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ON THE HULL MODELS ACCURACY FOR BARGE TYPE B1740T EUROPE B2 USED FOR THE PROCESSING OF THE DRAUGHT SURVEY RECORDS

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ABSTRACT

For the river shipping the transported cargo values have to be computed based on the DS-draught survey records. Differences for cargo masses are recorded between DS and the on-shore weight. In order to increase the accuracy of the DS - draught survey procedure, we have developed the DRSWIN program based on a digital barge shape model. The quality of the barge shape model has a significant influence on the overall draught processing accuracy. For the barge type B1740T Europe B2, we have developed three hull shapes digital models with different density of the offset-lines. The results point out the most suitable hull shape digital model for the best accuracy on DS - draught survey processing.

Keywords: DS - draught survey, barge B1740T Europe B2, numerical models, comparative analysis

1. INTRODUCTION

The draught survey procedures are common for the shipping operations, either river or maritime transport [4],[6],[9]. The reports for cargo values, by barges DS-draught survey [12], have some differences between the on-board and on-shore weight.

One solution to ensure the required DS-draught survey accuracy is to use a digital model for the barge hull shape. For this purpose we have developed the DRSWIN program [3].

The hull offset-lines density has a significant influence on the results accuracy.

For this study we have developed three digital hull shape models for the case of barge type B1740T Europe B2 [1],[10],[11]. The models have different offset-lines density, making possible to assess the DRSWIN accuracy for draught survey processing.

The theoretical bases for the DRSWIN program are presented in [3], by ship theory [2] and PLL [7], where also a software validation is included.

The DS-draught survey record data are provided by the NAVROM S.A. Galati [12], with results from authorized draught surveyors according to international DS rules [4],[9], covering different transport cargo cases and water density values.

In the next sections are included the description of the three numerical barge models, comparative tests for cargo for the digital models on several barges' DS-draught survey, for the DRSWIN accuracy assessment.

2. THE NUMERICAL MODEL FOR THE BARGE TYPE B1740 EUROPE B2

In this study, the numerical models for the displacement and cargo computation by DRSWIN program [3], based on DS-draught survey records [12], is developed for barge type B1740T Europe B2 [10],[11].

The initial barge type B1740T Europe B2 input data, granted by NAVROM S.A. Galati [10],[11], are the following:

- Table 1, the barge main dimensions [10], [11], *LOA*[m] overall length, *LBP*[m] length between perpendiculars, *B*[m] breadth, *H*[m] height, *XAP*[m], *XM*[m], *XFP*[m] draught scales aft, mid and fore position (reference to x=0 aft ship).
- Figure 2, B1740T, reference hull offset-lines (original drawings) [10];
- Figure 3, B1740T, draught mark scales position (original drawings) [11].

Two cases are considered (Table 1) for the fore draught scale position (Fig.3):

- B-v1 (version 1) – *XFP* = 63.750 m (12.750 m from fore);
- B-v2 (version 2) – *XFP* = 63.868 m (12.632 m from fore).

The precision of displacement and cargo computations, based on DS - draught survey records, is linked to the accuracy of barge offset-lines numerical model, the barge having significant curved hull shapes with knuckles at fore part. For the offset lines of barge type B1740T Euro B2 we have developed three numerical CAD models, with different geometric accuracy (Table 2):

- *B1 model* (Fig.5) – based only on the points from the main stations K0, K1,…,K20 (Fig.4), from the offset-lines drawing plan (Fig.2);
- *B2 model* (Fig.6) – based on the offset - lines drawing plan curves (Fig.2) numerical interpolation curves [5] are build up between the initial stations' (Fig.4), resulting a first and second order barge surface geometric model;
- *B3 model* (Fig.7) – based on the offset-lines drawing plan (Fig.2), using advanced surface CAD techniques [8], we developed an envelope surface over the whole barge hull surface, ensuring the slopes and curvatures shape continuity (higher order surface geometric model), which is used for accurate station curves generation over the barge length.

