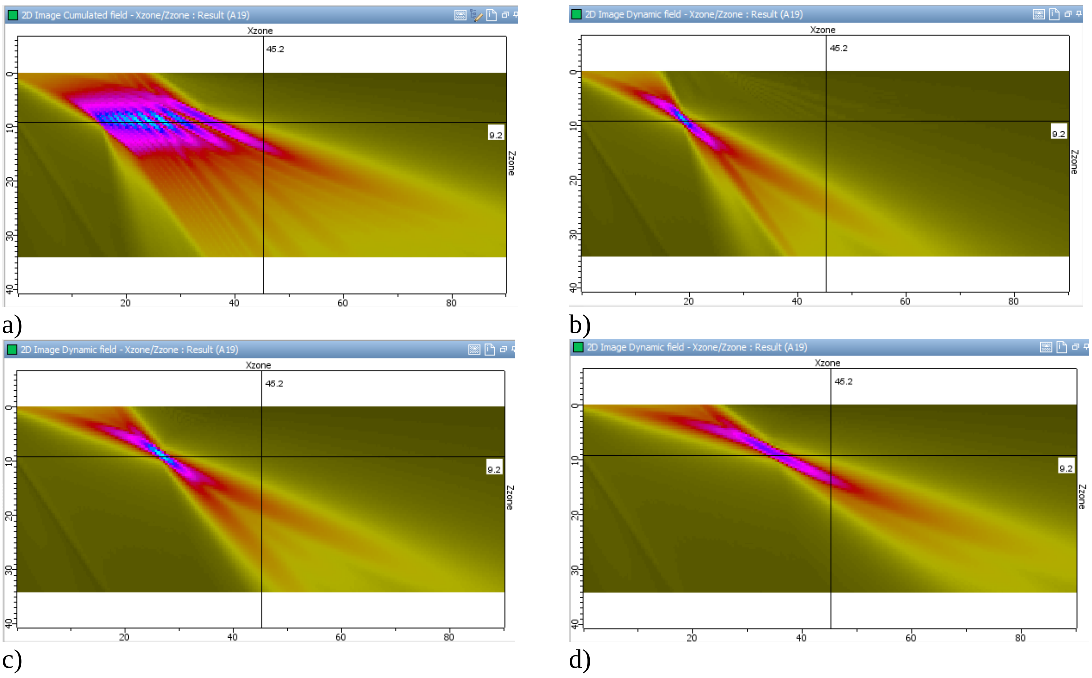

Figure 1: sound beam profile generating by the array PA3, 7MHz, 32 elements, focussed at 9mm in depth
a) Full sector
b) along 45°
c) along 60°
d) along 70°

Table A PAUT results of 20mm butt weld testing.

20mm butt							
	Measured with PAUT				Error in sizing of PAUT		
ID	Position from datum	Length	Heigth	Position	Position from datum	Length	Heigth
C1	60	18	5	Toe -	25	7	0
N1	84	8	1	Toe+	17	2	0.5
C2	139	42	10	Toe-	54	3	0
C3	185	20	7	CL	35	10	2
C4	251	42	10	CL	49	3	0
C5				Transverse			
C6	316	17	3	LOF -	16	7	0
N2	354	21	2	Toe+	24	1	1
C7	368	17	2	LOrootF	28	3	0
N3	402	12	2	CL	22	3	0
C8	416	23	1.4	Lopen	26	7	0.1
C9				Pores			

Table B PAUT results of 10mm butt weld testing.

10mm butt							
	Measured with PAUT				Error in sizing of PAUT		
ID	Position from datum	Length	Heigth	Position	Position from datum	Length	Heigth
C1	50	24	2.8	Toe-	16	4	0.3
N1	81	7	1	Toe+	11	2	0
C2	105	42	5	Toe-	15	2	0
C3	171	25	5	CL	16	0	2.5
C4	223	38	6	CL	18	2	1
C5				Transverse			
N2	287	17	1.1	Toe +	12	2	0.9
C6	303	28	2	LOF	8	8	1.5
C7	354	22	2	LOrootF	14	2	0
N3	380	16	1.7	CL	12	6	0.2
C8	398	22	2	Lopen	13	3	0.5
C9	441	27	3	Pores	4	7	0
N4	470	3	/	CL	10	2	/
N5	505	2	/	Toe+	7	1	/

Table C PAUT results of 6mm butt weld testing

6mm butt							
	Measured with PAUT				Error in sizing of PAUT		
ID	Position from datum	Length	Heigth	Position	Position from datum	Length	Heigth
C1	82	34	4	Toe-	46	9	2.5
C2	144	42	7.5	Toe-	58	2	4.5
C3	182	18	3	CL	27	7	1.5
C4	238	26	4	CL	33	14	1
C5				Transverse			
C6	327	26	1	LOF	32	6	2
N1	350	6	1	Toe+	20	1	0
C7	372	20	2	LorootF	32	0	0
N2	392	12	1.5	Toe +	24	2	0
C8	425	26	1.5	Lopen	38	1	0
N3	440	4	1	Toe +	15	1	0
C9	447	14	4.3	Pores	10	6	1.3
N4				CL			
N5				Toe+			

Table D PAUT results of 20mm fillet weld testing

20mm fillet							
	Measured with PAUT				Error in sizing of PAUT		
ID	Position from datum	Length	Heigth	Position	Position from datum	Length	Heigth
C1	18	33	7	Toe-	22	8	2
C2	73	31	10	Toe+	14	9	0
C3	150	24	5.8	Root	5	1	0.8
N1	150	22	3	Toe+	5	2	0
N2	189	20	2	CL	21	5	0
C4	199	38	10	Root	6	2	0
N3	228	17	2	Cl	12	7	0.5
C5				Transverse			
C6	284	23	4	LOF	16	3	1
C7	323	29	3	LorootF	17	9	1
C8	372	26	/	Lopen	13	1	/
C9	425	29	/	Pores	15	7	/

Table E PAUT results of 10mm fillet weld testing

10mm fillet							
	Measured with PAUT				Error in sizing of PAUT		
ID	Position from datum	Length	Heigth	Position	Position from datum	Length	Heigth
C1	43	24	1.3	Toe-	3	1	1.2
C2	86	44	6.9	Toe+	1	2	1.9
N1	157	16	2.4	Toe+	2	1	0.4
C3	156	32	3.1	Root-	1	7	0.6
N2	193	15	1.4	CL	2	5	0.1
C4	203	47	6.4	Root-	2	7	1.4
N3	226	6	/	CL	1	1	/
C5				Transverse			
C6	304	16	2	LOF	9	4	1
C7	349	24	4	LorootF	14	6	2
N4				Toe+			
N5				CL			
C8	394	26	/	Lopen	9	1	/
C9	450	12	4	Pores	15	10	1

Table F PAUT results of 6mm fillet weld testing.

6mm fillet							
	Measured with PAUT				Error in sizing of PAUT		
ID	Position from datum	Length	Heigth	Position	Position from datum	Length	Heigth
C1	49	30	2	Toe-	9	5	0.5
C2	93	47	3.3	Toe-	2	17	0.3
C3	175	24	/	Root -	20	1	/
N1	179	12	2	Toe+	9	2	0.5
C4	223	38	3.8	Root -	23	2	0.8
N2	219	6	1	Toe+	9	1	0
N3	252	4	1.1	Toe+	7	1	0.1
C5				Transverse			
C6	305	27	3	LOF	10	7	0
N4				Toe+			
C7	354	22	4.6	LorootF	14	2	2.6
N5				CL			
C8	398	27	/	Lopen	13	2	/
C9	450	21	3.7	Pores	5	1	0.7

