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ON THE SOFTWARE DRSWIN DESIGNED FOR BARGES DRAUGHT SURVEY PROCESSING

Leonard Domnişoru
"Dunărea de Jos" University of Galaţi,
Faculty of Naval Architecture, Galaţi,
47 Domnească Street, 800008, Romania,
E-mail:leonard.domnisoru@ugal.ro

Florin Păcuraru,
"Dunărea de Jos" University of Galaţi,
Faculty of Naval Architecture, Galaţi,
47 Domnească Street, 800008, Romania,
E-mail:florin.pacuraru@ugal.ro

Alina Modiga
"Dunărea de Jos" University of Galaţi,
Faculty of Naval Architecture, Galaţi,
47 Domnească Street, 800008, Romania,
E-mail:alina.modiga@ugal.ro

ABSTRACT

During the exploitation of a barge, the displacement is computed in order to establish the transported cargo mass. In this paper the DRSURVEY, DRCD, DRSWIN eigen softwares are presented, being an integrated system for displacement computation by DS - draught survey records. The accuracy of the DS - draught survey procedure is enhanced by taking into account the ship's girder real deflection and trim, based on a digital model for the barge lines. For several DS - draught surveys records, the displacements are computed and the eigen codes are validated.

Keywords: DS - draught survey records, barge, software code, validation

1. INTRODUCTION

For a barge exploitation the transported cargo mass must be assessed according to the standard international DS - draught survey rules [9], [18].

The cargo mass is computed as the difference between the barge's loaded displacement and unloaded displacement, based on the draught records at the aft, mid and fore scales. The standard procedure by rules [9], [18], [12], [15] requires to obtain the displacement value using the barge hydrostatics curves and a reference mean draught of the recorded draughts.

Significant differences occur for the cargo values by DS - draught survey standard approach and the on-shore weight [15],[16].

In order to improve the accuracy of the DS - draught survey procedure, we have developed eigen software codes DRSWIN, DRSURVEY, DRCD for displacement and cargo computation.

The accuracy of the DS - draught survey procedure is enhance by taking into account the real trim and hull girder deflection, based on a digital model for the barge's lines and the hydrostatic curves.

2. THEORETICAL BASES

In this section for the DS - draught survey softwares package the mathematical bases are presented. The area and volume integrals are calculated by the trapezoidal method [3],[10]:

- *Station area (Bonjean diagram)* [2÷7,11,14]

$$At(x,z)=\int_{z0}^{z} y(x,z)dz\,;\; x=0,L_{OA}\,;\; z=z_0,z_{\max}$$
$$At_{i,j}=\sum_{k=2}^{j}\left(y_{i.k}+y_{i,k-1}\right)\cdot\left(z_{i,k}-z_{i,k-1}\right) \quad (1)$$

where: $At_{i,j}, i=1,ns; j=1,np(i)$ is the station area at x_i for the $y_{i,j}$ ship offset lines; L_{OA} is the total barge length; ns is the stations number; $np(i)$ is the points number at j station.

-Draught mean port & starboard [9,12,15,16,18]

$$d_{AP,M,FP} = \left(d_{AP,M,FP-PS} + d_{AP,M,FP-SB}\right)/2 \quad (2)$$

where AP-aft, *M*-mid & *FP*-fore draught scales.

- Reference draught in the case with barge trim & deflection, the exact solution [9,12,15,16,18]

$$d_{M1}(x) = a_0 + a_1 \cdot x + a_2 \cdot x^2;\ x = 0, L_{OA} \quad (3)$$

$$a_0 = d_M - a_1 \cdot x_M - a_2 \cdot x_M^2; a_1 = b_4/b_3; a_2 = b_2/b_1$$

$$b_1 = \left(x_{AP}^2 - x_M^2\right)\cdot\left(x_{FP} - x_M\right) - \left(x_{FP}^2 - x_M^2\right)\cdot\left(x_{AP} - x_M\right)$$

