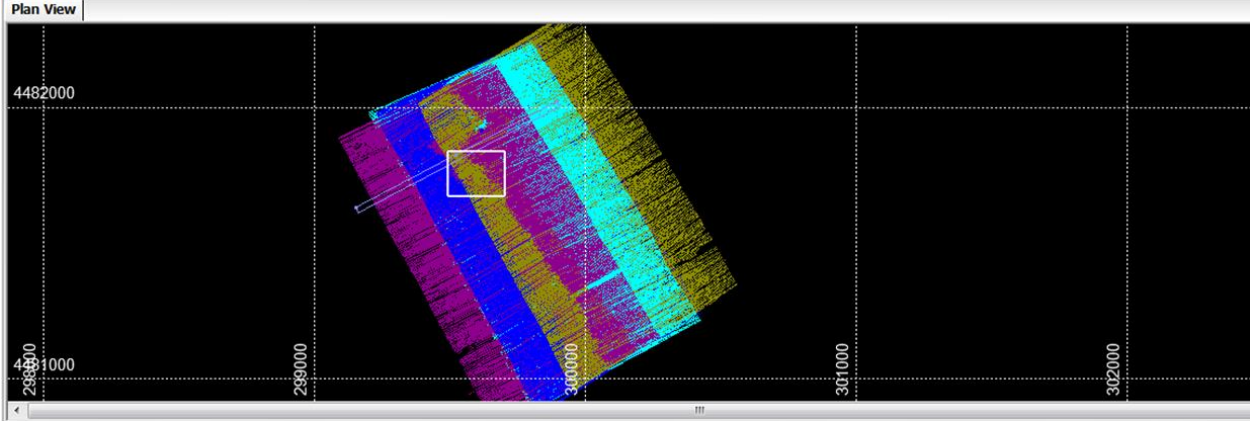
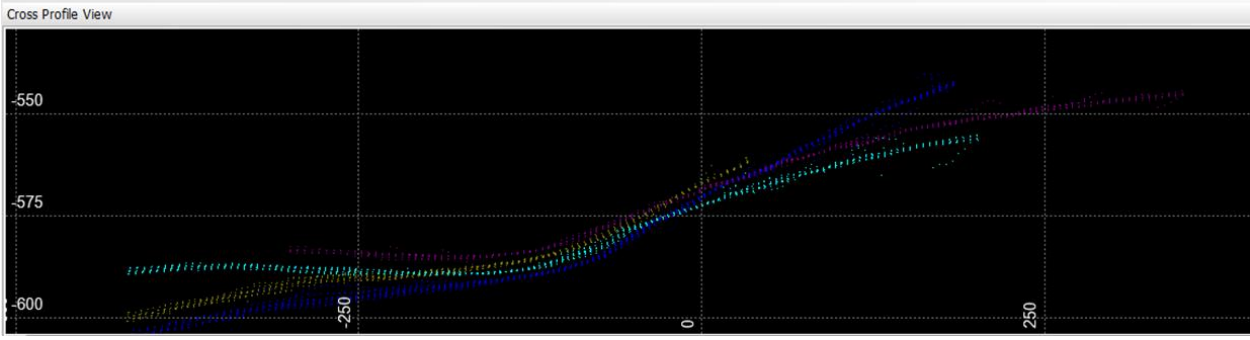
Image Description Screen dump from Fugro Starfix WorkBench Module	Pre Calibration	Reson SEABAT 7160 Echo Sounder
<div style="display: flex; flex-direction: column;"> <div> <p>Plan View</p>  </div> <div> <p>Cross Profile View</p>  </div> </div>		
<p>GENERAL INFORMATION</p> <p>Date of Survey: 07/12/2016 Vessel: MN ATLANTE Survey Equipment: Reson SEABAT 7160 Recording Medium: Starfix Logging Scaling: Image is taken by screen dump. Example is not to scale Frequency: 44 kHz</p>		

Figure 1.1: MBES data example (pre calibration)

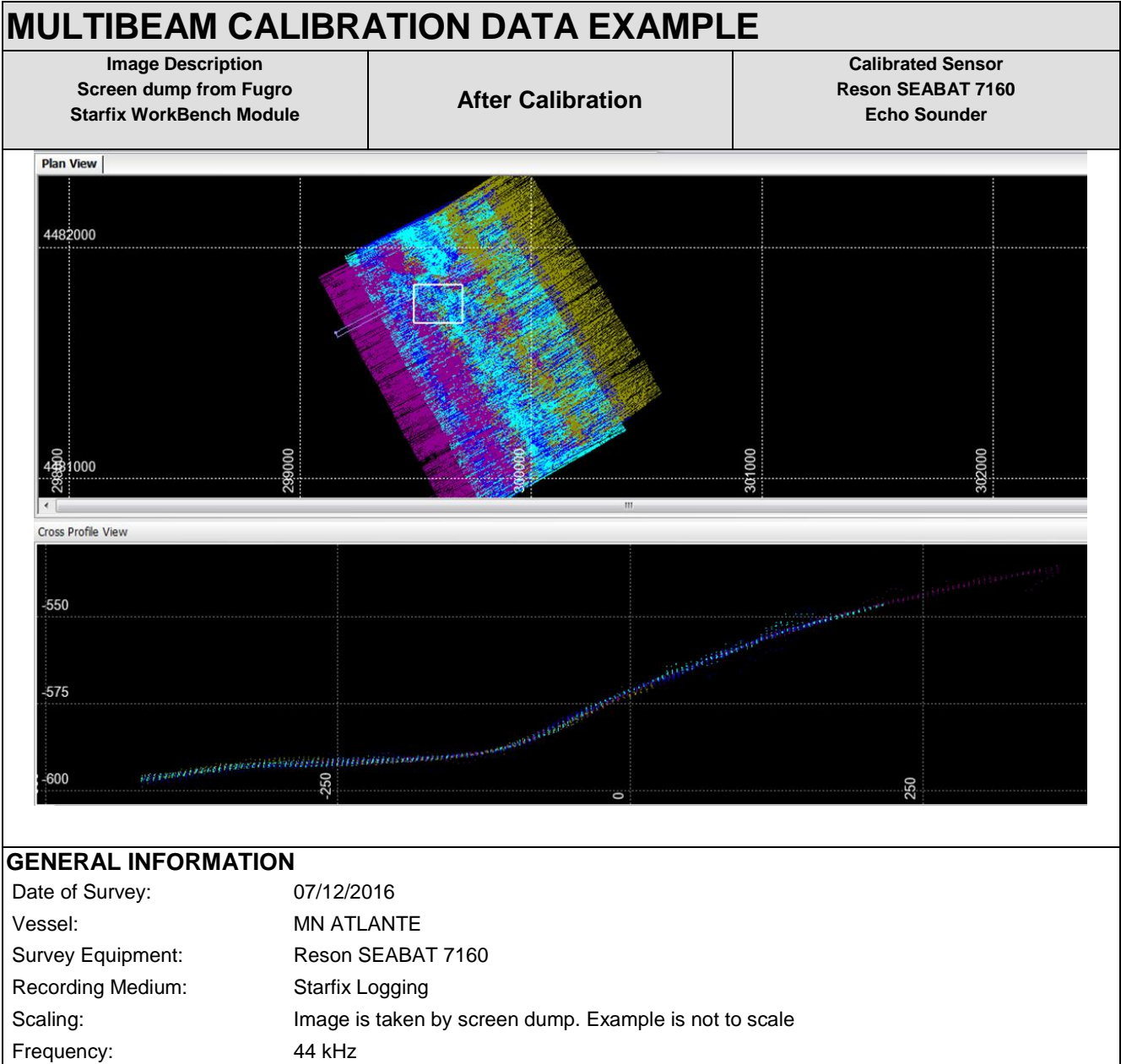
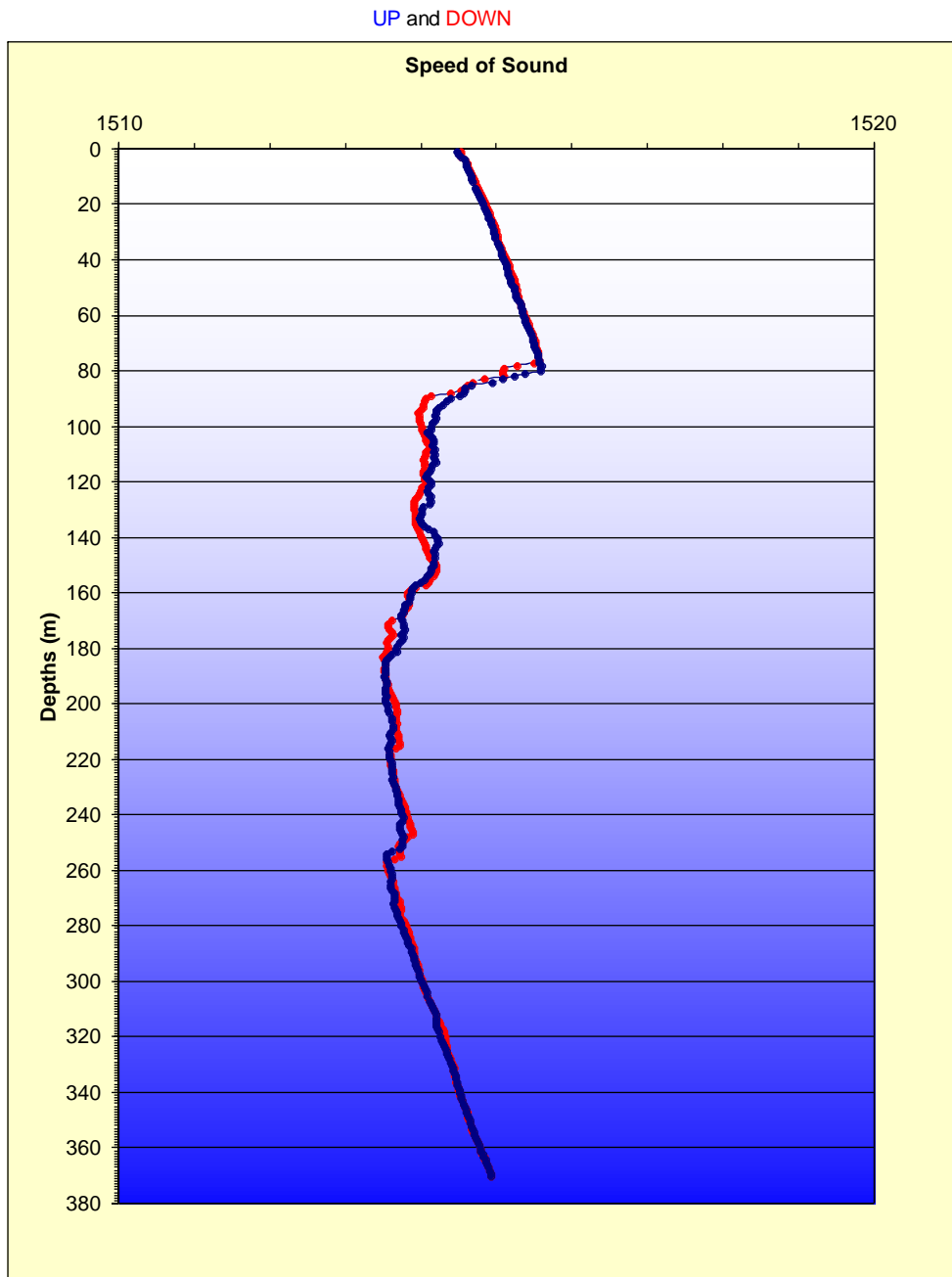