Figure 1 and Table 3 include comparison between the displacement diagrams (hydro-statics curves, ρ =1 t/m^3) computed with DRSWIN software [3], for the three offset-lines numerical models (B1, B2, B3). The B3 model (accurate model) displacement values are between the results based on B1 (points simple model) and B2 (interpolation curves model) preliminary numerical models (Table 3). The barge type B1740T Europe B2 hydrostatic curves (displacement diagram), from the class documentation, were not available for this study.

Table 1. B1740T–barge data [10],[11]

LOA[m]	76.50	XAP[m]	12.750
LBP[m]	75.45	XM[m]	38.250
B[m]	10.96	XFP[m] v1	63.750
H[m]	3.20	XFP[m] v2	63.868

Table 2. B1740T – barge offset lines

Model	No.S	No.P	CAD technique
B1	21	1082	Points
B2	405	21992	interpolation curves
B3	391	32663	envelope surface

Table 3. Comparative displacement diagrams

Barge B1740T DRSWIN ρ[t/m^3]=1.00				
No.	**z[m]**	**Δ[t]-B1**	**Δ[t]-B2**	**Δ[t]-B3**
1	0.0000	0.000	0.000	0.00
2	0.5000	358.88	368.23	368.23
3	0.7000	510.21	520.40	520.39
4	1.0000	740.65	751.44	751.26
5	1.2000	896.41	907.16	906.73
6	1.5000	1132.45	1142.96	1142.05
7	1.7000	1290.90	1301.51	1300.27
8	2.0000	1529.66	1541.17	1539.49
9	2.2000	1689.53	1702.15	1700.21
10	2.5000	1930.26	1945.36	1943.10
11	2.7000	2091.50	2108.66	2106.20
12	3.0000	2335.41	2355.17	2352.58

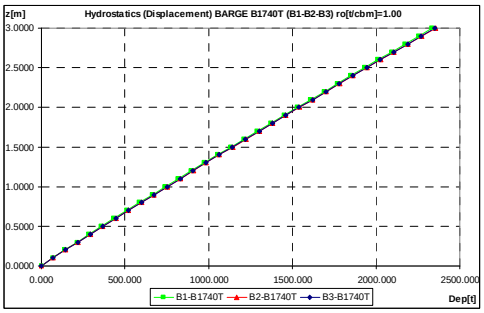

Fig.1 B1740T, numerical models B1,B2,B3, displacement diagrams (hydrostatics).

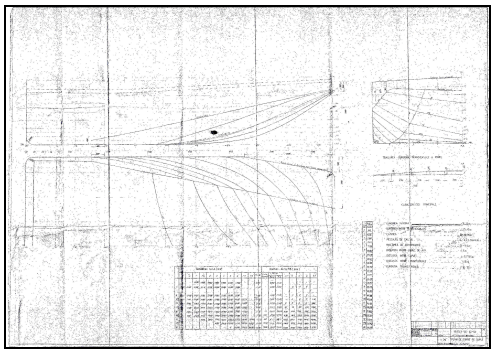

Fig.2 B1740T, Reference hull offset-lines (original drawings) [10].

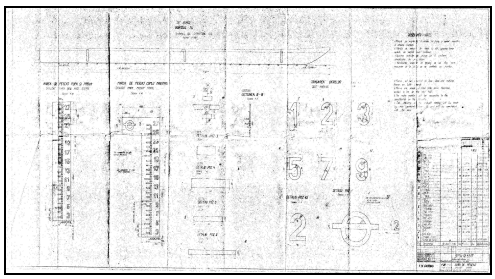

Fig.3 B1740T, Draught mark scales position (original drawings) [11].

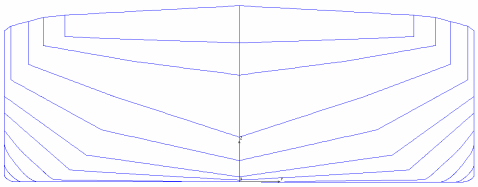

Fig.4 B1740T Reference offset lines main stations, K0, K1,…,K20.