$$b_2 = \left(d_{AP} - d_M\right)\cdot\left(x_{FP} - x_M\right) - \left(d_{FP} - d_M\right)\cdot\left(x_{AP} - x_M\right)$$

$$b_3 = \left(x_{AP} - x_M\right)\cdot\left(x_{FP}^2 - x_M^2\right) - \left(x_{FP} - x_M\right)\cdot\left(x_{AP}^2 - x_M^2\right)$$

$$b_4 = \left(d_{AP} - d_M\right)\cdot\left(x_{FP}^2 - x_M^2\right) - \left(d_{FP} - d_M\right)\cdot\left(x_{AP}^2 - x_M^2\right)$$

where: $x_{AP,M,FP}$ are draught scales position.

- Reference draught in the case mean of means value (3) [9,12,15,16,18]

$$d_{M2} = \left(d_{AP} + d_M + d_{FP}\right)/3 \quad (4)$$

- Reference draught in the case UN/ECE mean value (8) [9,12,15,16,18]

$$d_{M3} = \left(d_{AP} + 6 \cdot d_M + d_{FP}\right)/8 \quad (5)$$

- Barge trim, mid draught and deflection

$$trim = \left(d_{FP} - d_{AP}\right)/\left(x_{FP} - x_{AP}\right)\cdot 180/\pi$$

$$z_M = d_{AP} + \frac{\left(d_{FP} - d_{AP}\right)}{\left(x_{FP} - x_{AP}\right)}\cdot\left(x_M - x_{AP}\right) \quad (6)$$

$$AS = d_{FP} - d_{AP};\ w_M = d_M - z_M$$

$w_M > 0$ sagg.; $w_M < 0$ hogg; $w_M = 0$ not-def.

- Buoyancy V-volume & LBC-centre position, Δ displacement [2÷7,11,14] for $\#\in\{1,2,3\}$

$$V\left(d_{M\#}\right) = \int_0^{L_{OA}} At\left(x, d_{M\#}\right)dx;\ \Delta = V \cdot \rho \cdot s_k$$

$$V = \sum_{i=1}^{ns-1}\frac{1}{2}\cdot\left(At_i + At_{i+1}\right)\cdot\left(x_{i+1} - x_i\right)$$

$$x_B\left(d_{M\#}\right) = \frac{1}{V}\int_0^{L_{OA}} x \cdot At\left(x, d_{M\#}\right)dx \quad (7)$$

$$x_B = \frac{1}{V}\sum_{i=1}^{ns-1}\frac{1}{2}\cdot\left(x_i \cdot At_i + x_{i+1} \cdot At_{i+1}\right)\cdot\left(x_{i+1} - x_i\right)$$

3. MODULES OF DS - DRAUGHT SURVEY SOFTWARES PACKAGE

In this section, the eigen developed DRSWIN, DRSURVEY, DRCD softwares package is presented (Fig.1).