Figure 1.2: MBES data example (after calibration)

S.V.P. GRAPHIC PLOT UP/DOWN

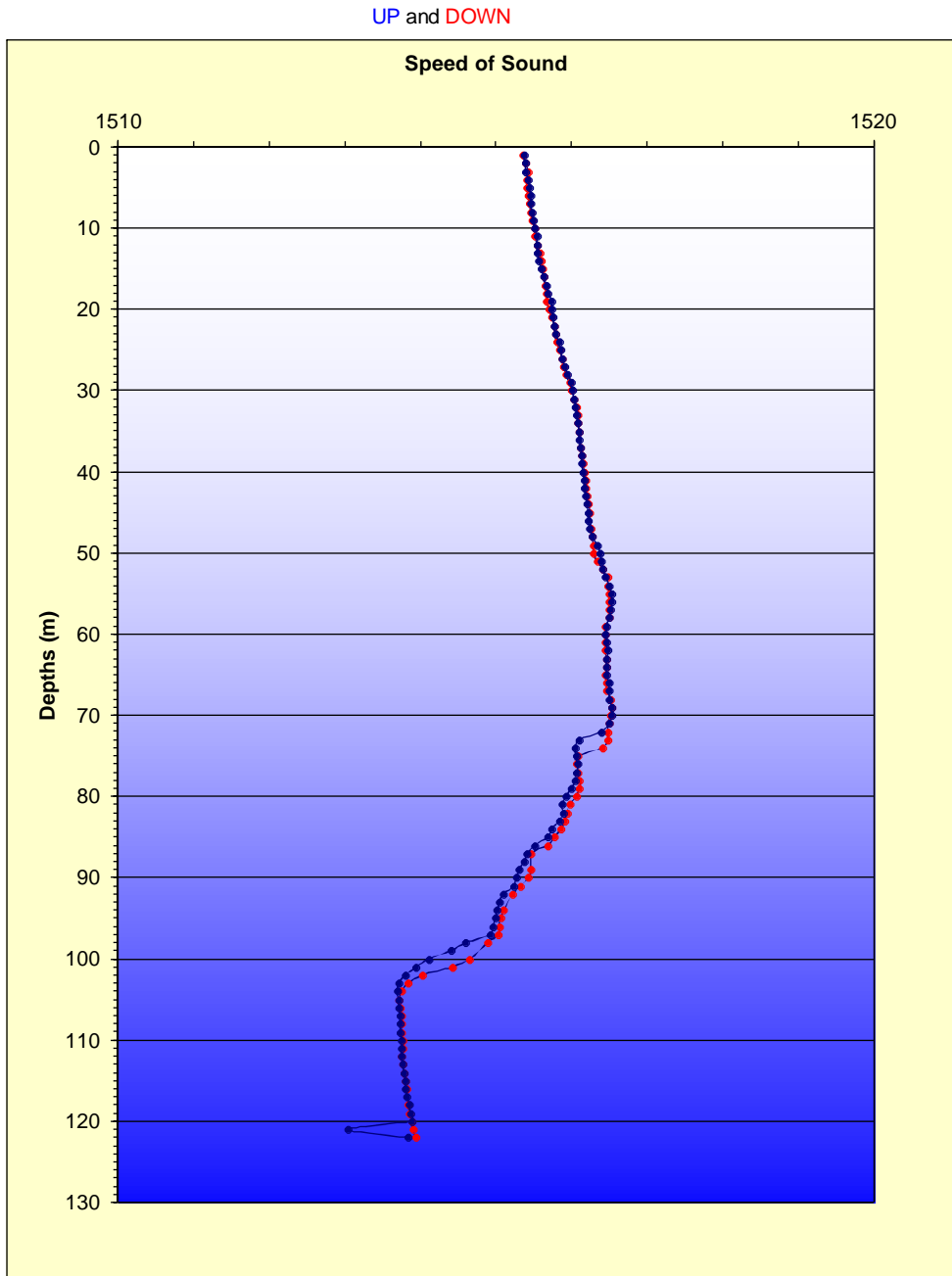
Date: 02/12/2016 Project: Trans Adriatic Pipeline - Geophysical survey
 Time: 6.50 (UTC +1) Client: RSK
 Project No: 16-J387 Wather Depth: 370
 Area: San Foca- Adriatic Sea Mean Value: 1514,23 m/s



Datum: Local Datum			
Latitude:	40° 27' 15.88"	Northing:	4480924
Longitude:	18° 36' 57.66"	Easting:	297850