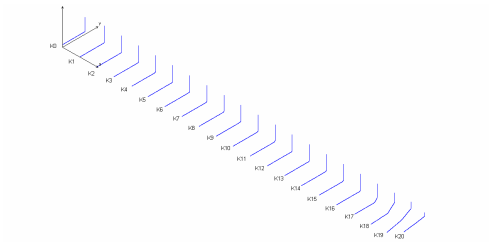

Fig.5 B1740T, B1 model, CAD offset-lines.

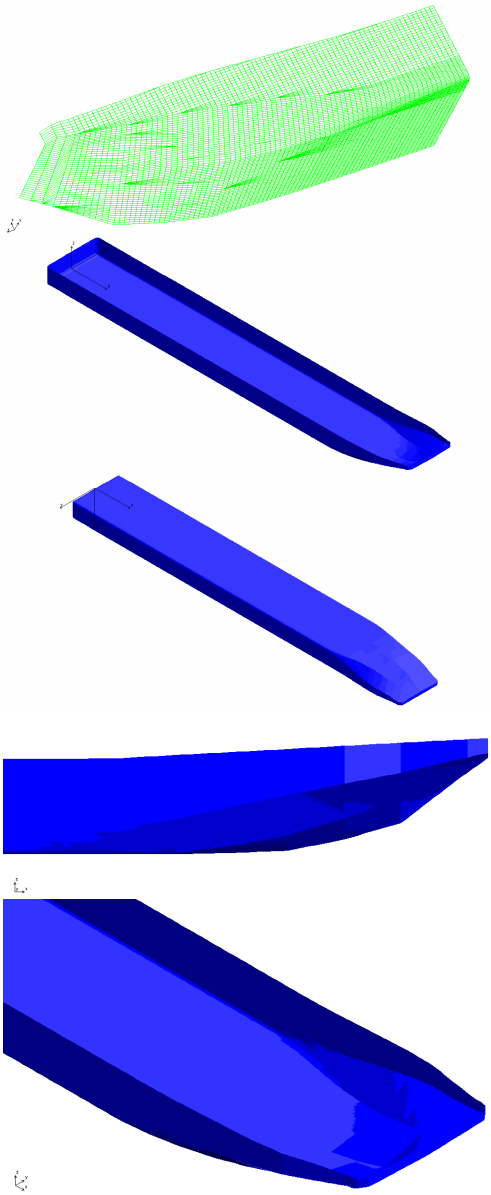

Fig.6 B1740T, B2 model, CAD offset-lines.