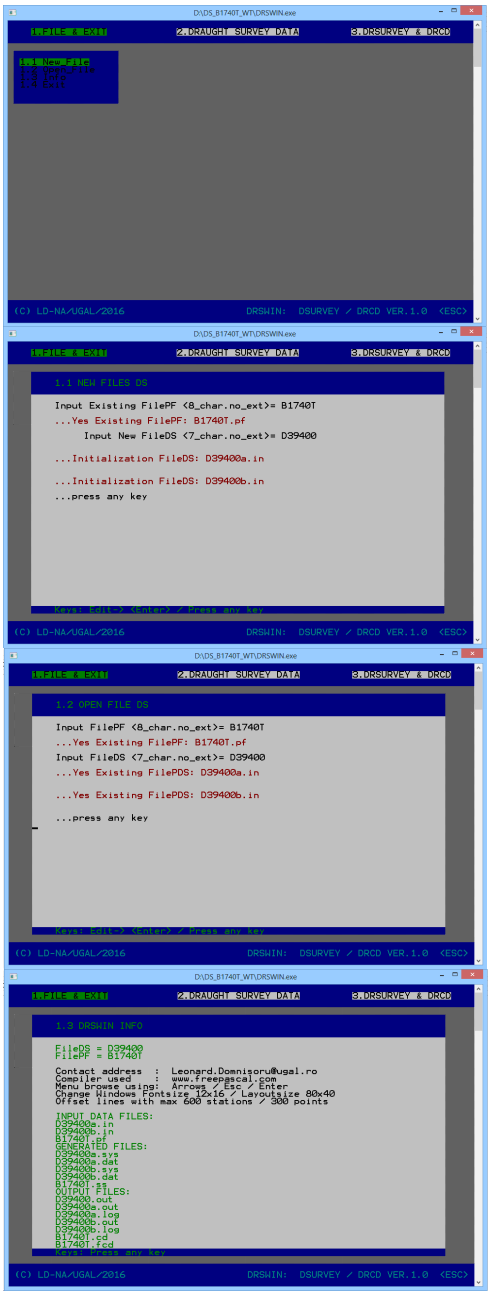


Fig.2 The DS File & Exit Menu.

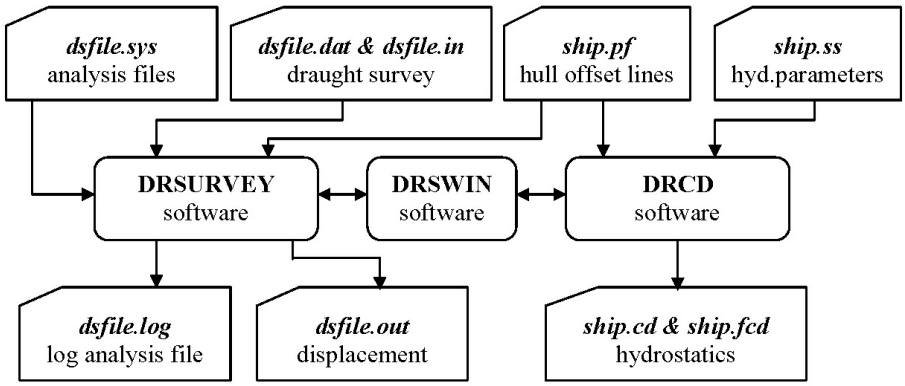


Fig.1 The DRSWIN, DRSURVEY, DRCD softwares input & output files flow chart

Fig.3.a DS Draught Survey Data Menu.

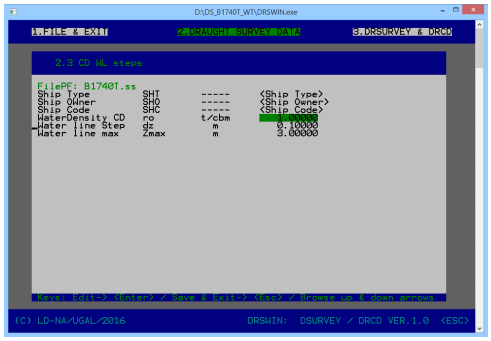


Fig.3.b DS Draught Survey Data Menu.

The softwares are designed by PPL-Pascal [13], only for Windows O.S.. Figure 1 presents the integrated data flow chart. The DRSWIN has safety precedence conditions for files.

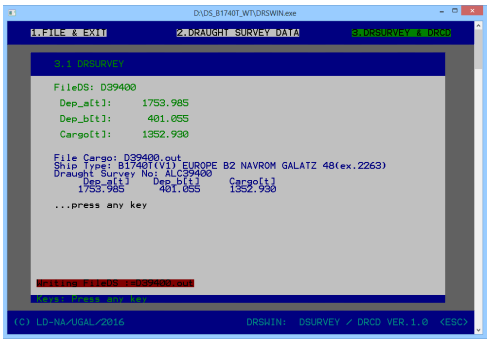
- *The DS File & Exit Menu* (Fig.2)

This menu includes the reading or the initialization of the following files: the hull lines (*ship.pf*), the parameters for hydrostatics computation (*ship.ss*), DS - draught survey recorded data (*dsfile.dat & dsfile.in*), analysis setup files (*dsfile.sys*). The hull lines files are generated by other CAD softwares [8],[17].