S.V.P. GRAPHIC PLOT UP/DOWN

Date: 02/12/2016 Project: Trans Adriatic Pipeline - Geophysical survey
 Time: 8.30 (UTC +1) Client: RSK
 Project No: 16-J387 Wather Depth: 122
 Area: San Foca- Adriatic Sea Mean Value: 1515,55 m/s

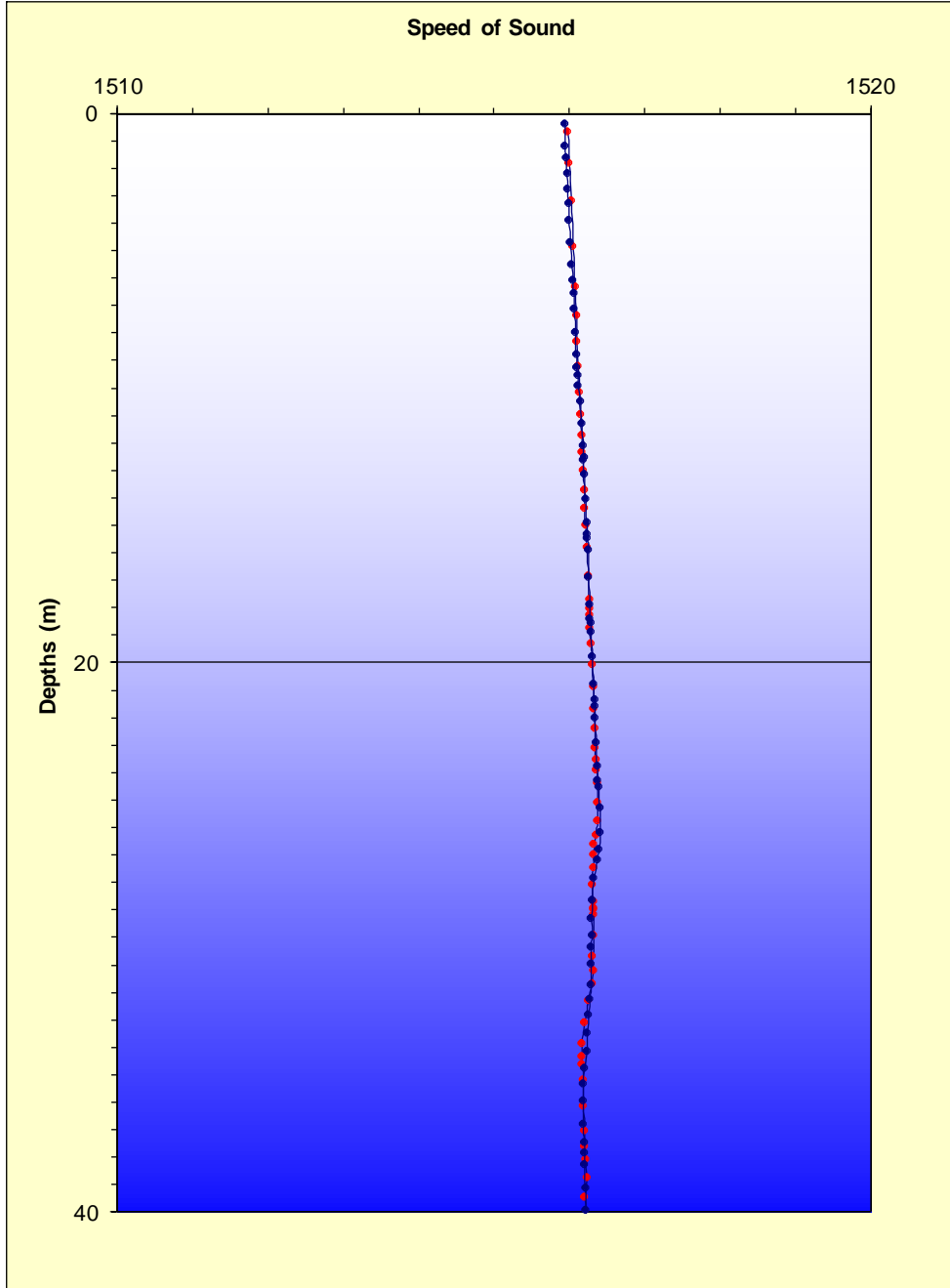


Datum: Local Datum			
Latitude:	40° 26' 56.78"	Northing:	4480496
Longitude:	18° 32' 48.49"	Easting:	291964

S.V.P. GRAPHIC PLOT UP/DOWN

Date:03/12/2016 Project: Trans Adriatic Pipeline - Geophysical survey
 Time:18,00 (UTC +1) Client: RSK
 Project No: 16-J387 Wather Depth: 75,5
 Area: San Foca- Adriatic Sea Mean Value: 1516,10 m/s

UP and DOWN

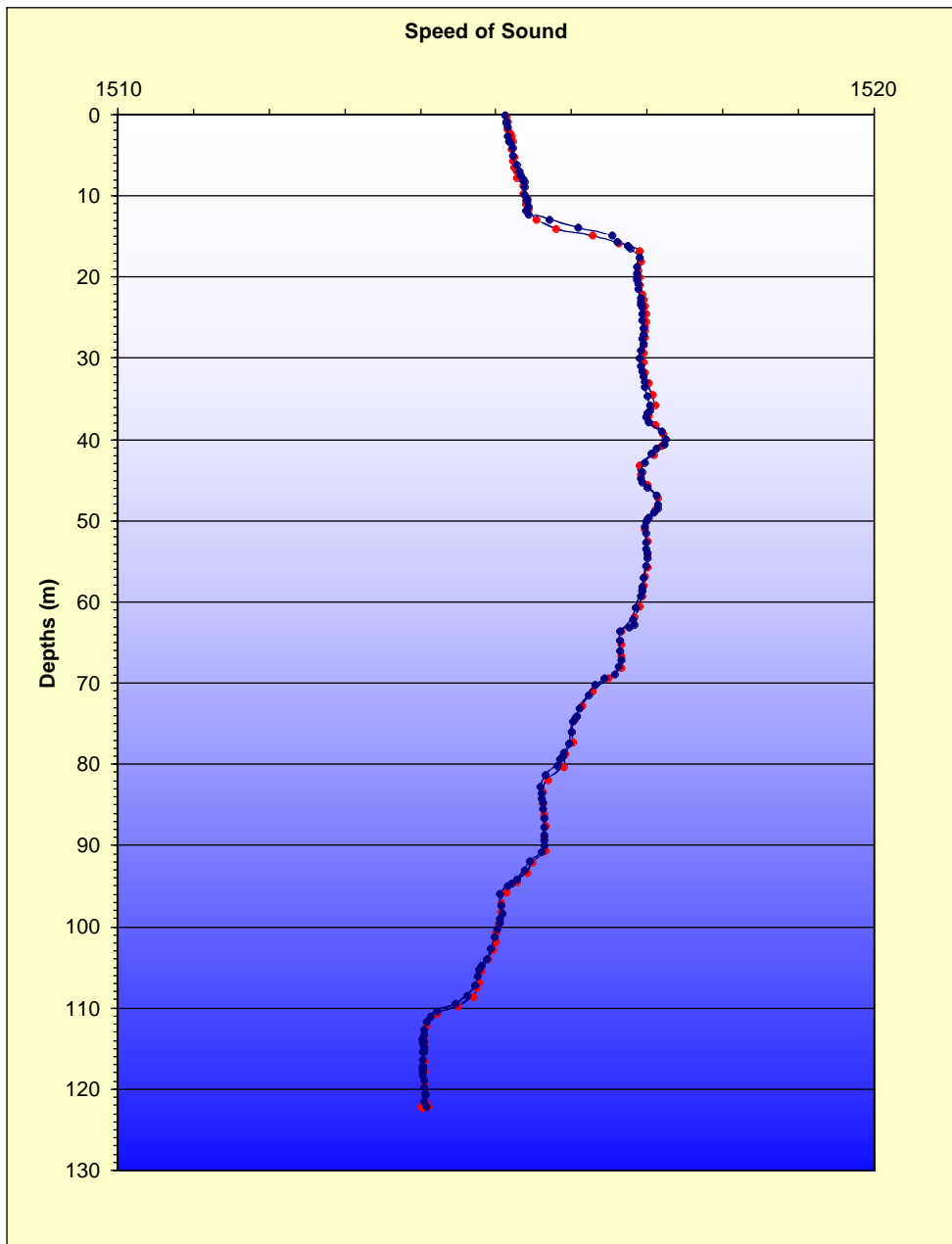


Datum: Local Datum			
Latitude:	40° 19' 08.48"	Northing:	446636,5
Longitude:	18° 25' 06.351"	Easting:	280654,7