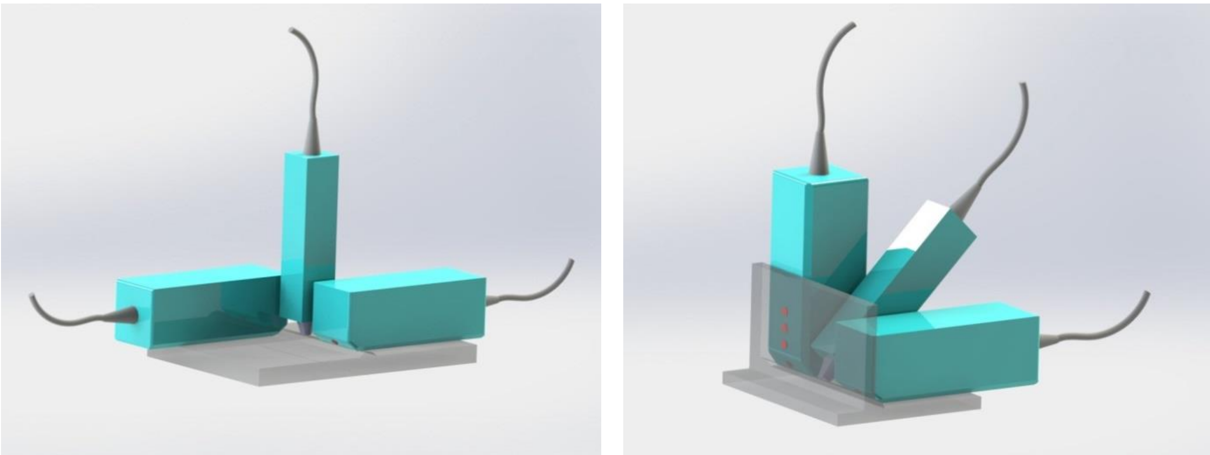

Figure 2: ACFM probes arrangement

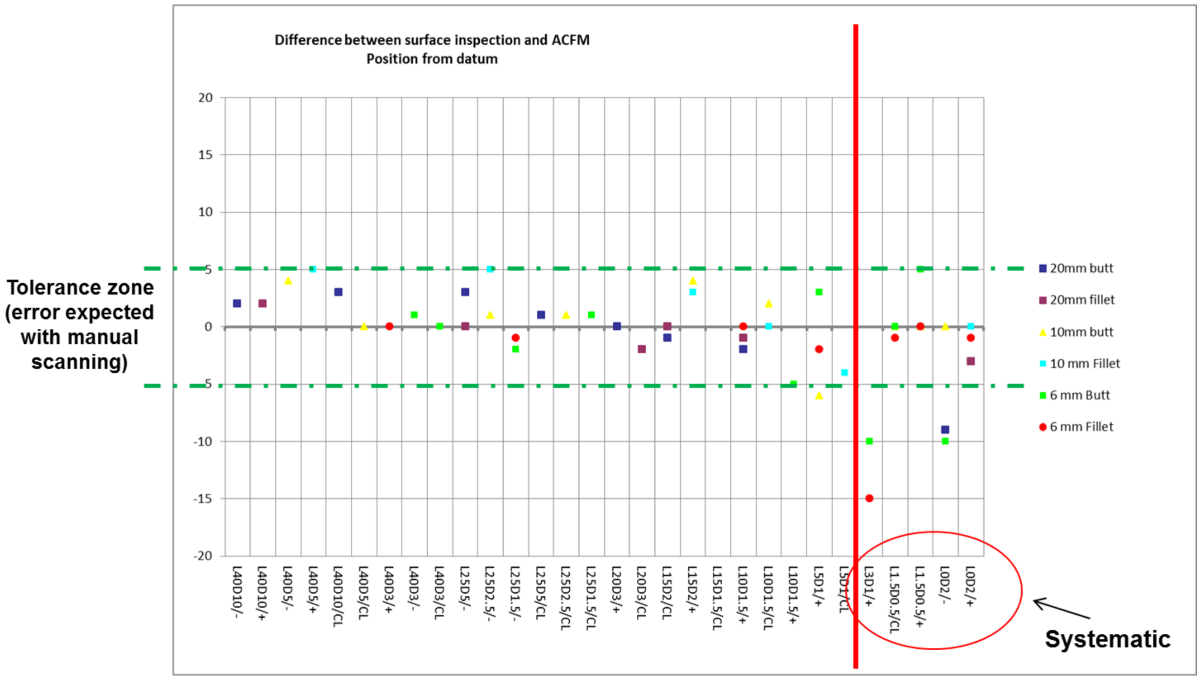

Figure 3: Difference in position between the ACFM and the MPI/DPI testing.

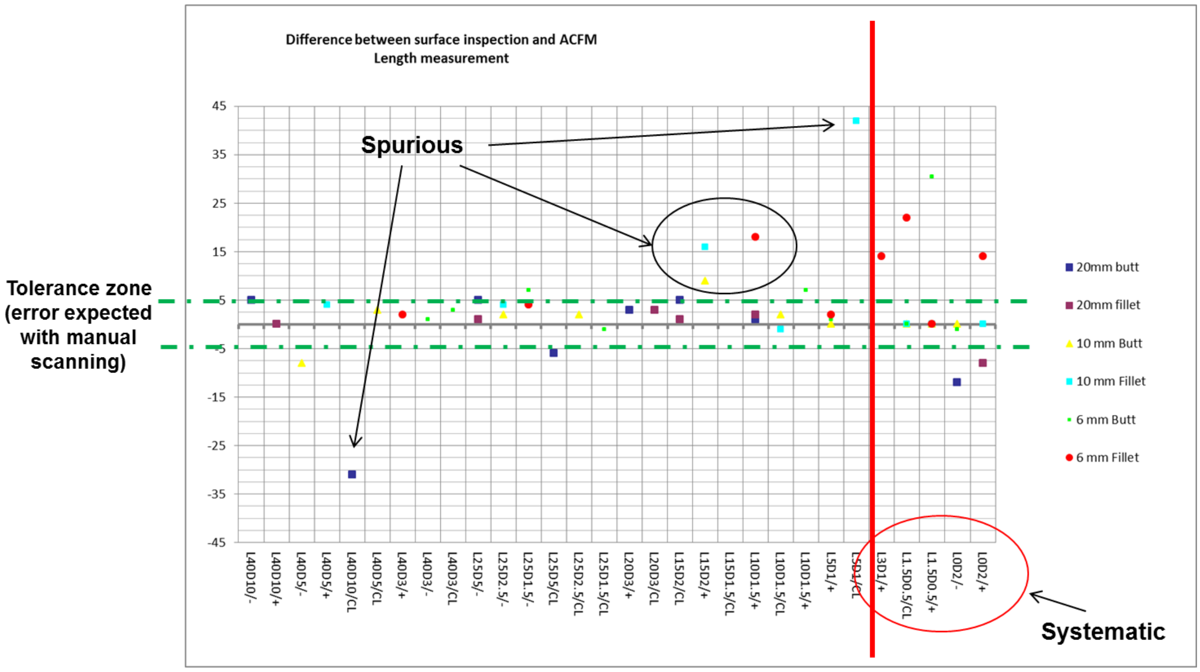

Figure 4: Difference in length sizing between the ACFM and the MPI/DPI testing.

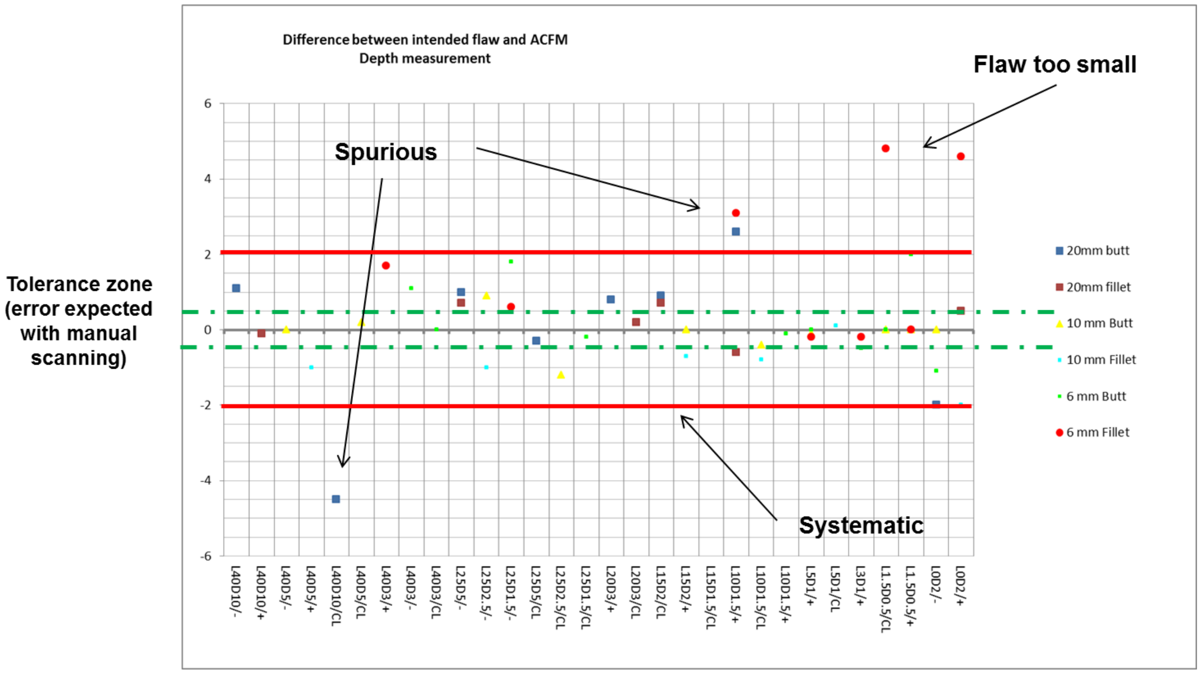

Figure 5: Difference in depth sizing between the ACFM and the MPI/DPI testing.