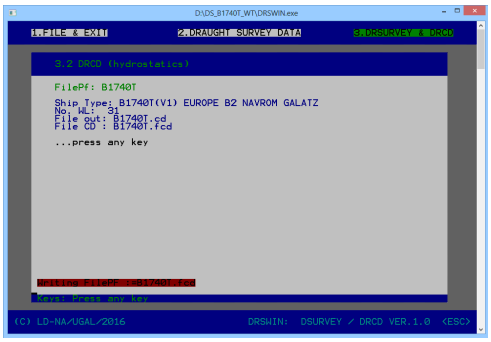
- *The DS - Draught Survey Data Menu* (Fig.3.a,b)

This menu includes the editing of the following input data files: DS-draught survey data initial loading condition (*dsfile(a).dat & dsfile(a).in*), DS- draught survey data final loading condition (*dsfile(b).dat & dsfile(b) .in*), the parameters for the hull hydrostatics (*ship.ss*).

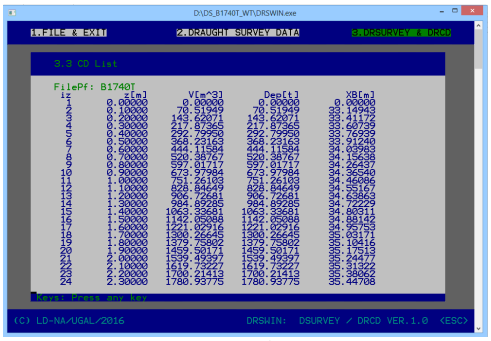
DRSURVEY/ DRCD:Cargo & hydrostatics computation



DRSURVEY: Displacements & cargo computation



DRCD: Hull hydrostatics computation



DRCD: Out data list of hull hydrostatics

Fig.4 DRSURVEY & DRCD Menu.

- *The DRSURVEY & DRCD Menu* (Fig.4)

This menu includes the computation of the displacement (initial and final), the cargo and the ship hydrostatics. The following output data files are obtained: analysis run log file (*dsfile.log*), the initial and final displacements (*dsfile(a).out & dsfile(b).out*), the transported cargo (*dsfile.out*), the barge hydrostatic curves (*ship.cd & ship.fcd*).

The DRSURVEY and DRCD programs can be also used in batch mode separately to the DRSWIN integrated interface, with the same files system (Fig.1).

Tables 1÷6 present the input and output files variables for the DRSWIN, DRCD and DRSURVEY softwares' package.

Table 1. File: <*ship.pf*>

Variable	**Unit**	**Data**
ship name	----	ship name & code
XAP	m	AP draught scale
XM	m	M draught scale
XFP	m	FP draught scale
L	m	ship length LBP
SK	----	shell thickness coefficient
x_i	m	x coordinate offset point i=1,ns origin at aft plane (AP)
y_{ij}	m	y coordinate offset point i=1,ns j=1,np(i) origin at centre line (CL)
z_{ij}	m	z coordinate offset point i=1,ns j=1,np(i) origin at base line (BL)
ns the stations number, max. 601		
np(i) the points number per station, max. 301		
code	-----	1 begin of station description 0 point on station 9 ending the offset lines description

Table 2. File: <*ship.ss*>

Variable	**Unit**	**Data**
ship name	----	ship name & code
ro	t/m^3	water density
dz	m	z step
Zmax	m	z max.