S.V.P. GRAPHIC PLOT UP/DOWN

Date: 04/12/2016 Project: Trans Adriatic Pipeline - Geophysical survey
 Time: 15,00 (UTC +1) Client: RSK
 Project No: 16-J387 Wather Depth: 122
 Area: San Foca- Adriatic Sea Mean Value: 1515,85 m/s

UP and DOWN

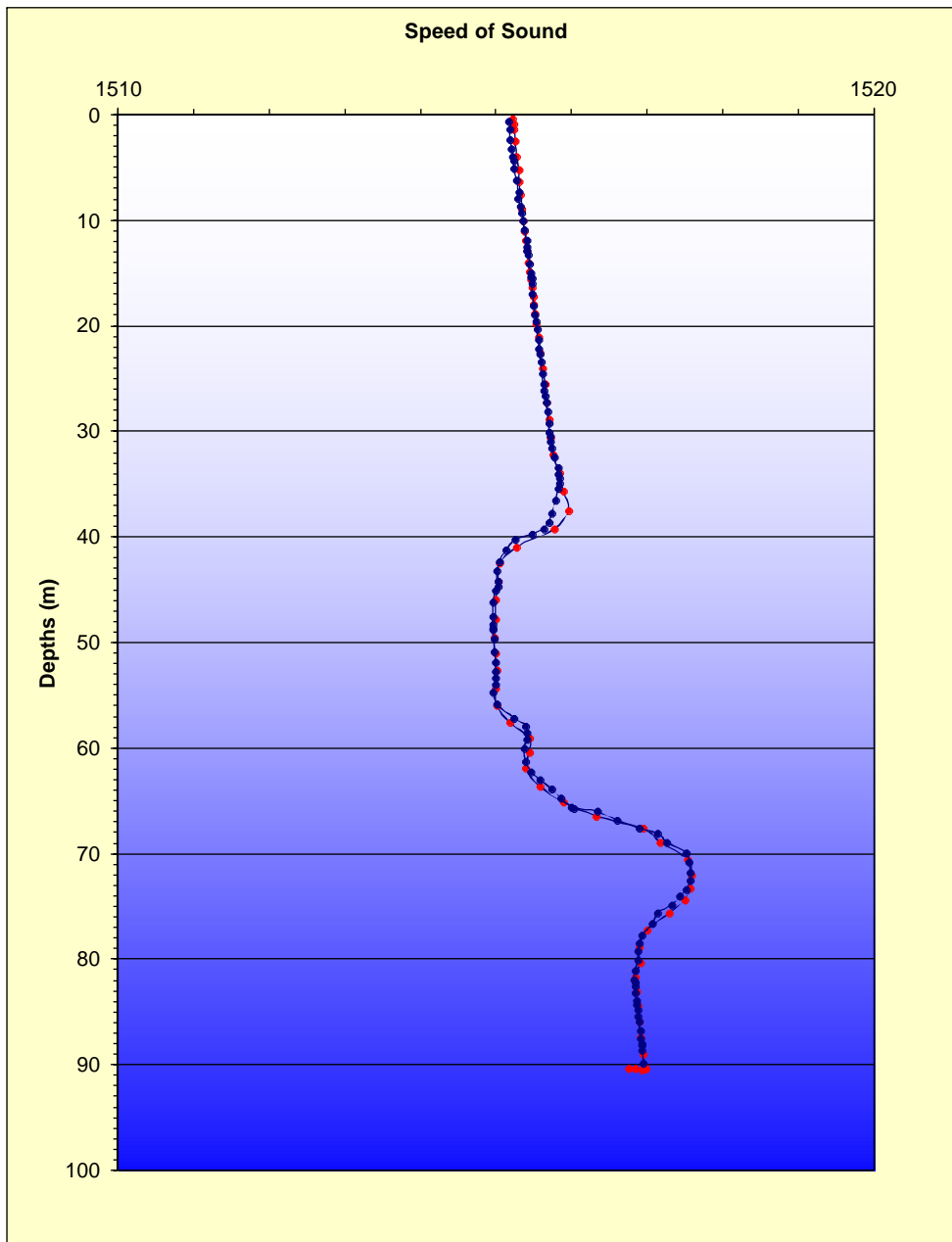


Datum: Local Datum			
Latitude:	40° 27' 16.738"	Northing:	4481104
Longitude:	18° 32' 59.48"	Easting:	292240

S.V.P. GRAPHIC PLOT UP/DOWN

Date: 04/12/2016 Project: Trans Adriatic Pipeline - Geophysical survey
 Time: 22,15 (UTC +1) Client: RSK
 Project No: 16-J387 Wather Depth: 90
 Area: San Foca- Adriatic Sea Mean Value: 1515,93 m/s

UP and DOWN

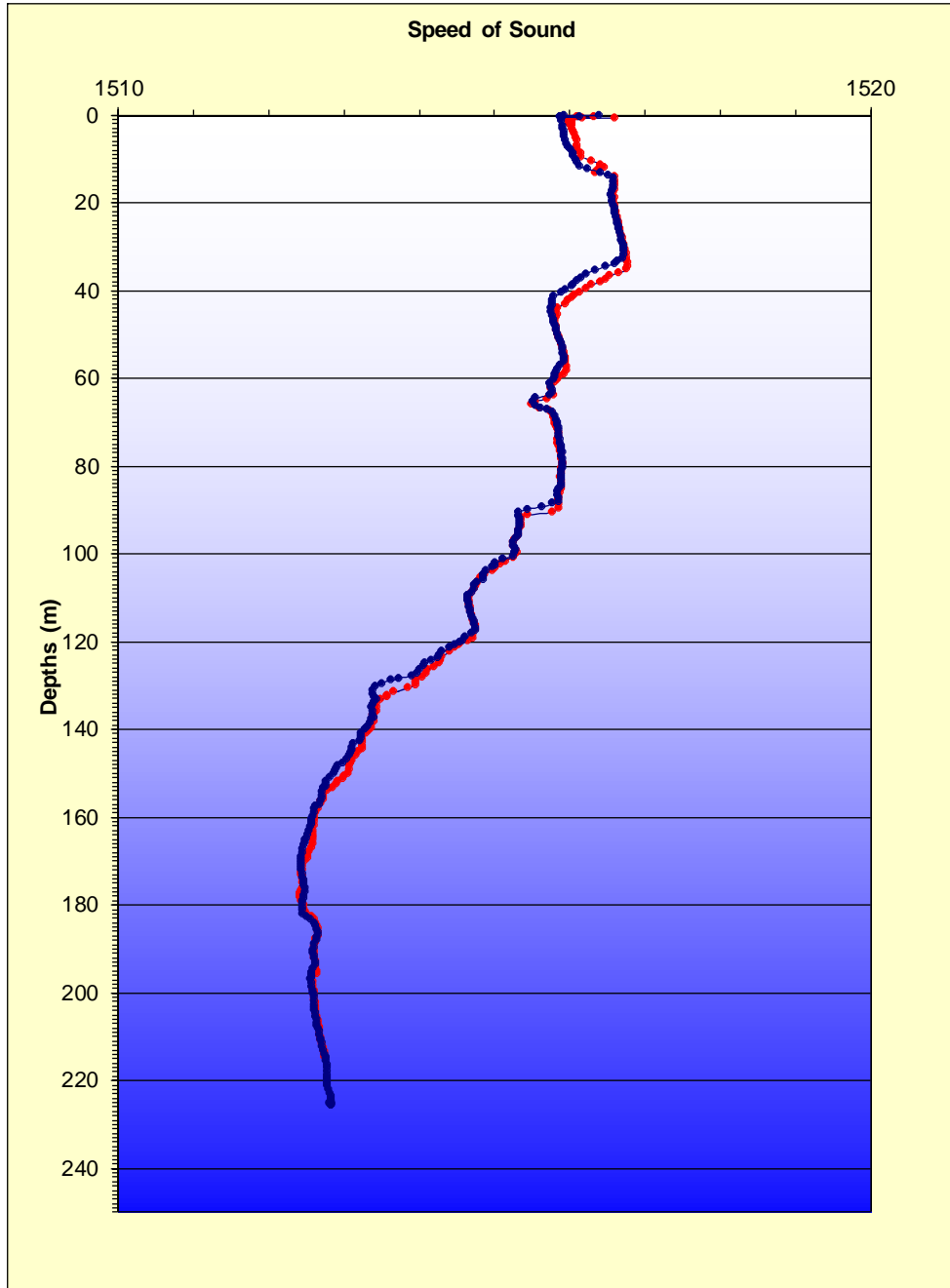


Datum: Local Datum			
Latitude:	40° 18' 56.47"	Northing:	4465939
Longitude:	18° 26' 27.56"	Easting:	282561