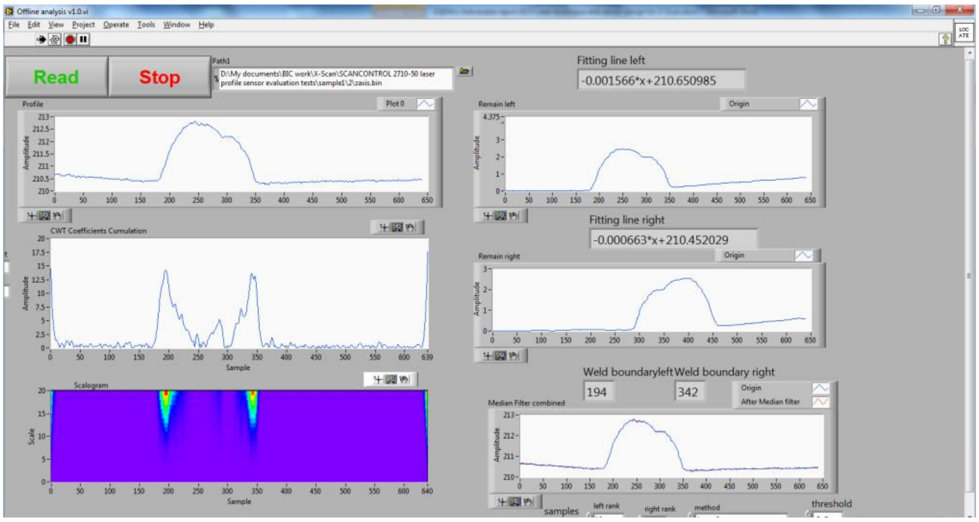

Figure 6: User interface of offline profile analysis programme

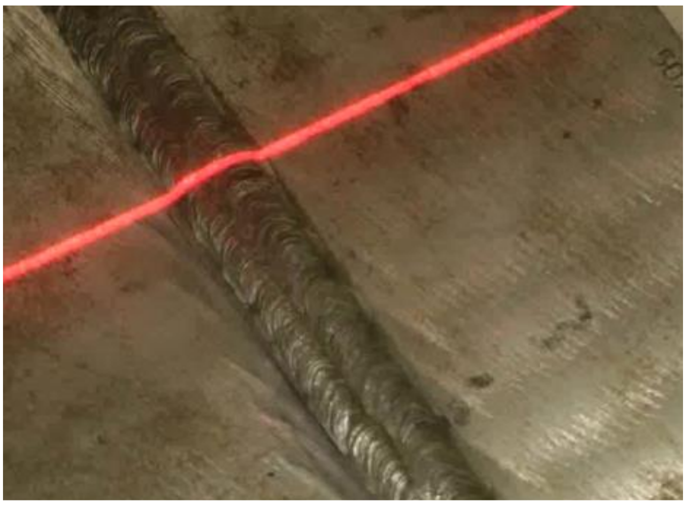

Figure 7: Weld being scanned by the laser profile sensor

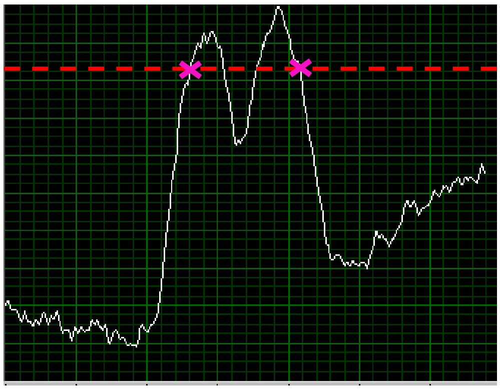

Figure 8: An example of butt weld tracking algorithm to find the error deviation from the current central weld seam position.

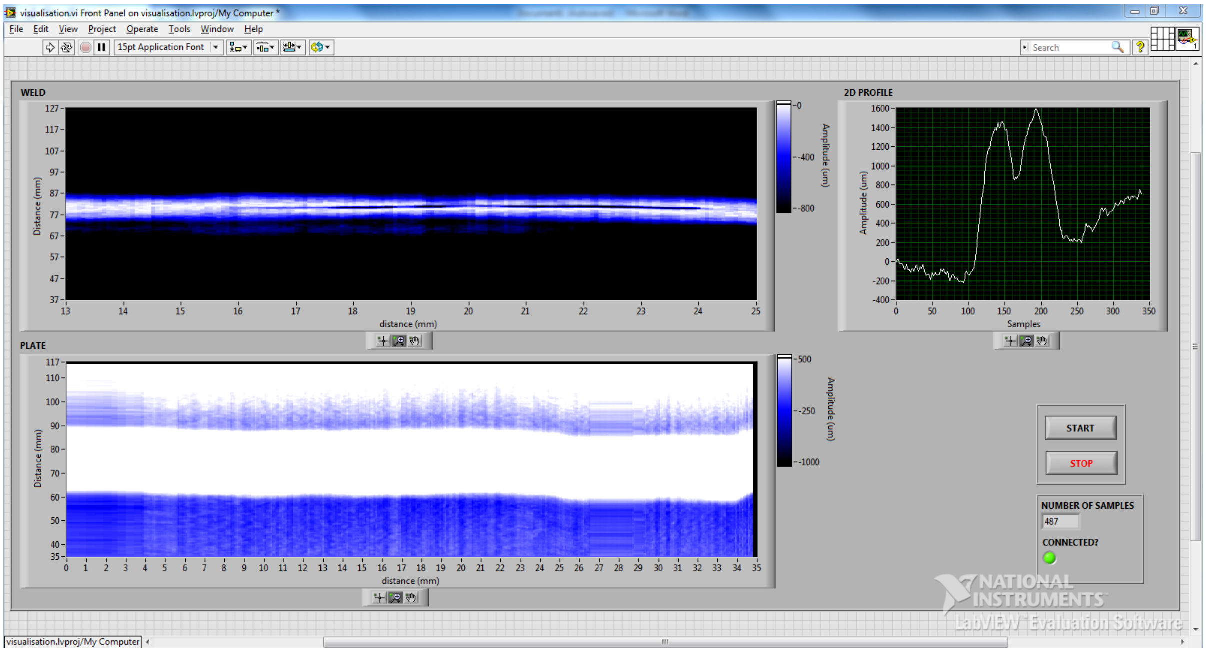

Figure 9: Visualisation software (GUI) for butt weld displayed on the visualisation inspection PC (ground station).

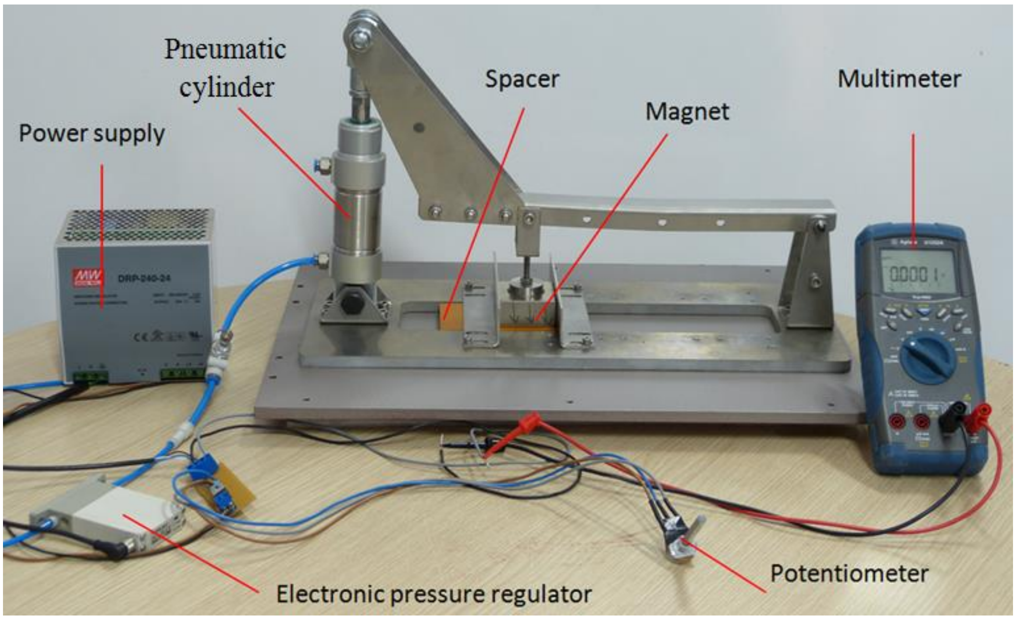

Figure 10: The magnets pulling force set-up.