Table 3. File: <*dsfile.dat*> & <*dsfile.in* >

Variable	Unit	Data
ship name	----	ship name & code
draught survey no	----	DS - draught survey number
date	----	date of survey
place	----	place of survey
ro	t/m^3	water density
DAP_PS *DM_PS* *DFP_PS*	m	port side draughts
DAP_PS *DM_PS* *DFP_PS*	m	starboard side draughts

Table 4. File: <*dsfile.sys*>

Variable	Unit	Data
dsfile.dat	----	DS-draught survey file
dsfile.out	----	displacement results file
dsfile.log	----	log analysis file
ship.pf	----	ship offset file

Table 5. File: <*dsfile.out*> & <*dsfile.log*>

Variable	Unit	Data
dsfile.sys	----	analysis system files
dsfile.dat	----	DS- draught survey file
ship.pf	----	ship offset file
ns	----	stations number
a0	m	ship hull with parabolic shape of deflection; curve parameters, based on the aft, mid & fore scales
a1	m/m	
a2	m/m^2	
trim	deg.	trim angle
As	m	trim displacement fore-aft perpendiculars
Zm	m	mid ship average between AP&FP draughts
Wm	m	mid ship deflection
sag/hog	----	deflection case sagging / hogging
DDM2	m	reference mean draught method 2
DDM3	m	reference mean draught method 3
$V_{1,2,3}$	m^3	buoyancy volume
$Dep_{1,2,3}$	t	displacement
$XB_{1,2,3}$	m	LBC-buoyancy centre position

Table 6. File: <*ship.cd*> & <*ship.fcd*>

Variable	Unit	Data
ship.ss	----	parameters for ship's hydrostatics computation
ship.pf	----	ship's hull lines
ns	----	number of stations
np(i)	----	number of points on current station i
y_{ij}	m	y coordinate offset point i=1,ns j=1,np(i) origin at centre line (CL)
z_{ij}	m	z coordinate offset point i=1,ns j=1,np(i) origin at base line (BL)
At_{ij}	m^2	station area (Bonjean diagram)
z_{iz}	m	z water line position iz=1,nz
nz number of water lines as in *ship.ss*		
V_{iz}	m^3	buoyancy volume at iz WL
Dep_{iz}	t	displacement at iz WL
XB_{iz}	m	LBC-buoyancy centre position

4. COMPARATIVE TESTS FOR DISPLACEMENT VALUES BASED ON THE BARGES' DS RECORDS. SOFTWARES VALIDATION

In this section the DRSURVEY & DRCD softwares are validated based on the test barges data granted by SDG [15],[16].

BARGE 1 has an analytical shape, making possible to compare the displacement results between: analytical solution [15], SDG CARENA [15] and DRSURVEY softwares.

BARGE 2 used in the DRSURVEY application has an equivalent shape of the 2000T barge type, ANR/RNR [1]. The displacement results are compared between: DS-draught survey data [16], SDG CARENA software [16] and DRSURVEY software.

Table.7 presents the results list for testing BARGE 1 & BARGE 2.

Figures 5.1,2 & 6.1,2 present the barges hull shape and the displacement curve.

Tables 8.1,2 & 9.1,2 present the barges main dimensions and the displacement curve.

Tables 10.1,2 present the barges DS-draught survey displacement comparative tests.

Table 7. Displacement barges tests

Barge Test	*BARGE 1*	*BARGE 2*
Hull shape	Fig.5.1	Fig.5.2
Main dimensions	Table 8.1	Table 8.2
Hydrostatics (displacement)	Fig.6.1 Table 9.1	Fig.6.2 Table 9.2
Displacement comparative tests	Table 10.1	Table 10.2

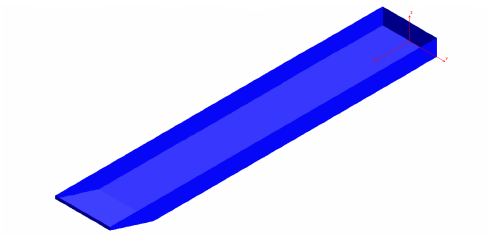


Fig.5.1 BARGE 1 - Hull shape [15]

