MEC-E1004 Principles of Naval Architecture

Defining Hull Lines and Sectional Area Curve

Aalto University
School of Engineering

Defining the hull form in 2D

Tips before modelling

- This tutorial explain how to use the excel sheet in defining the hull lines and sectional area curves.
- By this stage the main dimensions of your ship should be defined.
- Frame spacing must be defined along Lpp (x-direction) into 10 frames.

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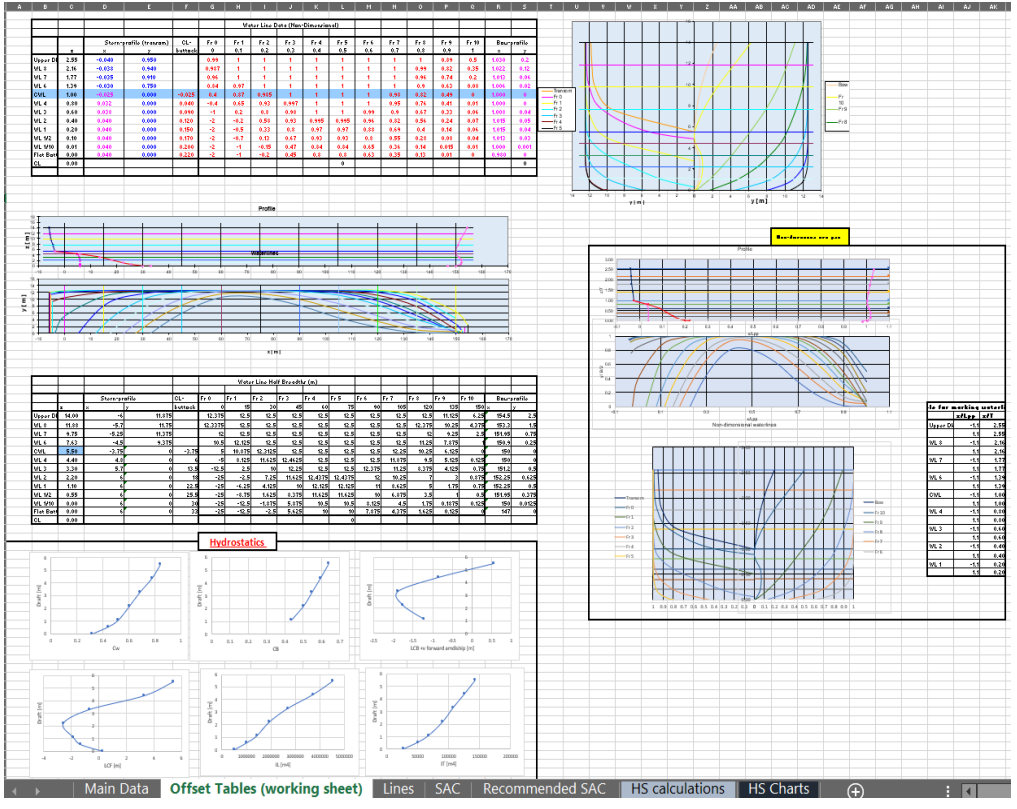
Input Main Data

- **The Vessel type, Lpp, B, T, D and Speed (V) need to be input first in the Main Data Sheet. These are coloured in red.**

Ship type:	Passenger Ferry, 2 propellers		
Loa	144,5	[m]	From lines
Lpp	135,0	[m]	Given data
Lwl	140,4	[m]	From lines
B	25,0	[m]	Given data
T	5,5	[m]	Given data
D	14,0	[m]	Given data
Displacement Volume (Vol):	11 965	[m3]	Hull + Skeg
Displacement Weight (Displ)	12 265	[ton]	1,025*Vol
Hull Volume to Upper Deck	39442	[m3]	
Speed (V):	19,0	[kn]	Given data
Froude Nr. (Fn):	0,26		

Working sheet

- **“Offset Tables (working sheet)” is the place you can amend the offset table and fair your lines plan.**
- **The charts of half breadth plan, profile, body plan, nondimensional lines plan and the hydrostatics will be updated while working on the offset table.**
- **The plots here should help in the fairing process. The smoothest the curves, the better the lines.**