S.V.P. GRAPHIC PLOT UP/DOWN

Date: 06/12/2016 Project: Trans Adriatic Pipeline - Geophysical survey
 Time: 17,30 (UTC +1) Client: RSK
 Project No: 16-J387 Wather Depth: 225,69
 Area: San Foca- Adriatic Sea Mean Value: 1514,58 m/s

UP and DOWN

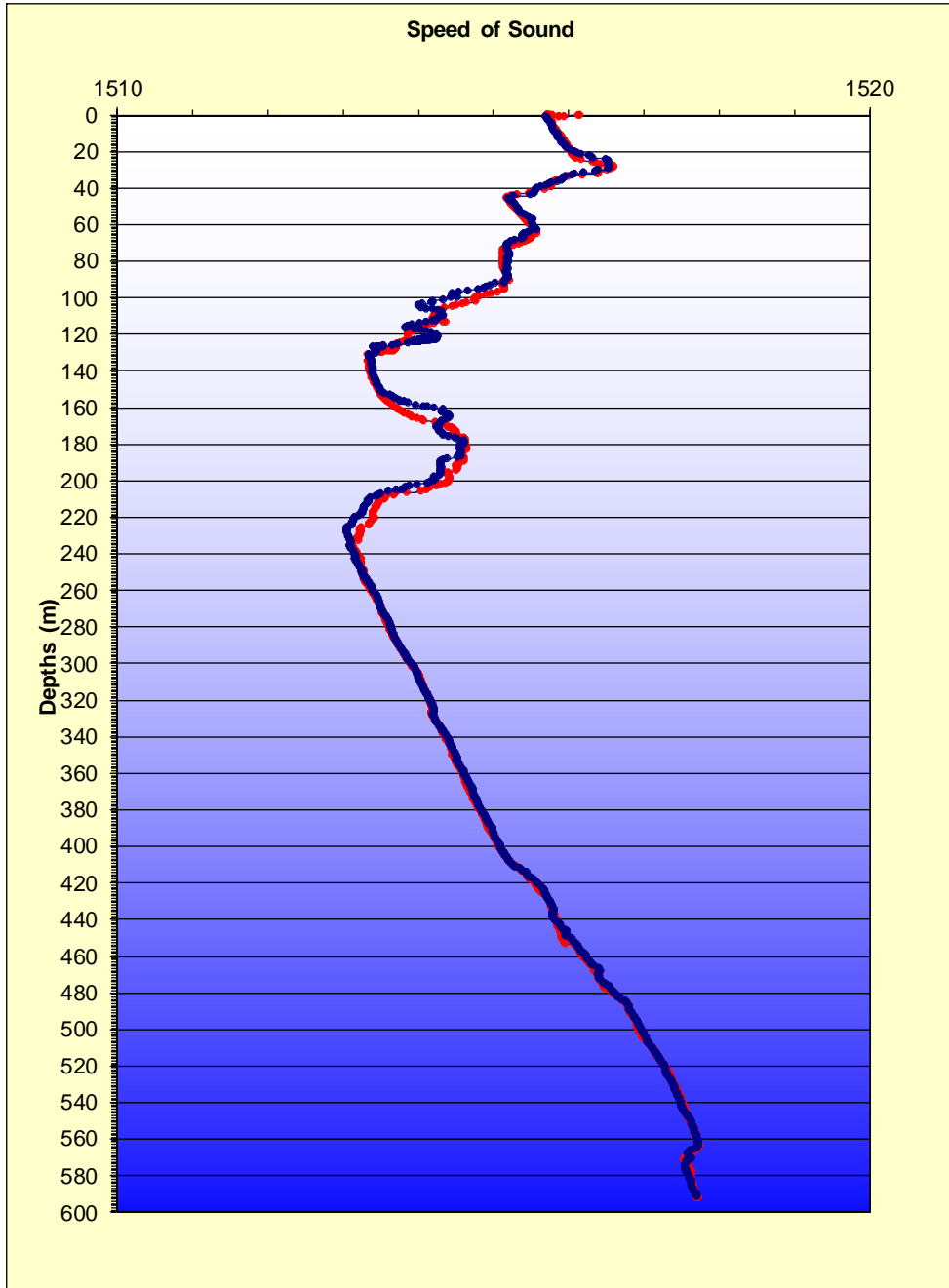


Datum: Local Datum			
Latitude:	40° 25' 24.06"	Northing:	4477705
Longitude:	18° 31' 04.59"	Easting:	289436

S.V.P. GRAPHIC PLOT UP/DOWN

Date: 07/12/2016 Project: Trans Adriatic Pipeline - Geophysical survey
 Time: 10.55 (UTC +1) Client: RSK
 Project No: 16-J387 Wather Depth: 591
 Area: San Foca- Adriatic Sea Mean Value: 1515,1 m/s