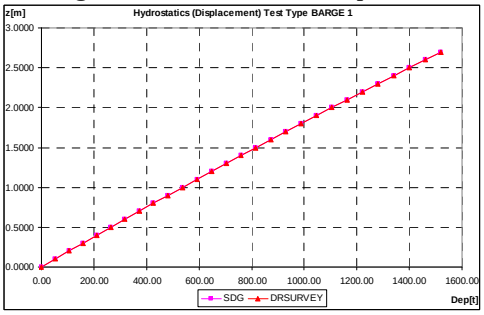


Fig.6.1 BARGE 1-Hydrostatics (displacement)

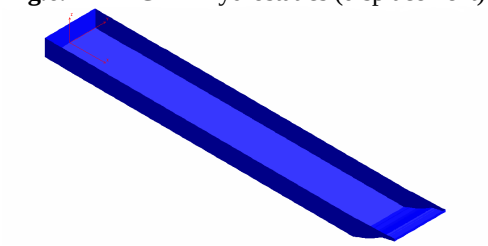


Fig.5.2 BARGE 2 - Hull shape [1],[16]

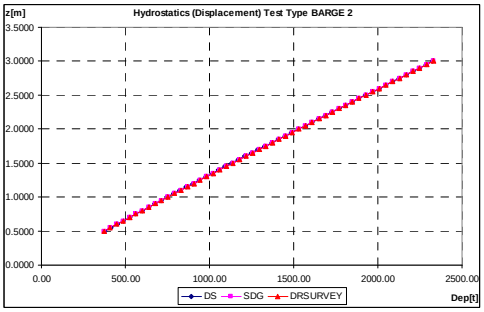


Fig.6.2 BARGE 2-Hydrostatics (displacement)

Table 8.1 BARGE 1- Main dimensions

LOA[m]	**LBP[m]**	**B[m]**	**H[m]**
60.000	60.000	10.000	3.000

Table 8.2 BARGE 2- Main dimensions

LOA[m]	**LBP[m]**	**B[m]**	**H[m]**
76.180	75.720	11.000	3.600

Table 9.1 BARGE 1 - Displacement

ro[t/m^3]=1.00		**CARENA** [15]	**DRSURVEY**
No.	**z[m]**	**Dep[t]-SDG**	**Dep[t]-test**
1	0.0000	0.00	0.00
2	0.5000	264.00	264.00
3	1.0000	536.00	536.00
4	1.5000	816.00	816.00
5	2.0000	1104.00	1104.00
6	2.5000	1400.00	1400.00
7	2.7000	1520.00	1520.00

Table 9.2 BARGE 2 - Displacement

ro[t/m^3]=1		Ref.[16]	**CARENA**	**DRSURVEY**
No.	**z[m]**	**Dep[t]-DS**	**Dep[t]-SDG**	**Dep[t]-test**
1	0.5000	377.79	372.93	372.93
2	0.6000	451.86	448.26	448.29
3	0.7000	525.93	523.94	523.99
4	0.8000	600.00	599.94	599.99
5	0.9000	674.08	676.24	676.28
6	1.0000	748.16	752.83	752.85
7	1.1000	823.09	829.70	829.69
8	1.2000	900.01	906.82	906.79
9	1.3000	976.93	984.18	984.13
10	1.4000	1053.85	1061.78	1061.71
11	1.5000	1130.77	1139.58	1139.51
12	1.6000	1208.00	1217.58	1217.54
13	1.7000	1288.00	1295.78	1295.77
14	1.8000	1368.00	1374.19	1374.21
15	1.9000	1448.00	1452.80	1452.84
16	2.0000	1528.00	1531.61	1531.68
17	2.1000	1608.00	1610.61	1610.69
18	2.2000	1688.00	1689.81	1689.91
19	2.3000	1768.00	1769.22	1769.30
20	2.4000	1848.00	1848.82	1848.87
21	2.5000	1928.00	1928.62	1928.63
22	2.6000	2008.00	2008.60	2008.58
23	2.7000	2088.00	2088.75	2088.69
24	2.8000	2168.00	2169.06	2169.01
25	2.9000	2248.00	2249.53	2249.51
26	3.0000	2328.00	2330.16	2330.19