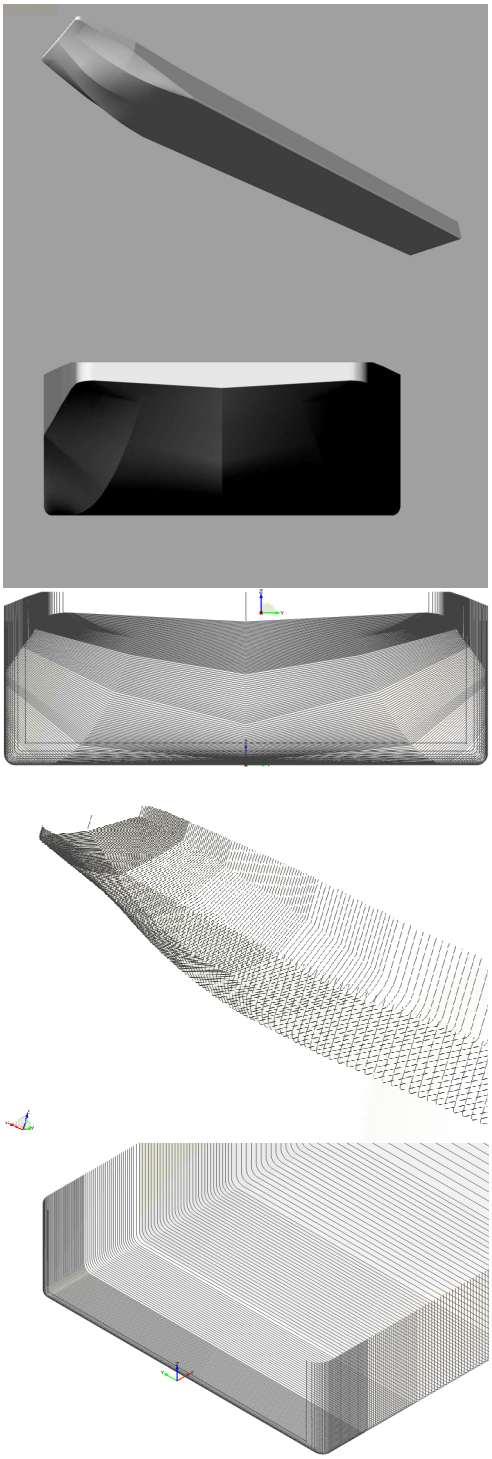

Fig.7 B1740T, B3 model, CAD offset-lines.

3. COMPARATIVE ANALYSIS OF THE CARGO RESULTS BY DRSWIN FOR BARGE B1740T EUROPE B2

For the seven DS - draught survey records [12] and the three offset-lines models (Figs.5,6,7) for the barge type B1740T Europe B2, based on original drawings (Fig.2,3) [10], [11], the following displacement and cargo values are obtained:

- Table 4, displacement and cargo values comparison in the case of draught mark scales version V1 (XFP = 63.750 m);
- Table 5, displacement and cargo values comparison in the case of draught mark scales version V2 (XFP = 63.868 m);
- Table 6, displacement and cargo values comparison in the case of draught mark scales versions V1 and V2 for the offset lines B3 model.

Table 7 includes the comparative cargo results from Tables 4,5,6.

Figure 8 includes the final offset-lines numerical model (B3), with the best geometric accuracy for the barge offset lines description.

Table 7 Synthesis of the comparative cargo differences results

Draught mark	Case	Min.diff.[t]	Max.diff.[t]	Med.diff.[t]
V1	B1 - DS	-5.116	+8.132	3.701
XFP=	B2 - DS	-1.949	+13.878	8.806
63.750 m	B3 - DS	-3.964	+12.378	7.131
V2	B1 - DS	-5.025	+8.283	3.853
XFP=	B2 - DS	-1.855	+14.034	8.963
63.868 m	B3 - DS	-3.870	+12.533	7.287

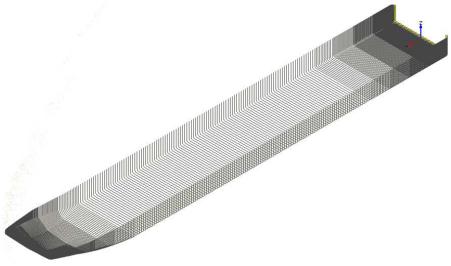

Fig.8 The best geometric digital CAD model.

Table 4 BARGE B1740T [10],[11], Draught Marks – Version V1 (XFP[m] = 63.750) Draught survey comparison standard DS versus numerical models B1, B2, B3 Measured draught survey DS [12]