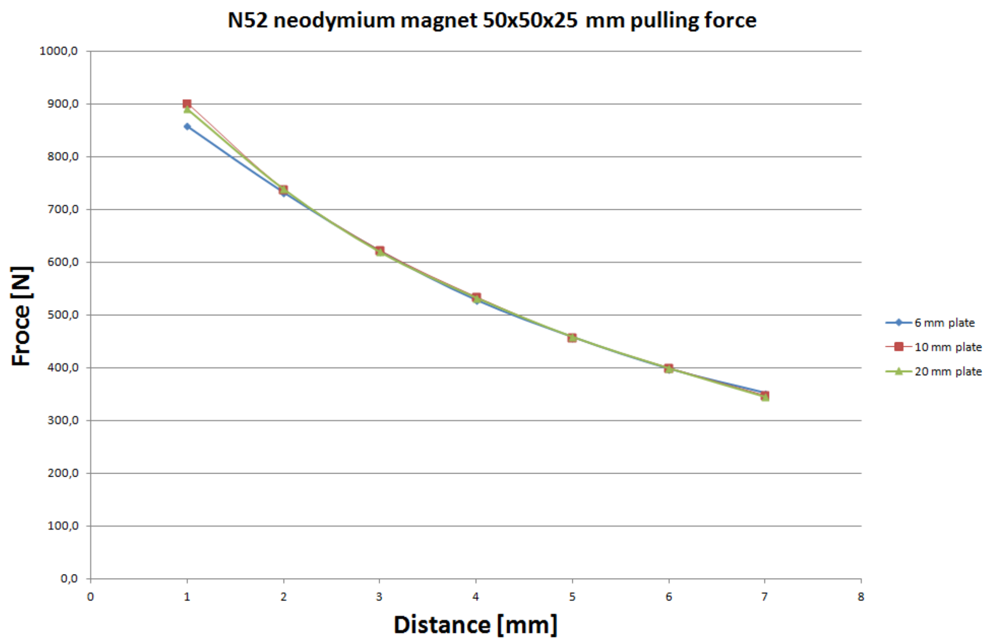

Figure 11: Magnet pulling force.

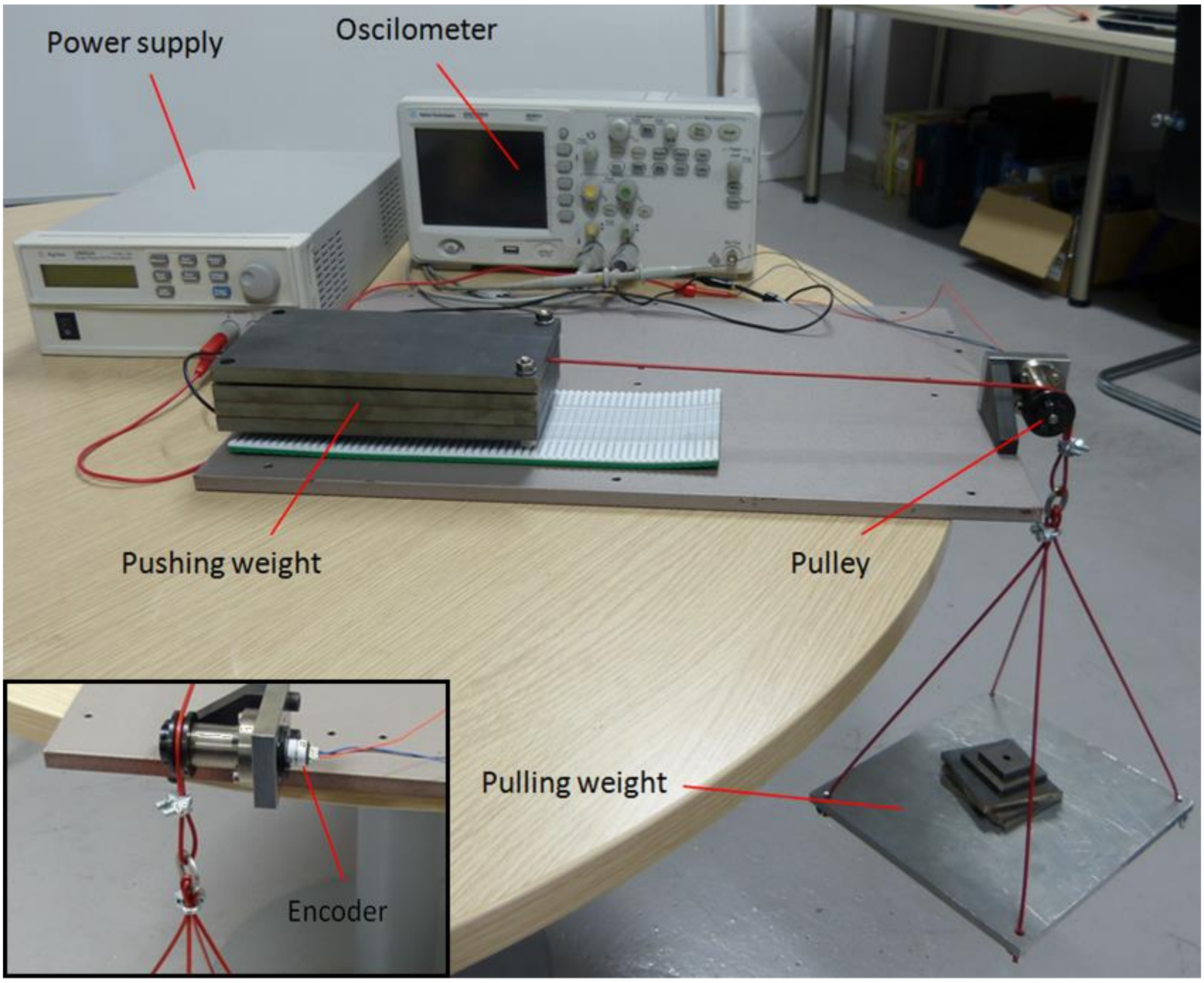

Figure 12: Set-up for measurement of the friction between the belt and the magnet.

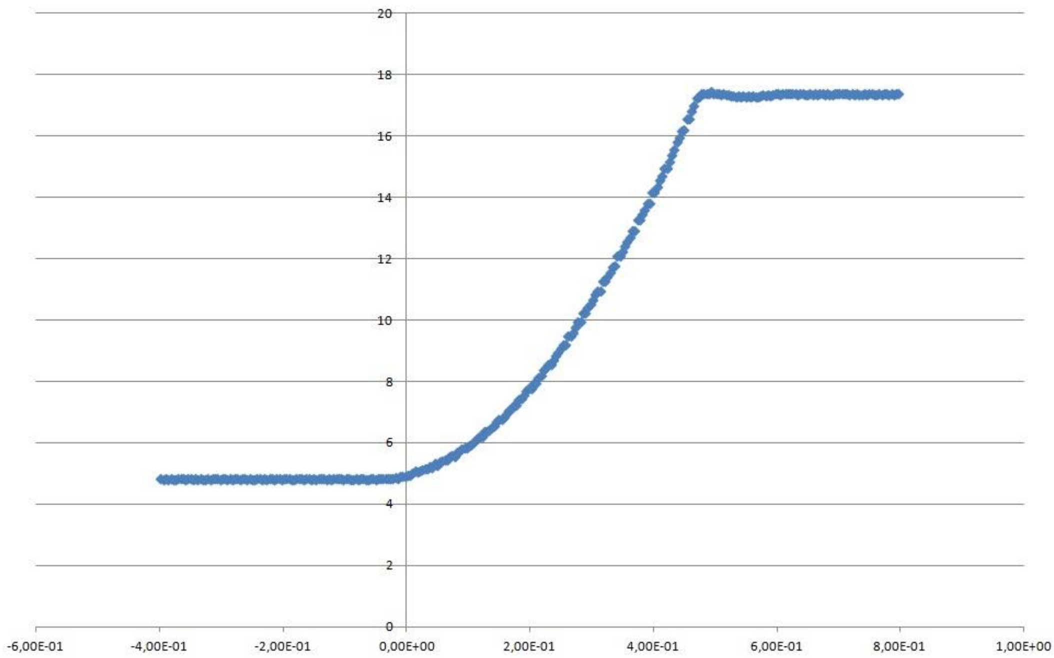

Figure 13: Motion recorded from encoder and acceleration part of the recorded data.

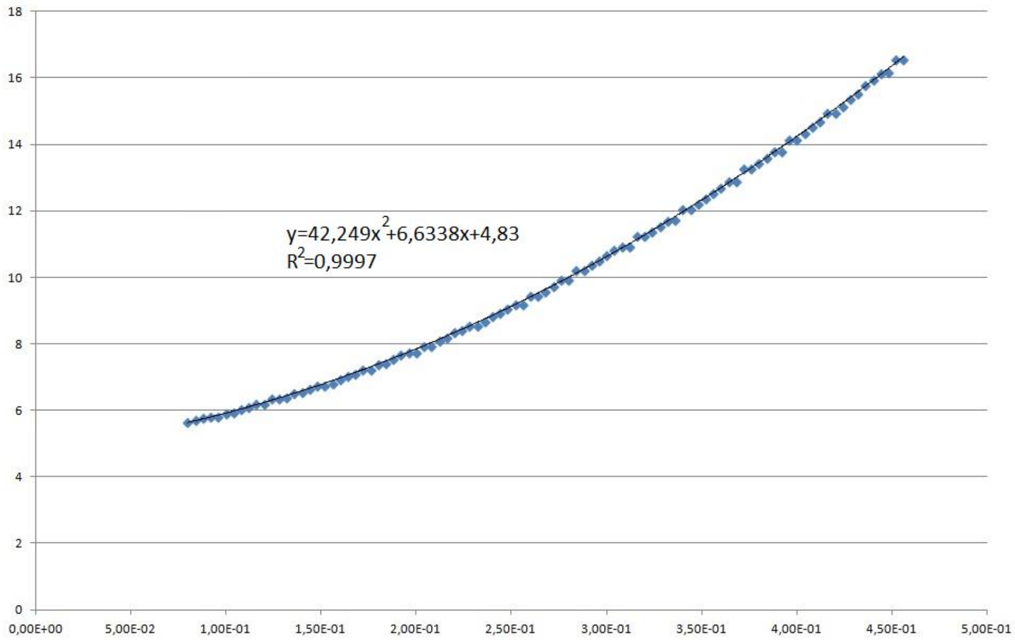

Figure 14: Acceleration part of the recorded data.