Table 10.1 BARGE 1 - Comparative tests

TEST BARGE 1				Ref.[15]	Analytic	CARENA	DRSWIN
No.	ro[t/m^3]	d_{AP}[m]	d_M[m]	d_{FP}[m]	Dep[t]	Dep[t]	Dep[t]
1	1.0000	0.4000	0.5000	0.4000	231.24	230.76	230.85
2	1.0000	0.6000	0.5000	0.6000	297.28	297.87	297.79
3	1.0000	0.5500	0.5000	0.5500	280.60	280.85	280.81
4	1.0000	2.2500	2.2000	2.2500	1242.13	1243.13	1243.08
5	1.0000	2.1500	2.2000	2.1500	1200.96	1200.11	1200.17
6a	1.0000	0.5500	0.5000	0.5500	280.60	280.85	280.81
6b	1.0000	2.1500	2.2000	2.1500	1200.96	1200.11	1200.17
				cargo[t]	920.36	919.26	919.36
7a	1.0000	0.7500	0.5000	0.2500	286.78	286.78	286.80
7b	1.0000	2.4500	2.2000	1.9500	1227.01	1227.01	1227.03
			cargo[t]		940.23	940.23	940.23
8a	1.0000	0.2500	0.5000	0.7500	244.00	244.00	244.01
8b	1.0000	1.9500	2.2000	2.4500	1220.00	1220.00	1220.00
				cargo[t]	976.00	976.00	975.99
9a	1.0000	0.5500	0.5500	0.6500	---	303.80	303.77
9b	1.0000	2.1500	2.2000	2.1000	---	1190.10	1190.21
				cargo[t]	---	886.30	886.44
10a	1.0000	0.5000	0.5500	0.6500	---	293.30	293.23
10b	1.0000	2.1000	2.2000	2.1000	---	1179.10	1179.21
				cargo[t]	---	885.80	885.98
11a	1.0000	0.5000	0.6000	0.6500	---	303.20	303.20
11b	1.0000	2.1000	2.2500	2.1000	---	1187.50	1187.67
				cargo[t]	---	884.30	884.47