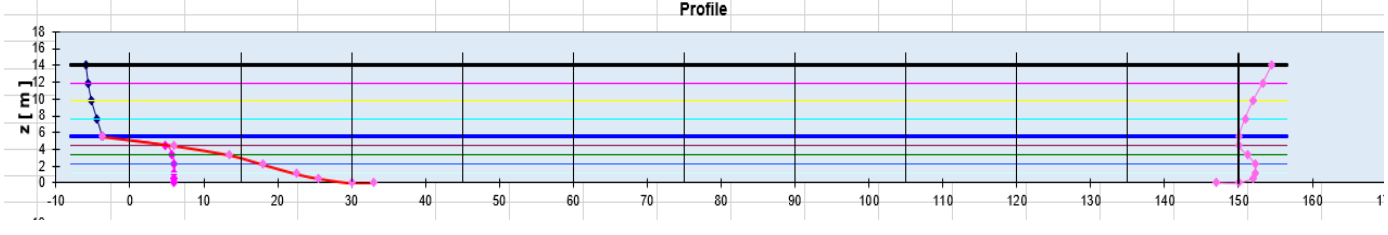


Defining Stern and Bow profile

- The default stern and bow profile in the excel are for a twin propeller passenger ferry.
- You should define your ship stern and bow profile in the Non-dimensional water line data table, in the “Offset Tables (working sheet)”. (marked in red)
- Trace the changes in the profile view to make sure you have fair stem and stern.
- The CL-buttock is needed if the hull lines are defined without a CL-skeg. This simplifies the aft hull lines for slender hull forms.
- The x coordinates are x/Lpp, y coordinates are y/(B/2) and z coordinates are z/T

Water Line Data (Non-Dimensional)

		Stern-profile		CL-buttock	Fr 0	Fr 1	Fr 2	Fr 3	Fr 4	Fr 5	Fr 6	Fr 7	Fr 8	Fr 9	Fr 10	Bow-profile	
	z	x	y		0	0,1	0,2	0,3	0,4	0,5	0,6	0,7	0,8	0,9	1	x	y
Upper Dk	2,55	-0,040	0,950		0,99	1	1	1	1	1	1	1	1	0,89	0,5	1,030	0,2
WL 8	2,16	-0,038	0,940		0,987	1	1	1	1	1	1	1	0,99	0,82	0,35	1,022	0,12
WL 7	1,77	-0,035	0,910		0,96	1	1	1	1	1	1	1	0,96	0,74	0,2	1,013	0,06
WL 6	1,39	-0,030	0,750		0,84	0,97	1	1	1	1	1	1	0,9	0,63	0,08	1,006	0,02
CWL	1,00	-0,025	0,000	-0,025	0,4	0,87	0,985	1	1	1	1	0,98	0,82	0,49	0	1,000	0
WL 4	0,80	0,032	0,000	0,040	-0,4	0,65	0,93	0,997	1	1	1	0,95	0,76	0,41	0,01	1,000	0
WL 3	0,60	0,038	0,000	0,090	-1	0,2	0,8	0,98	1	1	0,99	0,9	0,67	0,33	0,06	1,008	0,04
WL 2	0,40	0,040	0,000	0,120	-2	-0,2	0,58	0,93	0,995	0,995	0,96	0,82	0,56	0,24	0,07	1,015	0,05
WL 1	0,20	0,040	0,000	0,150	-2	-0,5	0,33	0,8	0,97	0,97	0,88	0,69	0,4	0,14	0,06	1,015	0,04
WL 1/2	0,10	0,040	0,000	0,170	-2	-0,7	0,13	0,67	0,93	0,93	0,8	0,55	0,28	0,08	0,04	1,013	0,03
WL 1/10	0,01	0,040	0,000	0,200	-2	-1	-0,15	0,47	0,84	0,84	0,65	0,36	0,14	0,015	0,01	1,000	0,001
Flat Bott	0,00	0,040	0,000	0,220	-2	-1	-0,2	0,45	0,8	0,8	0,63	0,35	0,13	0,01	0	0,980	0
CL	0,00									0							0



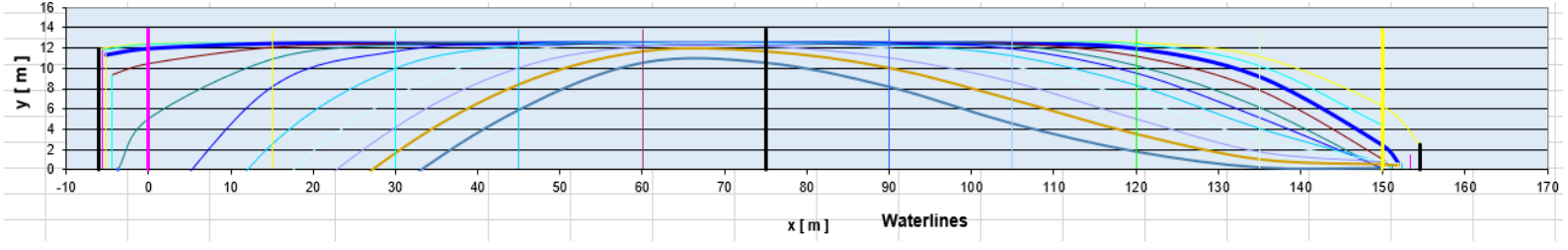
Defining the half breadths

- **Define the non-dimensional half breadths for each of the frames coinciding with the correct waterlines (y/(B/2)) where y are the half-breadths.(marked in red)**
- **These half breadths are used to plot the Non-dimensional waterline and Frame Section on the Form sheet.**