Table G: Static and kinetic friction coefficient between inner side of the belt and antifriction materials.

	Maximum acceleration [m/sec^2]	Pushing mass m1 [kg]	Pulling mass m2 [kg]	Total mass [kg]	Kinetic friction coefficient	Static friction coefficient
PTFE	0,463	7,500	2,200	9,700	0,232	0,067
	0,424	7,500	2,200	9,700	0,237	
	0,430	7,500	2,200	9,700	0,237	
	1,232	7,500	3,400	10,900	0,271	
	1,230	7,500	3,400	10,900	0,271	
	1,273	7,500	3,400	10,900	0,265	
	0,885	7,500	2,800	10,300	0,249	
	0,844	7,500	2,800	10,300	0,255	
	0,802	7,500	2,800	10,300	0,261	
MC Nylon (MC703HL)	0,786	7,500	4,600	12,100	0,484	0,493
	0,822	7,500	4,600	12,100	0,478	
	0,816	7,500	4,600	12,100	0,479	
	1,183	7,500	5,200	12,700	0,489	
	1,211	7,500	5,200	12,700	0,484	
	1,214	7,500	5,200	12,700	0,484	
	1,655	7,500	5,800	13,300	0,474	
	1,606	7,500	5,800	13,300	0,483	
	1,571	7,500	5,800	13,300	0,489	
Polyacetal (10 mm)	0,438	7,500	2,800	10,300	0,312	0,267
	0,475	7,500	2,800	10,300	0,307	
	0,443	7,500	2,800	10,300	0,311	

	0,927	7,500	3,400	10,900	0,316	
	0,901	7,500	3,400	10,900	0,320	
	0,909	7,500	3,400	10,900	0,319	
	0,901	7,500	4,000	11,500	0,393	
Ultra High MolecularWeight Polyethylene (3 mm)	0,254	7,500	2,200	9,700	0,260	0,192
	0,211	7,500	2,200	9,700	0,265	
	0,251	7,500	2,200	9,700	0,260	
	0,682	7,500	2,800	10,300	0,278	
	0,691	7,500	2,800	10,300	0,277	
	0,677	7,500	2,800	10,300	0,279	
	1,106	7,500	3,400	10,900	0,290	
	1,054	7,500	3,400	10,900	0,297	
	1,103	7,500	3,400	10,900	0,290	

Table F: Kinetic friction coefficient between belt coating and painted plate.

	Dry ECOMAR AF 70 RED BROWN	Dry WILKOR A/C SILVER LIGHT	Wet ECOMAR AF 70 RED BROWN	Wet WILKOR A/C SILVER LIGHT
G/GSTR, rubber	0,973	0,886	1,058	0,759
	0,944	-	0,873	0,864
	0,951	1,008	0,923	0,676
	0,973	0,956	0,759	0,617
	0,974	1,090	0,777	0,615
	0,958	1,096	0,731	0,599
Linatrile, NBR	0,566	0,701	0,898	0,658
	0,580	0,713	0,863	0,713
	0,550	0,719	0,808	0,603
	0,546	0,725	0,795	0,662
	0,627	0,743	0,835	0,655
	0,636	0,750	0,805	0,638
Linatex, Natural rubber	1,738	1,953	0,658	0,521
	1,756	1,764	0,665	0,644
	1,719	1,875	0,681	0,661
	1,702	1,810	0,617	0,568
	1,738	1,752	0,741	0,630
	1,878	1,734	0,591	0,777
EPDM, Rubber	1,006	0,702	0,802	0,705
	1,008	0,936	0,832	0,684
	1,001	0,888	0,671	0,717
	0,991	0,862	0,704	0,711

	1,021	0,889	0,552	0,653
	1,041	0,855	0,552	0,661
Pimple top, PVC	0,860	0,477	0,602	0,418
	0,860	-	0,658	0,401
	0,933	0,686	0,599	0,358
	0,911	0,683	0,467	0,352
	0,957	0,699	0,550	0,323
	0,983	0,705	0,484	0,354
PU foil 60, polyurethane	1,011	1,062	0,901	-
	1,009	1,007	-	0,798
	0,935	1,198	0,724	0,750
	0,916	1,010	0,733	0,652
	0,898	0,984	0,707	0,674
	0,836	0,939	0,774	0,570
PVC	0,809	0,725	0,915	0,772
	0,767	0,656	0,944	0,767
	0,790	0,583	0,959	0,851
	0,775	0,564	1,443	0,793
	1,021	0,582	1,638	0,783
	1,021	0,563	1,599	0,703

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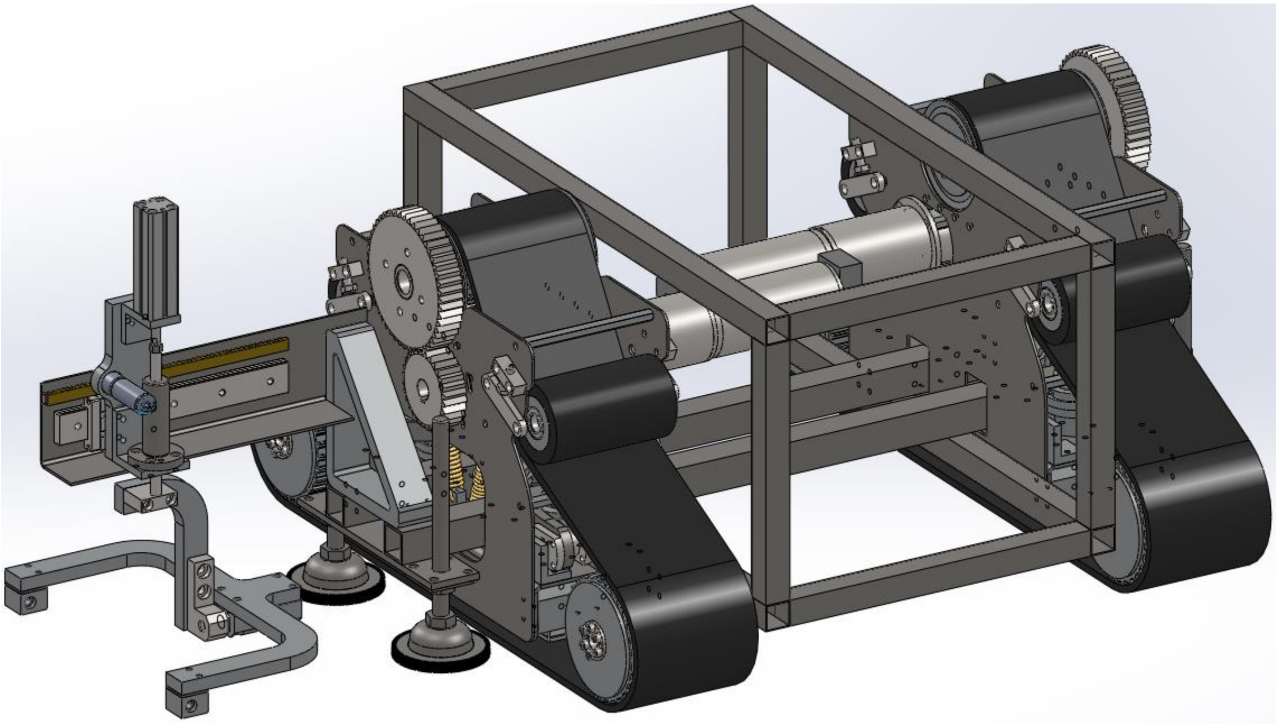

Figure 15: The main manipulator.