No	ro	d_{AP}[m]	d_M[m]	d_{FP}[m]	Δ[t]-DS	Δ[t]-B1	Δ[t]-B2	Δ[t]-B3
1	1.0100	2.1950	2.3000	2.2525	1739.54	1743.35	1755.94	1753.99
	1.0095	0.4000	0.5775	0.6950	393.25	395.35	401.20	401.06
	transported cargo[t]				1346.29	1348.00	1354.74	1352.93
	cargo difference DRSWIN & DS[t]					1.709	8.451	6.641
2	1.0100	1.6850	1.7050	1.6875	1282.70	1297.51	1308.20	1306.99
	1.0100	0.4700	0.5700	0.6250	391.58	398.44	406.37	406.31
	transported cargo[t]				891.12	899.08	901.82	900.68
	cargo difference DRSWIN & DS[t]					7.952	10.699	9.558
3	0.9970	0.5475	0.6000	0.6450	417.89	426.17	435.96	435.94
	0.9970	2.2200	2.3075	2.3050	1740.31	1743.47	1756.43	1754.40
	transported cargo[t]				1322.42	1317.30	1320.47	1318.46
	cargo difference DRSWIN & DS[t]					-5.116	-1.949	-3.964
4	1.0100	2.1075	2.2075	2.3150	1707.10	1709.58	1723.07	1720.93
	1.0100	0.4075	0.5400	0.7350	395.94	394.03	401.37	401.23
	transported cargo[t]				1311.17	1315.55	1321.69	1319.70
	cargo difference DRSWIN & DS[t]					4.384	10.528	8.531
5	1.0100	1.9000	1.9925	1.9550	1492.19	1501.56	1512.71	1511.14
	1.0100	0.4400	0.5875	0.6650	398.43	403.33	410.12	410.01
	transported cargo[t]				1093.76	1098.24	1102.59	1101.13
	cargo difference DRSWIN & DS[t]					4.479	8.831	7.367
6	1.0100	1.9400	2.0100	1.9925	1517.77	1527.44	1538.80	1537.15
	1.0100	0.3950	0.5850	0.7100	397.81	399.34	404.96	404.81
	transported cargo[t]				1119.96	1128.10	1133.84	1132.34
	cargo difference DRSWIN & DS[t]					8.132	13.878	12.378
7	0.9980	0.4150	0.6150	0.7850	423.45	422.99	429.16	428.97
	0.9980	2.3650	2.3925	2.3050	1805.87	1809.78	1822.78	1820.80
	transported cargo[t]				1382.42	1386.79	1393.63	1391.83
	cargo difference DRSWIN & DS[t]					4.368	11.205	9.404

Table 5 BARGE B1740T [10],[11], Draught Marks – Version V2 (XFP[m] = 63.868) Draught survey comparison standard DS versus numerical models B1, B2, B3 Measured draught survey DS [12]

No	ro	d_{AP}[m]	d_M[m]	d_{FP}[m]	Δ[t]-DS	Δ[t]-B1	Δ[t]-B2	Δ[t]-B3
1	1.0100	2.1950	2.3000	2.2525	1739.54	1743.49	1756.09	1754.13
	1.0095	0.4000	0.5775	0.6950	393.25	395.27	401.12	400.98
	transported cargo[t]				1346.29	1348.22	1354.97	1353.16
	cargo difference DRSWIN & DS[t]					1.931	8.681	6.869
2	1.0100	1.6850	1.7050	1.6875	1282.70	1297.55	1308.24	1307.03
	1.0100	0.4700	0.5700	0.6250	391.58	398.41	406.34	406.28
	transported cargo[t]				891.12	899.14	901.89	900.75
	cargo difference DRSWIN & DS[t]					8.020	10.769	9.627
3	0.9970	0.5475	0.6000	0.6450	417.89	426.13	435.92	435.91
	0.9970	2.2200	2.3075	2.3050	1740.31	1743.53	1756.48	1754.46
	transported cargo[t]				1322.42	1317.40	1320.57	1318.55
	cargo difference DRSWIN & DS[t]					-5.025	-1.855	-3.870
4	1.0100	2.1075	2.2075	2.3150	1707.10	1709.45	1722.93	1720.79
	1.0100	0.4075	0.5400	0.7350	395.94	393.83	401.16	401.02
	transported cargo[t]				1311.17	1315.62	1321.77	1319.77
	cargo difference DRSWIN & DS[t]					4.456	10.602	8.605
5	1.0100	1.9000	1.9925	1.9550	1492.19	1501.68	1512.83	1511.26
	1.0100	0.4400	0.5875	0.6650	398.43	403.290	410.08	409.97
	transported cargo[t]				1093.76	1098.39	1102.75	1101.28
	cargo difference DRSWIN & DS[t]					4.633	8.988	7.523
6	1.0100	1.9400	2.0100	1.9925	1517.77	1527.51	1538.88	1537.23
	1.0100	0.3950	0.5850	0.7100	397.81	399.26	404.88	404.73
	transported cargo[t]				1119.96	1128.25	1134.00	1132.50
	cargo difference DRSWIN & DS[t]					8.283	14.034	12.533
7	0.9980	0.4150	0.6150	0.7850	423.45	422.86	429.01	428.83
	0.9980	2.3650	2.3925	2.3050	1805.87	1809.95	1822.96	1820.97
	transported cargo[t]				1382.42	1387.10	1393.94	1392.14
	cargo difference DRSWIN & DS[t]					4.676	11.523	9.721