UP and DOWN

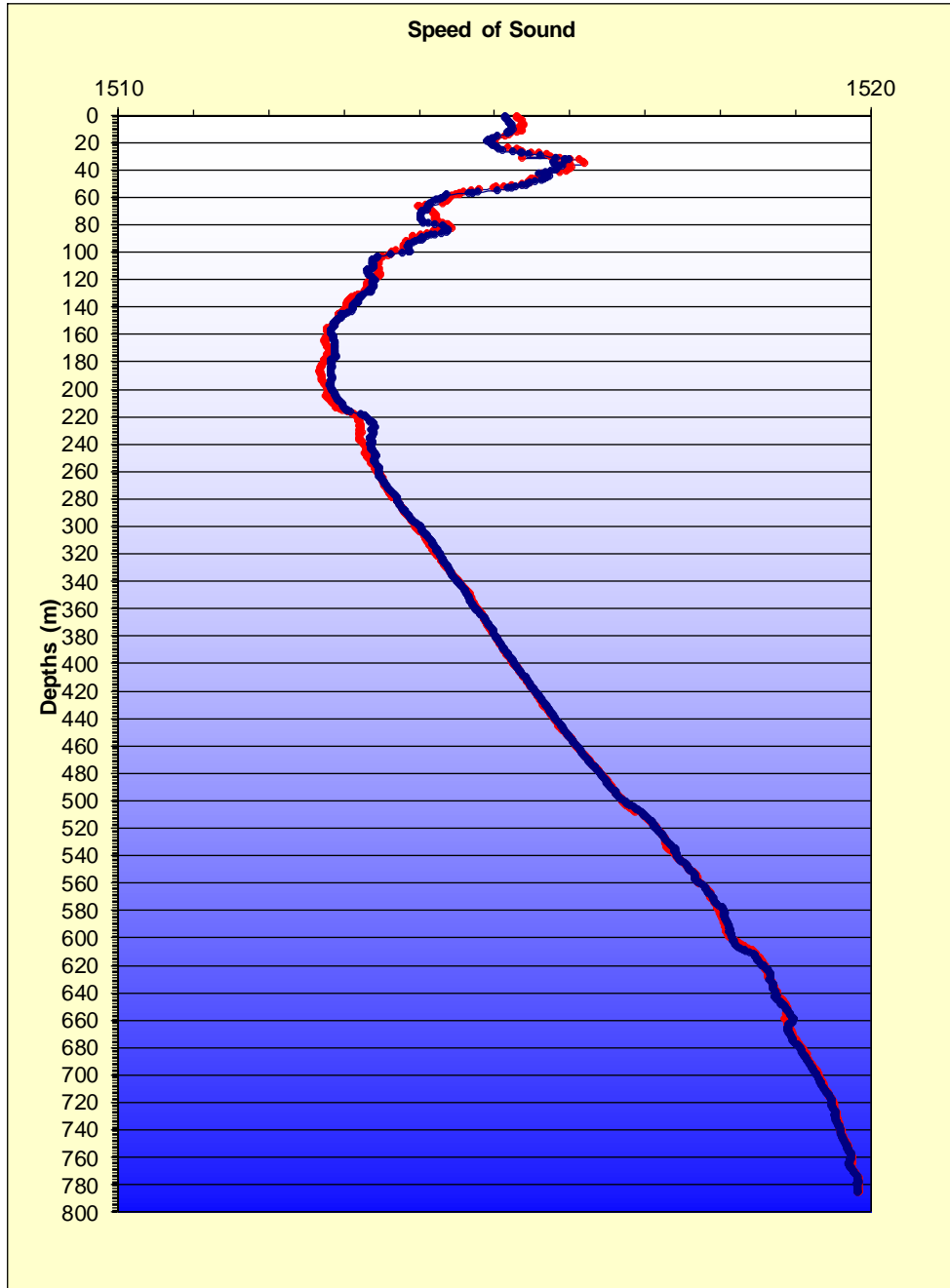


Datum: Local Datum			
Latitude:	40° 27' 26.53"	Northing:	4481189
Longitude:	18° 38' 38.29"	Easting:	300229

S.V.P. GRAPHIC PLOT UP/DOWN

Date: 08/12/2016 Project: Trans Adriatic Pipeline - Geophysical survey
 Time: 14.20 (UTC +1) Client: RSK
 Project No: 16-J387 Wather Depth: 785,5
 Area: San Foca- Adriatic Sea Mean Value: 1516,1 m/s

UP and DOWN



Datum: Local Datum			
Latitude:	40° 31' 29.09"	Northing:	4488375,4
Longitude:	18° 47' 01.00"	Easting:	312281,4

S.V.P. GRAPHIC PLOT UP/DOWN

Date: 09/12/2016

Time: 15.50 (UTC +1)

Project No: 16-J387

Area: San Foca- Adriatic Sea

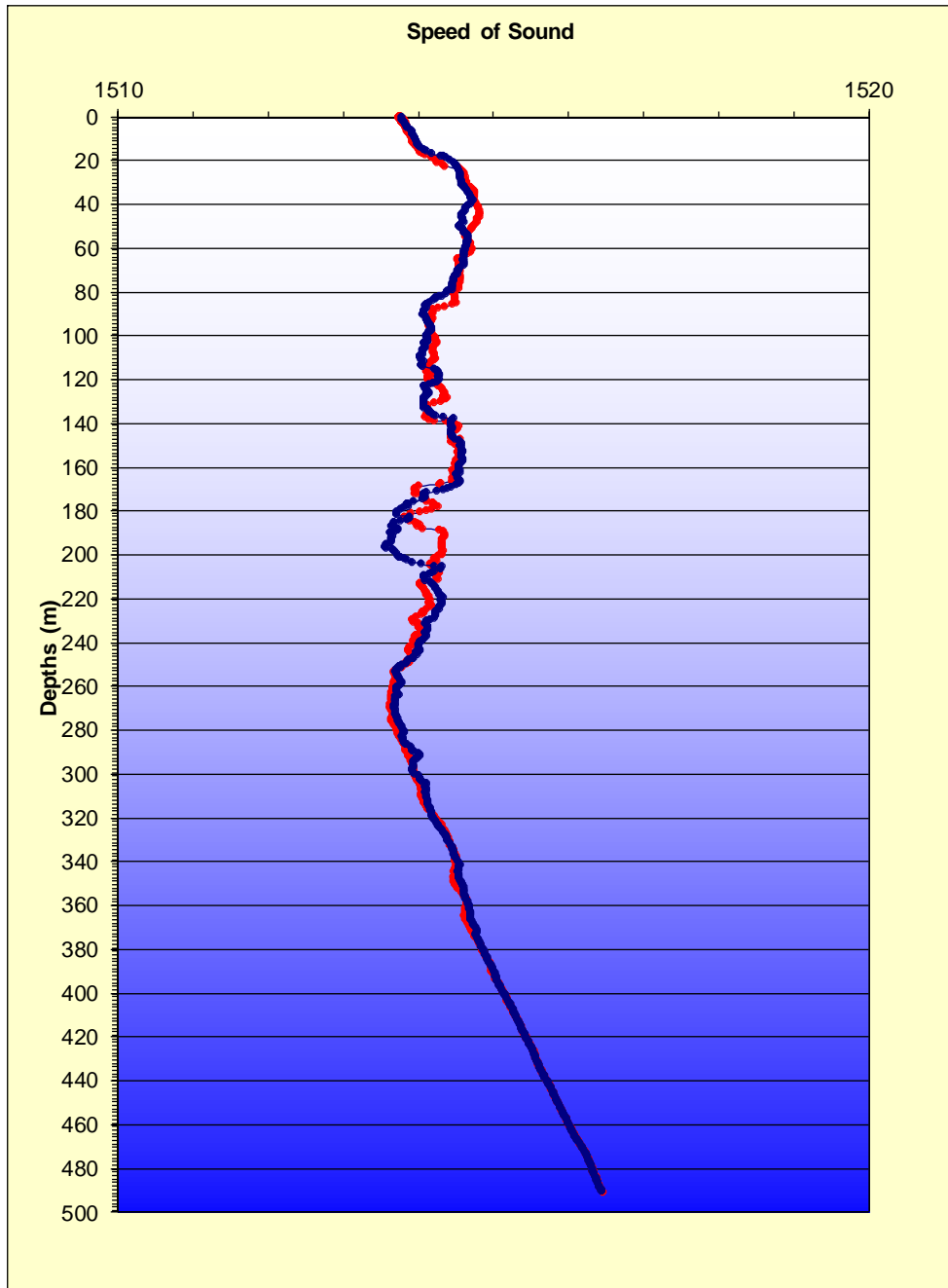
Project: Trans Adriatic Pipeline - Geophysical survey