Table 10.2 BARGE 2 - Comparative tests

TEST BARGE 2				Ref.[16]	Mean	CARENA	DRSWIN
No.	ro[t/m^3]	d_{AP}[m]	d_M[m]	d_{FP}[m]	Dep[t]	Dep[t]	Dep[t]
1a	1.0085	0.4425	0.6225	0.6525	---	415.74	418.22
1b	1.0085	2.3675	2.5125	2.4650	---	1892.43	1894.43
				cargo[t]	1467.50	1476.69	1476.22
2a	1.0100	0.5100	0.6825	0.7325	---	468.36	471.38
2b	1.0100	2.1950	2.4075	2.4525	---	1813.55	1815.91
				cargo[t]	1339.90	1345.19	1344.53
3a	1.0000	0.5150	0.6850	0.6250	452.30	444.65	446.54
3b	1.0000	2.2750	2.4100	2.2650	1775.40	1773.37	1774.33
				cargo[t]	1323.10	1328.72	1327.79
4a	1.0100	2.2350	2.3775	2.2175	1760.80	1759.22	1759.70
4b	1.0100	0.5450	0.7050	0.6300	467.30	464.44	466.34
				cargo[t]	1293.50	1294.78	1293.36
5a	1.0000	0.5150	0.6850	0.6250	452.30	444.65	446.54
5b	1.0000	2.2750	2.4100	2.2650	1775.40	1773.37	1774.33
				cargo[t]	1323.10	1328.72	1327.79
6a	1.0090	2.4675	2.5625	2.4775	1947.37	1938.55	1941.71
6b	1.0090	0.4500	0.6075	0.6300	427.90	408.98	412.58
				cargo[t]	1519.47	1529.57	1529.14
7a	1.0090	2.5575	2.7075	2.6375	2053.65	2042.41	2044.50
7b	1.0090	0.4350	0.6700	0.6975	456.55	434.76	436.65
				cargo[t]	1597.10	1607.65	1607.85
8a	1.0070	2.0675	2.1550	2.0875	1621.94	1615.83	1619.55
8b	1.0070	0.4525	0.6100	0.5975	420.22	403.45	406.43
				cargo[t]	1201.72	1212.38	1213.13
9a	1.0090	2.4725	2.5225	2.4050	1918.45	1911.96	1915.52
9b	1.0090	0.4450	0.6000	0.6375	426.66	406.86	410.78
				cargo[t]	1491.79	1505.10	1504.74
10a	1.0020	2.2615	2.3675	2.3100	1782.22	1773.21	1776.71
10b	1.0000	0.4575	0.6000	0.6450	427.79	408.31	412.62
				cargo[t]	1354.43	1364.90	1364.09
11a	1.0090	2.4675	2.5575	2.4775	1946.00	1937.32	1940.70
11b	1.0090	0.4500	0.6075	0.6300	427.90	408.98	412.58
				cargo[t]	1518.10	1528.34	1528.12
12a	1.0035	2.2175	2.3100	2.2650	1745.42	1737.22	1741.31
12b	1.0060	0.4450	0.6000	0.6325	424.15	404.70	408.52
				cargo[t]	1321.27	1332.52	1332.79
13a	1.0045	2.4000	2.4725	2.3850	1871.72	1864.13	1867.79
13b	1.0070	0.4600	0.6025	0.6100	423.32	405.94	409.62
				cargo[t]	1448.40	1458.19	1458.17
14a	1.0090	2.1050	2.1550	2.1350	1648.00	1641.84	1647.48
14b	1.0065	0.4525	0.6100	0.5975	420.00	403.25	406.23
				cargo[t]	1228.00	1238.59	1241.26
15a	1.0040	2.6300	2.7925	2.7425	2113.96	2101.95	2104.13
15b	1.0050	0.4275	0.6100	0.6350	422.64	402.39	405.43
				cargo[t]	1691.32	1699.56	1698.70
16a	1.0110	2.1075	2.2150	2.1100	1661.40	1655.06	1657.53
16b	1.0110	0.4400	0.6275	0.6250	430.00	411.43	413.90
				cargo[t]	1231.40	1243.63	1243.63
17a	1.0070	0.4525	0.6125	0.5875	418.35	402.26	404.98
17b	1.0070	1.9700	2.0975	2.0175	1561.52	1555.14	1557.63
				cargo[t]	1143.17	1152.88	1152.66
18a	1.0080	2.2900	2.4125	2.3725	1829.18	1819.20	1822.69
18b	1.0080	0.4325	0.6225	0.6550	433.07	412.33	415.35
				cargo[t]	1396.11	1406.87	1407.35
19a	1.0080	2.6550	2.7750	2.6575	2101.34	2091.76	2093.52
19b	1.0080	0.4525	0.6125	0.5875	418.76	402.66	405.38
				cargo[t]	1682.58	1689.10	1688.15
20a	1.0080	1.6150	1.7900	1.7725	1319.00	1313.53	1316.10
20b	1.0080	0.4325	0.5800	0.5800	403.83	386.35	389.78
				cargo[t]	915.17	927.18	926.33

5. CONCLUSIONS

A new softwares package has been developed for the numerical processing of barges DS - draught survey recorded data and transported cargo values computation.

The numerical results obtained by DRSWIN, DRSURVEY & DRCD softwares, section 4, are in a very good agreement with the analytical [15] and SDG [15],[16] results.

Besides the inclusion of the barge hull trim and deflection influence for the displacement and cargo computation, the results by DRSWIN, DRSURVEY & DRCD softwares are also function of the input hull shape lines and the DS - draught survey recorded data accuracy.

Further studies will be focused on the development of a barges' data base, so that the shipping companies will have a better accuracy for the DS - draught survey data processing and cargo computation.

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