Table 6 BARGE B1740T DS [10],[11],[12] Model B3 with 391 sections, 32663 points

No	ro	d_{AP}[m]	d_M[m]	d_{FP}[m]	Δ[t]-DS	Δ[t]-V1	Δ[t]-V2
1	1.0100	2.1950	2.3000	2.2525	1739.54	1753.99	1754.13
	1.0095	0.4000	0.5775	0.6950	393.25	401.06	400.98
	transported cargo[t]				1346.29	1352.93	1353.16
	cargo difference DRSWIN & DS[t]					6.641	6.869
2	1.0100	1.6850	1.7050	1.6875	1282.70	1306.99	1307.03
	1.0100	0.4700	0.5700	0.6250	391.58	406.31	406.28
	transported cargo[t]				891.12	900.68	900.75
	cargo difference DRSWIN & DS[t]					9.558	9.627
3	0.9970	0.5475	0.6000	0.6450	417.89	435.94	435.91
	0.9970	2.2200	2.3075	2.3050	1740.31	1754.40	1754.46
	transported cargo[t]				1322.42	1318.46	1318.55
	cargo difference DRSWIN & DS[t]					-3.964	-3.870
4	1.0100	2.1075	2.2075	2.3150	1707.10	1720.93	1720.79
	1.0100	0.4075	0.5400	0.7350	395.94	401.23	401.02
	transported cargo[t]				1311.17	1319.70	1319.77
	cargo difference DRSWIN & DS[t]					8.531	8.605
5	1.0100	1.9000	1.9925	1.9550	1492.19	1511.14	1511.26
	1.0100	0.4400	0.5875	0.6650	398.43	410.01	409.97
	transported cargo[t]				1093.76	1101.13	1101.28
	cargo difference DRSWIN & DS[t]					7.367	7.523
6	1.0100	1.9400	2.0100	1.9925	1517.77	1537.15	1537.23
	1.0100	0.3950	0.5850	0.7100	397.81	404.81	404.73
	transported cargo[t]				1119.96	1132.34	1132.50
	cargo difference DRSWIN & DS[t]					12.378	12.533
7	0.9980	0.4150	0.6150	0.7850	423.45	428.97	428.83
	0.9980	2.3650	2.3925	2.3050	1805.87	1820.80	1820.97
	transported cargo[t]				1382.42	1391.83	1392.14
	cargo difference DRSWIN & DS[t]					9.404	9.721

4. CONCLUSIONS

From section 3 the following conclusions result:

- The minimum cargo differences result for the B1 model (Fig.5), in average 3.701÷3.853 t. The B1 model is simple with 1082 points on 21 stations, having the smallest geometric accuracy for the barge offset-lines description.
- The maximum cargo differences result for the B2 model (Fig.6), in average 8.806÷8.963 t. The B2 model based on interpolation curves, with a total of 21992 points, can be considered with medium geometric accuracy for the barge offset lines description.
- The cargo differences for the B3 model (Fig.7) are in average 7.131÷7.287 t. The B3 model, based on an advanced surface approach, with a total of 32663 points, has the best geometric accuracy for the barge offset lines description and shall be considered for the practical application on barge type B1740T Europe B2 using DRSWIN program [3].

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