Client: RSK

Water Depth: 490

Mean Value: 1514,1 m/s

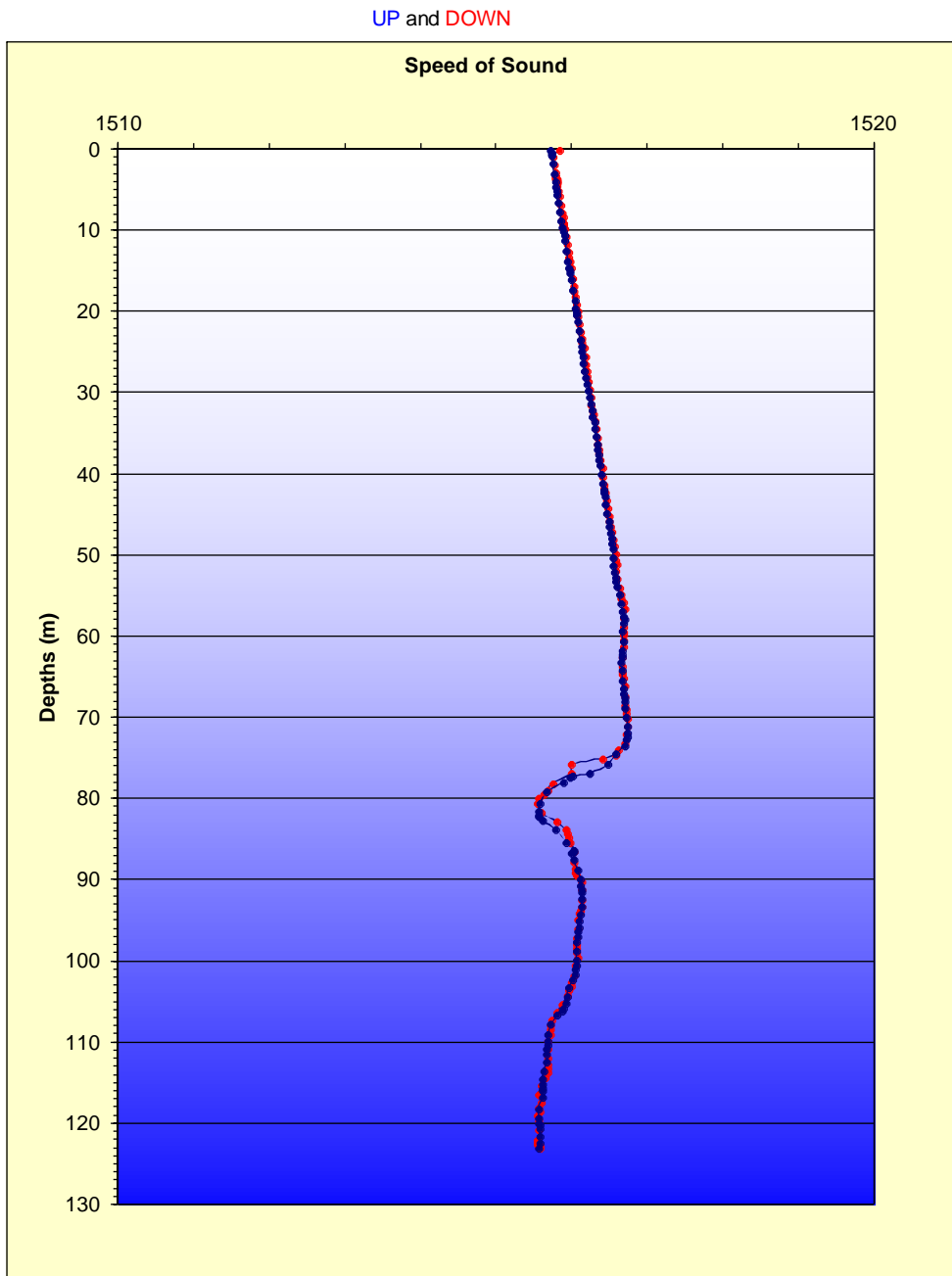
UP and DOWN



Datum: Local Datum			
Latitude:	40° 27' 04.50"	Northing:	4480554
Longitude:	18° 37' 26.73"	Easting:	2985245,4

S.V.P. GRAPHIC PLOT UP/DOWN

Date: 11/12/2016 Project: Trans Adriatic Pipeline - Geophysical survey
 Time: 08,10 (UTC +1) Client: RSK
 Project No: 16-J387 Wather Depth: 123
 Area: San Foca- Adriatic Sea Mean Value: 1516,1 m/s

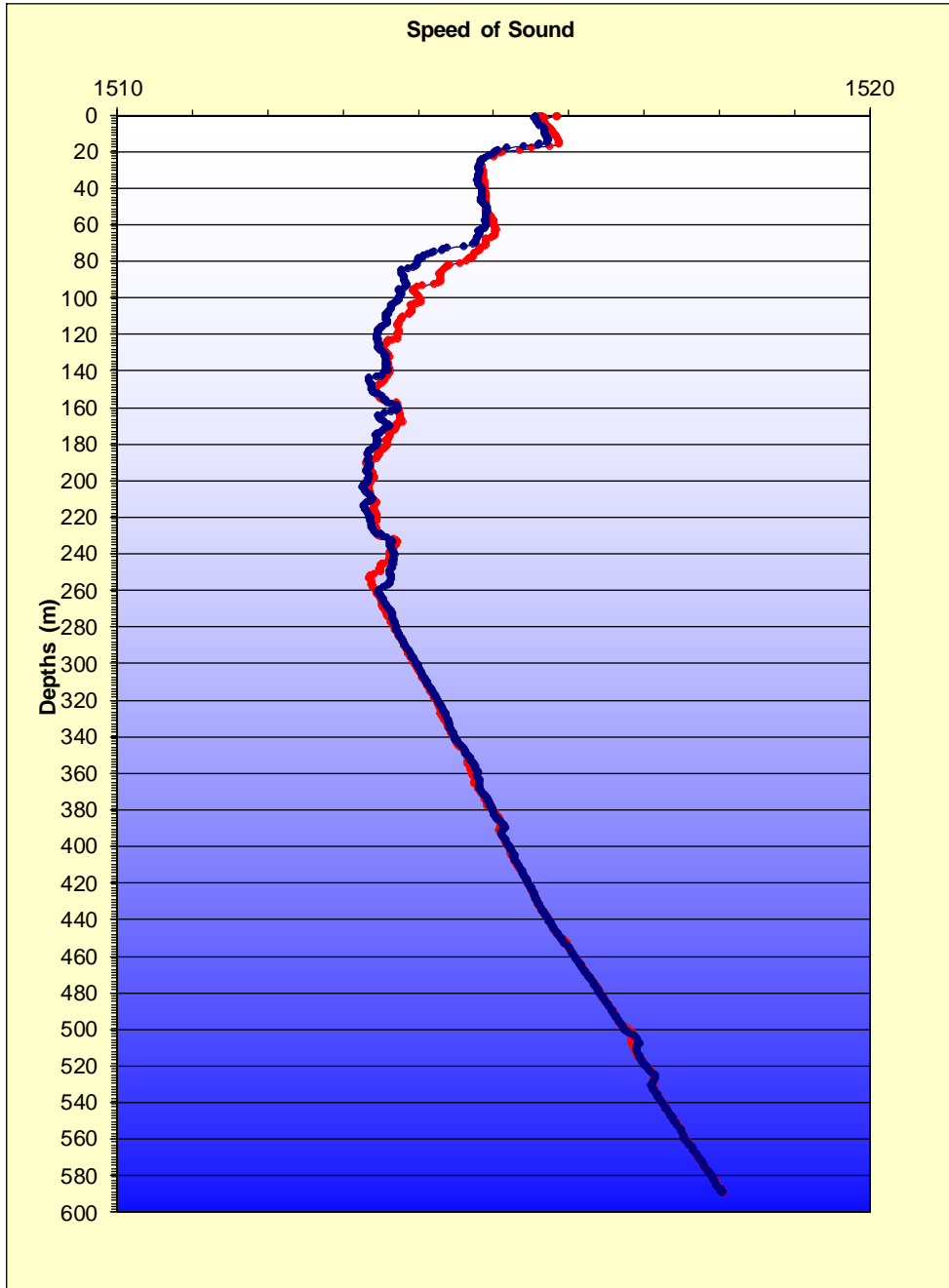


Datum: Local Datum			
Latitude:	40° 26' 51.05"	Northing:	4480346,3
Longitude:	18° 32' 07.34"	Easting:	290989,6

S.V.P. GRAPHIC PLOT UP/DOWN

Date: 14/12/2016 Project: Trans Adriatic Pipeline - Geophysical survey
 Time: 07.15 (UTC +1) Client: RSK
 Project No: 16-J387 Wather Depth: 589
 Area: San Foca- Adriatic Sea Mean Value: 1515,7 m/s