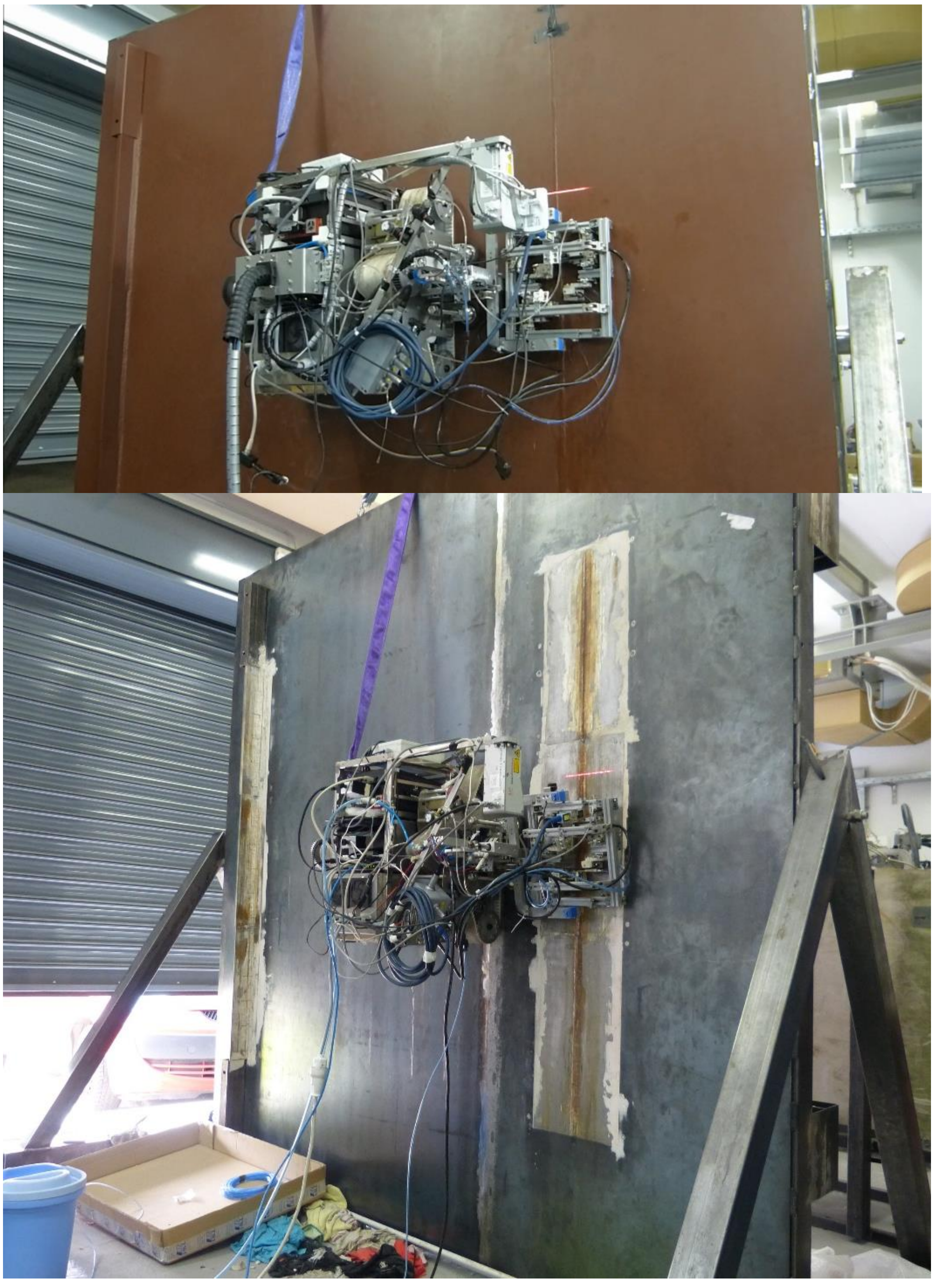

Figure 16: The demo plate uncoated and coated

Figure 17: Mounting points of the sensor holder on the robot

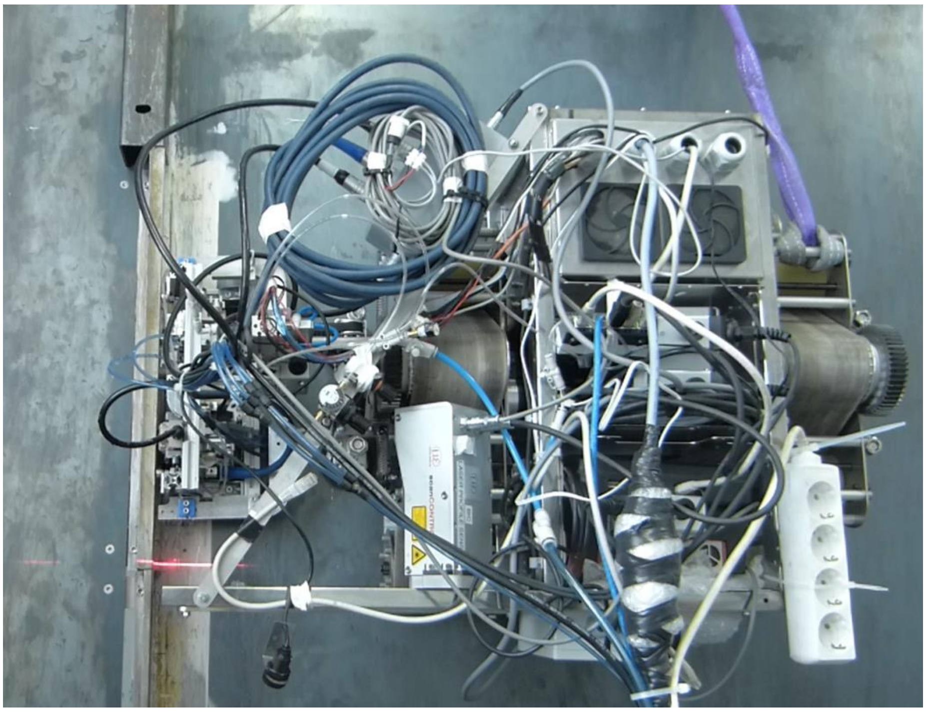

Figure 18: The integrated system automatically scanning the 20mm fillet weld

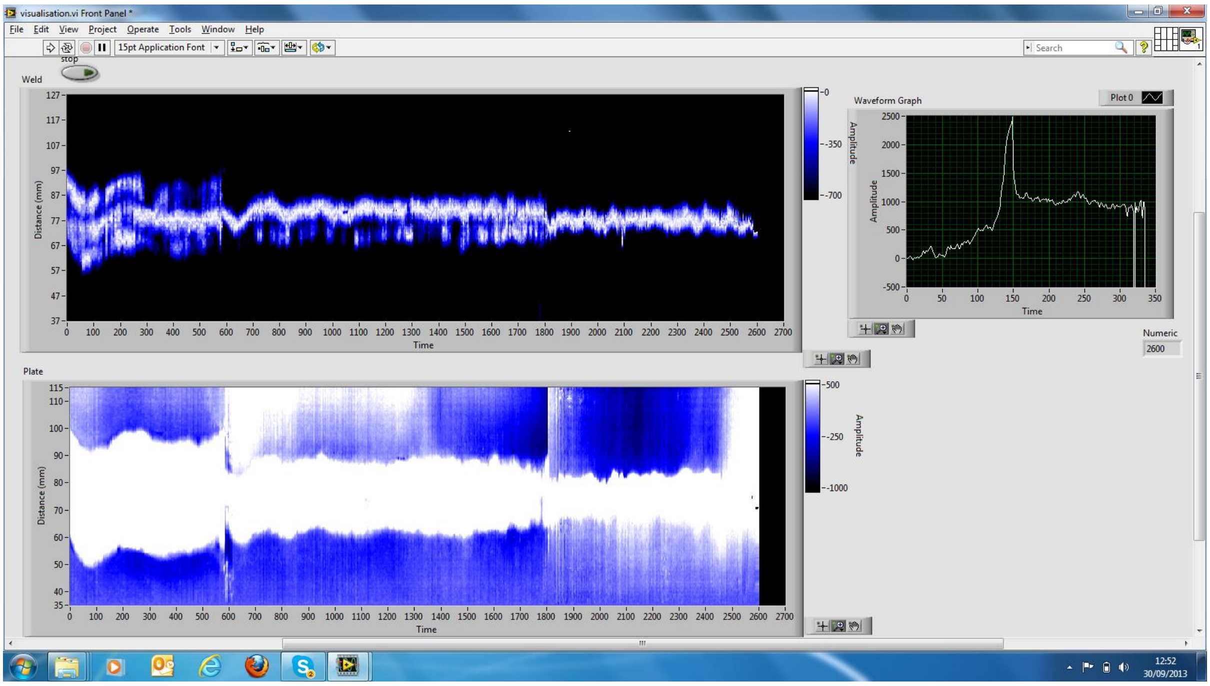

Figure 19: Visualisation on the ground station (inspector PC). Top: surface plot build up for the weld region. Bottom: time build up for the plates region. Right: current 2D profile.