					Water Line Data (Non-Dimensional)												
		Stern-profile		CL-	Fr 0	Fr 1	Fr 2	Fr 3	Fr 4	Fr 5	Fr 6	Fr 7	Fr 8	Fr 9	Fr 10	Bow-profile	
	z	x	y	buttock	0	0,1	0,2	0,3	0,4	0,5	0,6	0,7	0,8	0,9	1	x	y
Upper Dk	2,55	-0,040	0,950		0,99	1	1	1	1	1	1	1	1	0,89	0,5	1,030	0,2
WL 8	2,16	-0,038	0,940		0,987	1	1	1	1	1	1	1	0,99	0,82	0,35	1,022	0,12
WL 7	1,77	-0,035	0,910		0,96	1	1	1	1	1	1	1	0,96	0,74	0,2	1,013	0,06
WL 6	1,39	-0,030	0,750		0,84	0,97	1	1	1	1	1	1	0,9	0,63	0,08	1,006	0,02
CWL	1,00	-0,025	0,000	-0,025	0,4	0,87	0,985	1	1	1	1	0,98	0,82	0,49	0	1,000	0
WL 4	0,80	0,032	0,000	0,040	-0,4	0,65	0,93	0,997	1	1	1	0,95	0,76	0,41	0,01	1,000	0
WL 3	0,60	0,038	0,000	0,090	-1	0,2	0,8	0,98	1	1	0,99	0,9	0,67	0,33	0,06	1,008	0,04
WL 2	0,40	0,040	0,000	0,120	-2	-0,2	0,58	0,93	0,995	0,995	0,96	0,82	0,56	0,24	0,07	1,015	0,05
WL 1	0,20	0,040	0,000	0,150	-2	-0,5	0,33	0,8	0,97	0,97	0,88	0,69	0,4	0,14	0,06	1,015	0,04
WL 1/2	0,10	0,040	0,000	0,170	-2	-0,7	0,13	0,67	0,93	0,93	0,8	0,55	0,28	0,08	0,04	1,013	0,03
WL 1/10	0,01	0,040	0,000	0,200	-2	-1	-0,15	0,47	0,84	0,84	0,65	0,36	0,14	0,015	0,01	1,000	0,001
Flat Bott	0,00	0,040	0,000	0,220	-2	-1	-0,2	0,45	0,8	0,8	0,63	0,35	0,13	0,01	0	0,980	0
CL	0,00									0							0

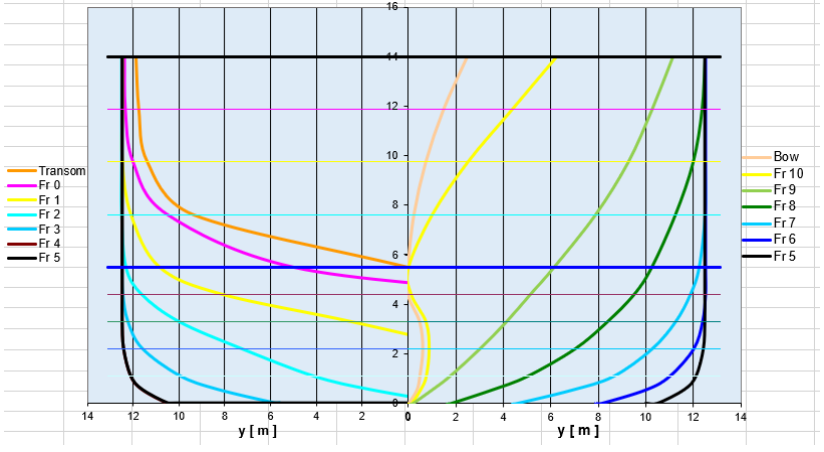
Defining the half breadths

- **The waterline curves are defined by taking each frame into consideration.**
- **The fairness of the waterlines must be checked**