UP and DOWN

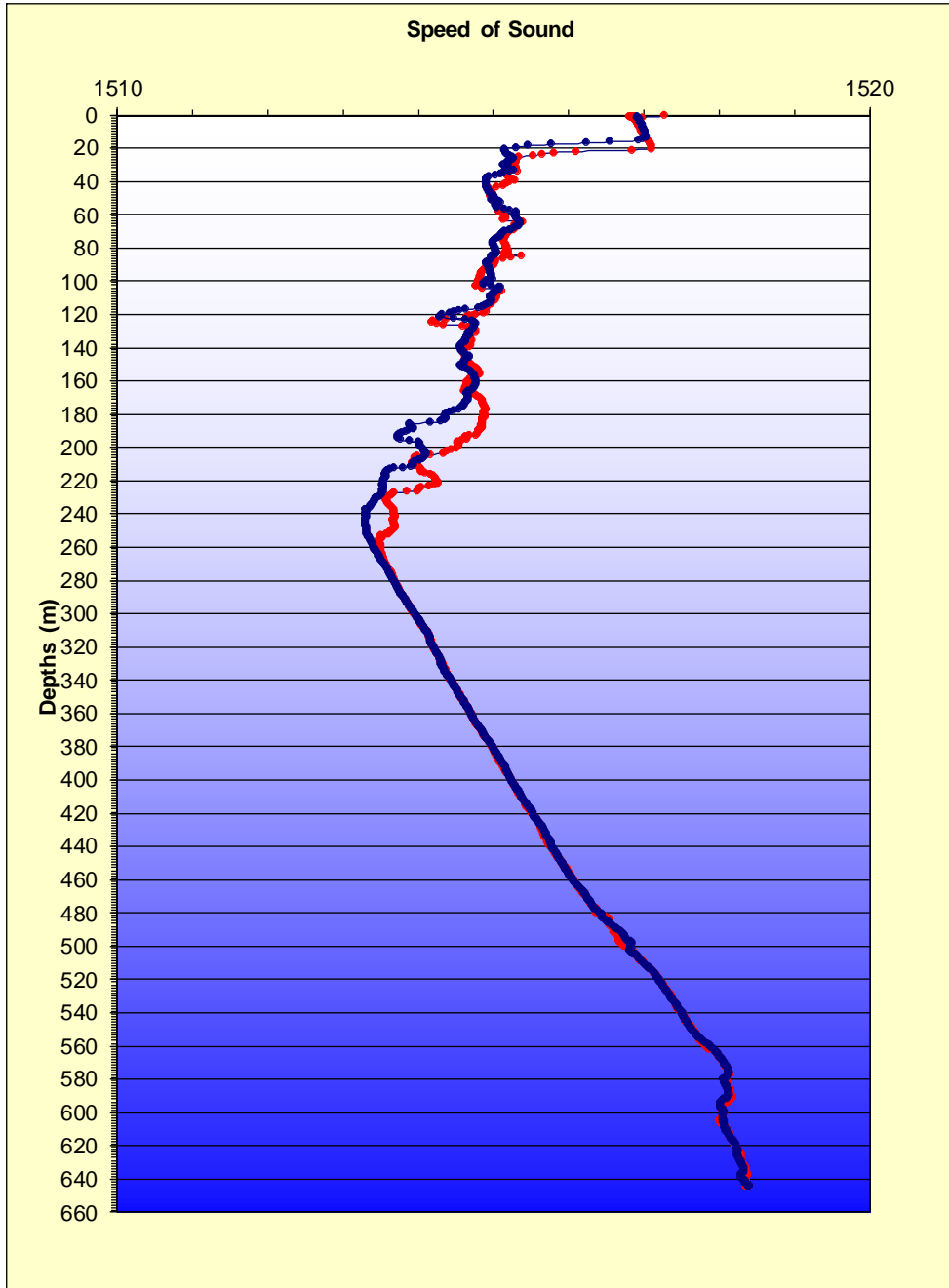


Datum: Local Datum			
Latitude:	40° 27' 35.05"	Northing:	4481460,9
Longitude:	18° 38' 23.55"	Easting:	299889,1

S.V.P. GRAPHIC PLOT UP/DOWN

Date: 15/12/2016 Project: Trans Adriatic Pipeline - Geophysical survey
 Time: 12.20 (UTC +1) Client: RSK
 Project No: 16-J387 Wather Depth: 644,3
 Area: San Foca- Adriatic Sea Mean Value: 1515,8 m/s

UP and DOWN



Datum: Local Datum			
Latitude:	40° 27' 37.00"	Northing:	4481494
Longitude:	18° 39' 06.36"	Easting:	300899

S.V.P. GRAPHIC PLOT UP/DOWN

Date: 27/11/2016

Time: 7,34 (UTC +1)

Project No: 16-J387

Area: San Foca- Adriatic Sea

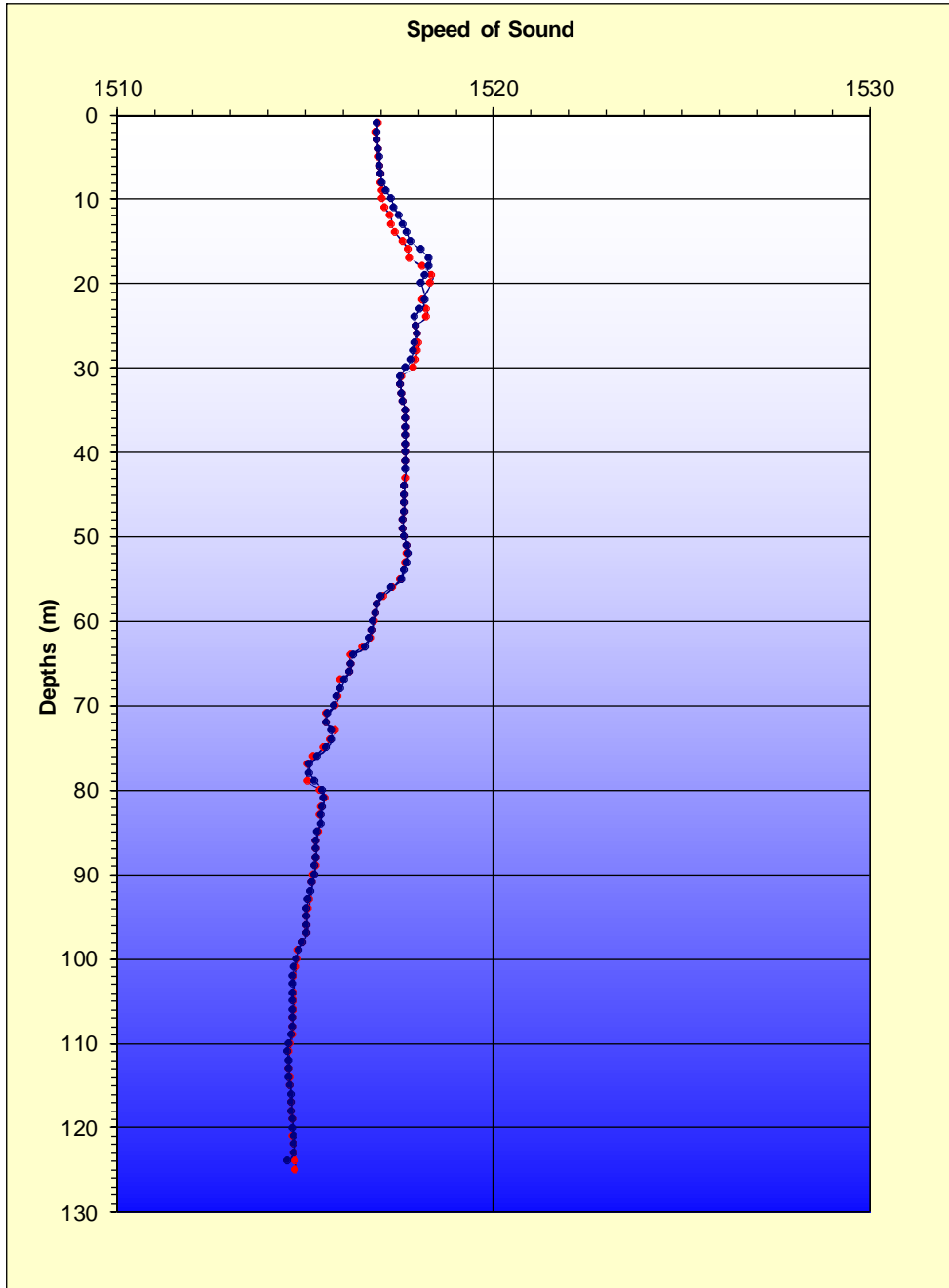
Project: Trans Adriatic Pipeline - Geophysical survey

Client: RSK

Water Depth: 125

Mean Value: 1516,36 m/s

UP and DOWN



Datum: Local Datum			
Latitude:	40° 27' 04.35"	Northing:	4480740.16
Longitude:	18° 32' 32.01"	Easting:	291584.21