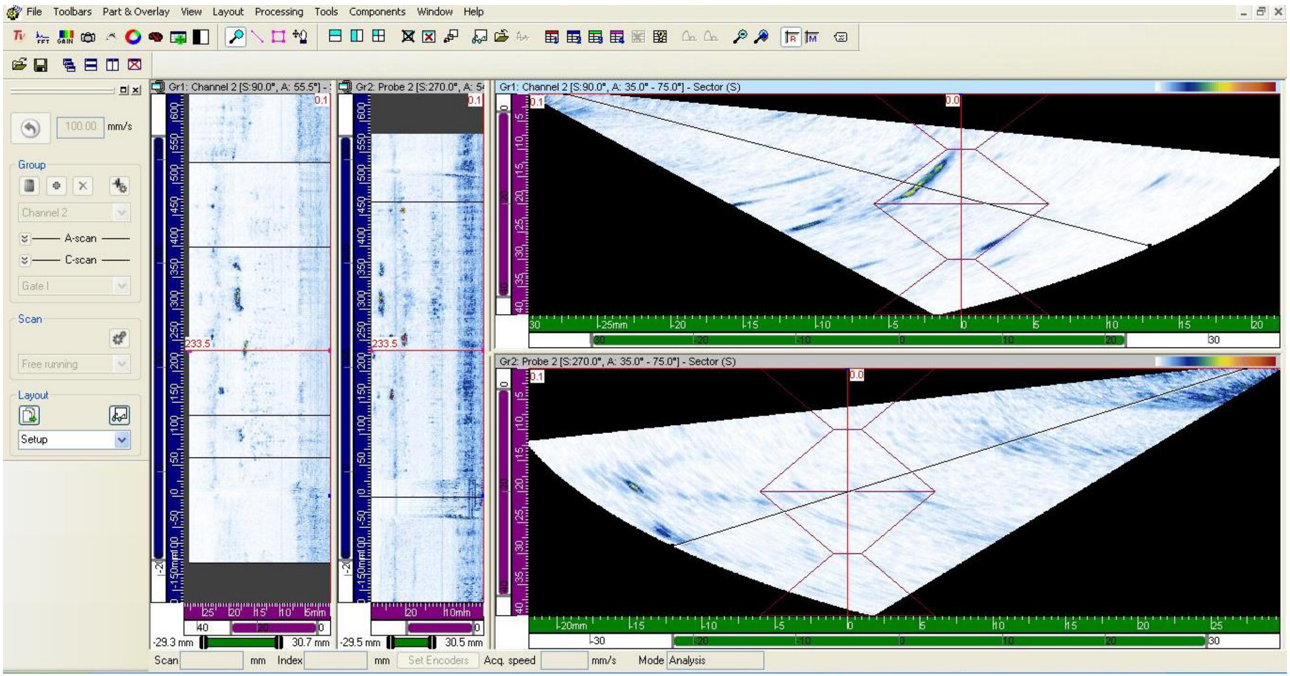

Figure 20: Butt weld 10mm, 20mm/s speed (indication on weld side wall)

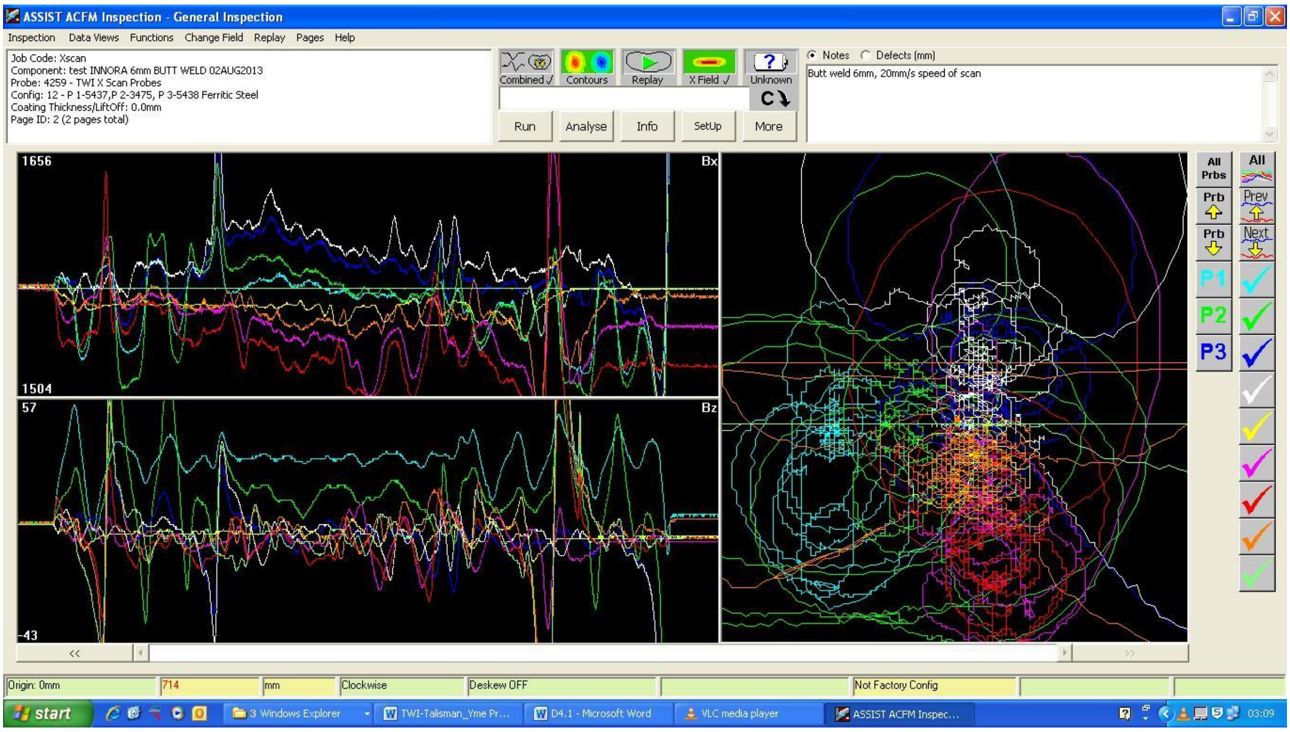

Figure 21: Butt weld 6mm, 20mm/s speed

Figure 22: Tests on the 13th of November

Figure 23: Preparation on the 14th of November

Figure 24: 4 meters high and going

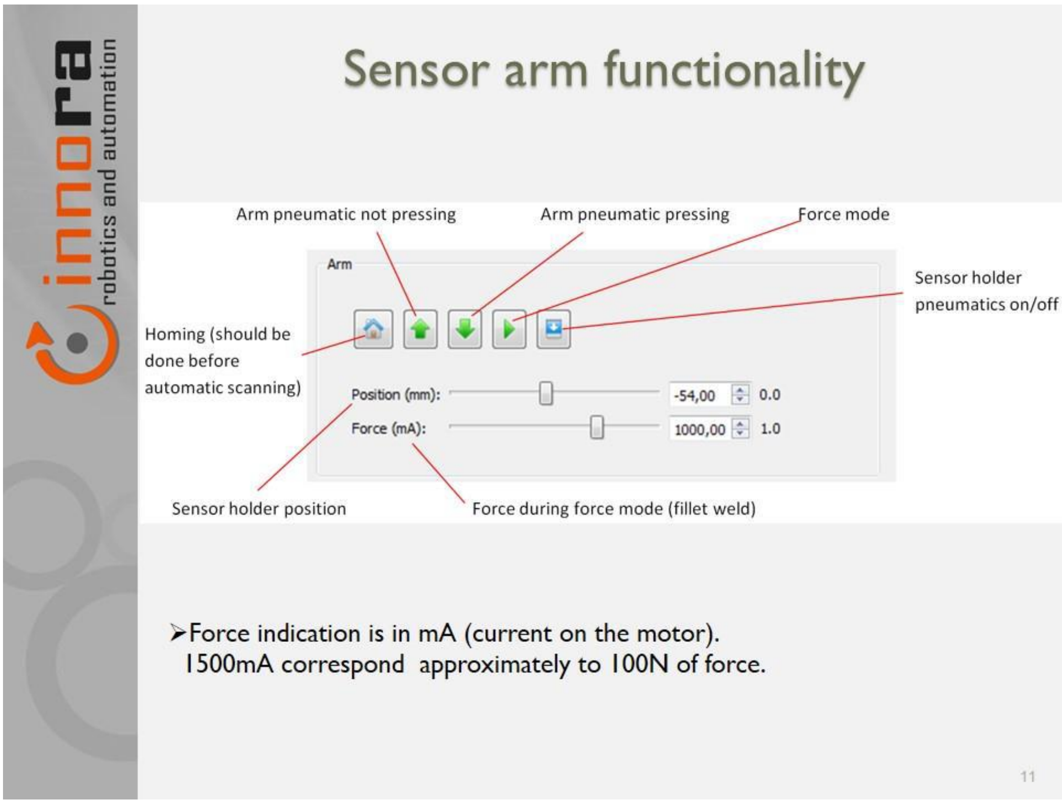

Figure 25: Explanation of the button functions of the robot control GUI, focus on the sensor arm control

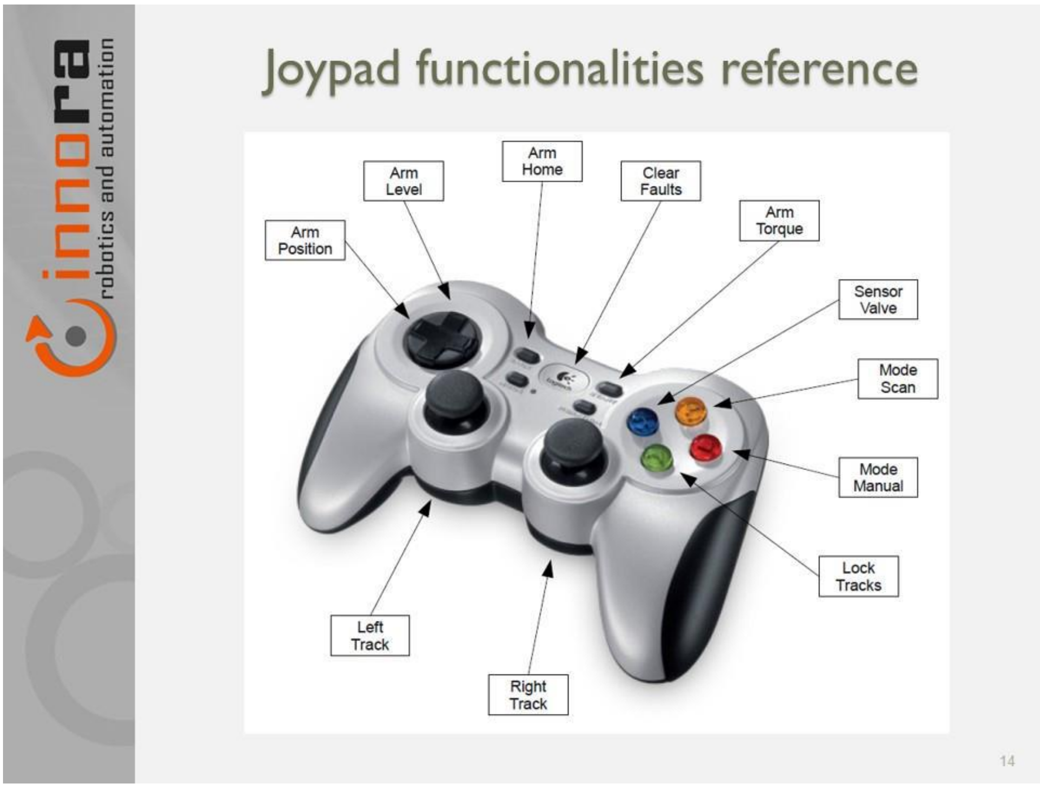

Figure 26: Button functions of the joypad controlling the robot

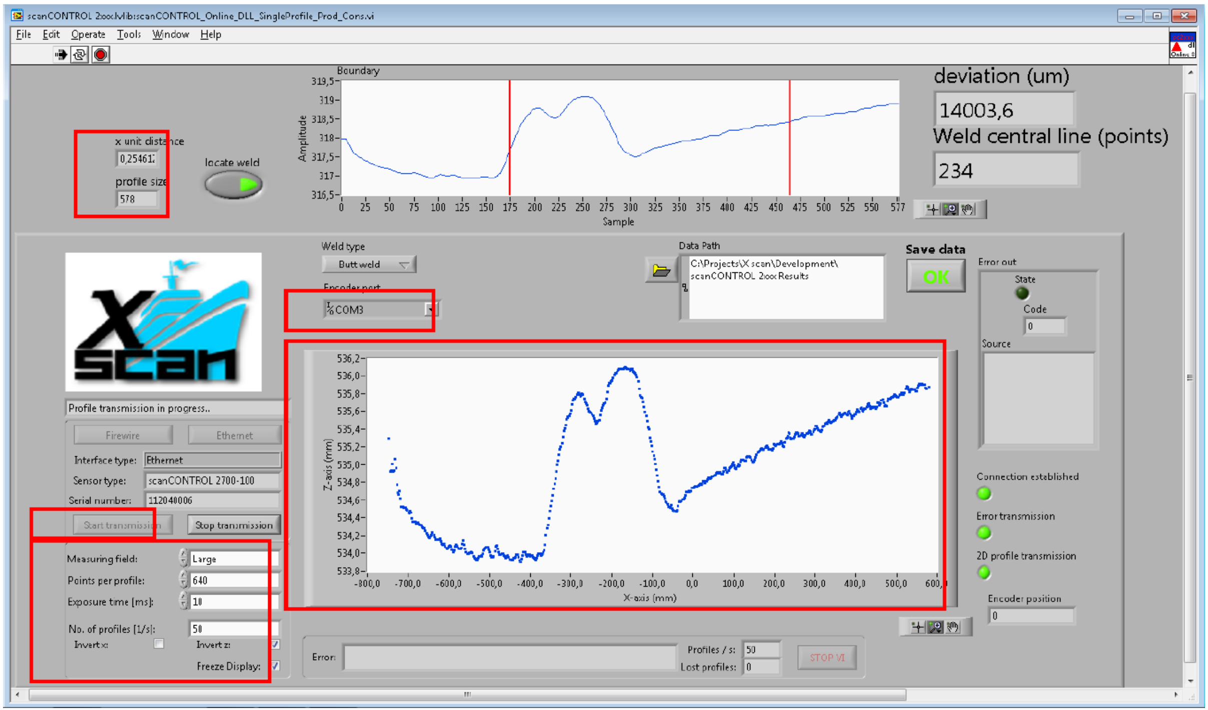

Figure 27: Main program GUI on the mini PC and start data transmission of the laser system (actions are boxed in red)

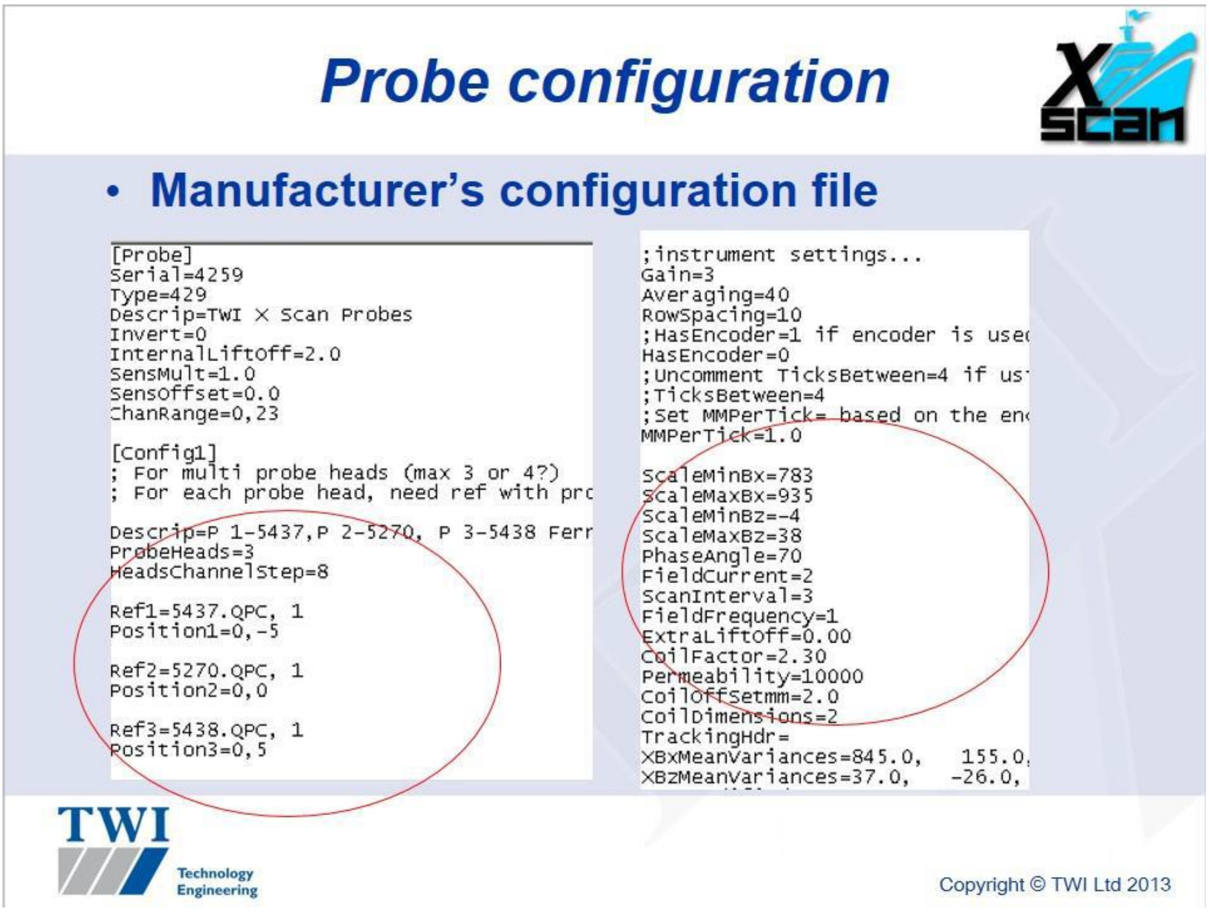

Figure 28: Extract from ACFM probe configuration file, changes needed circled in red