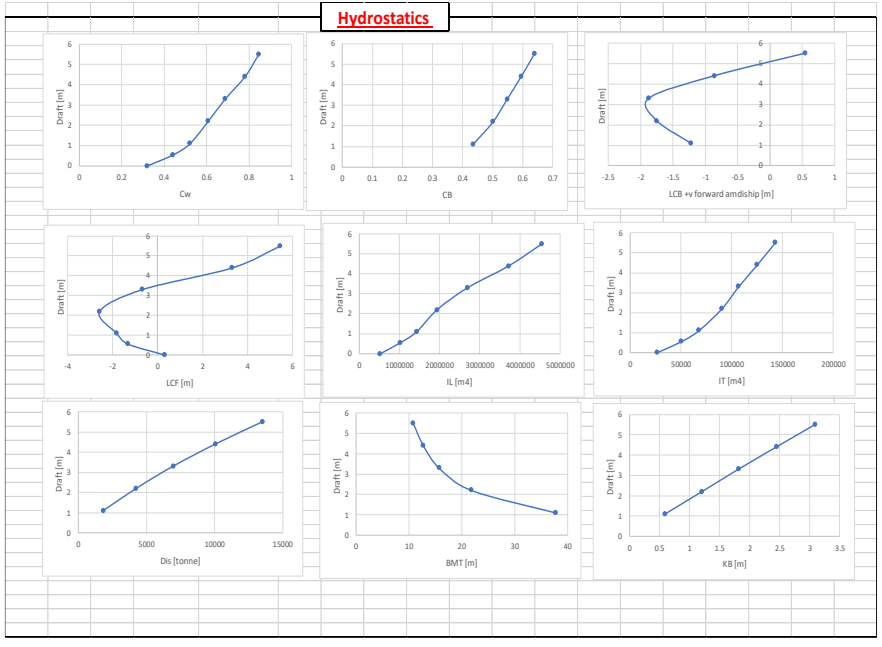
Defining the half breadths

- **The frame sections are defined by taking each frame into consideration.**
- **The fairness of the frame section must be checked.**



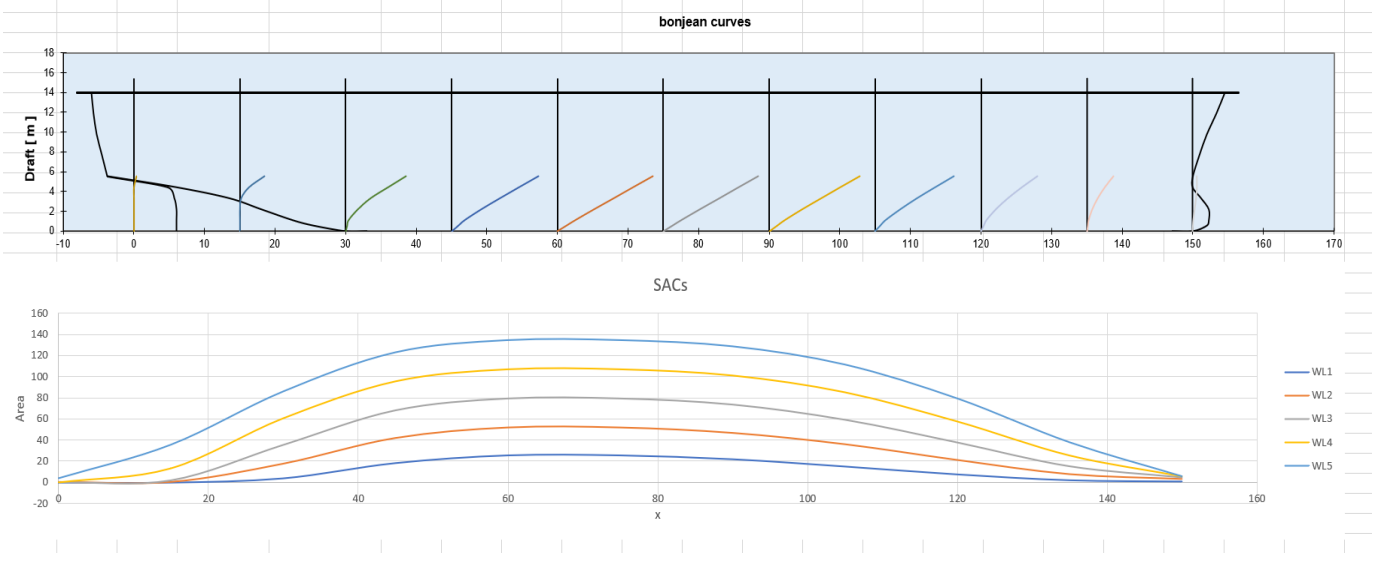
Hydrostatics

- The hydrostatics curves (Draft vs LCB, C_b, C_w, LCF, I_L, I_T, KB, BM_T, Dispalacement) are linked to the offset table.
- They should be fair enough and reliable.
- Check the draft or dispalcement of the ballast and fully loaded conditions (using the draft vs displacement plot) and make sure they are appropriate.



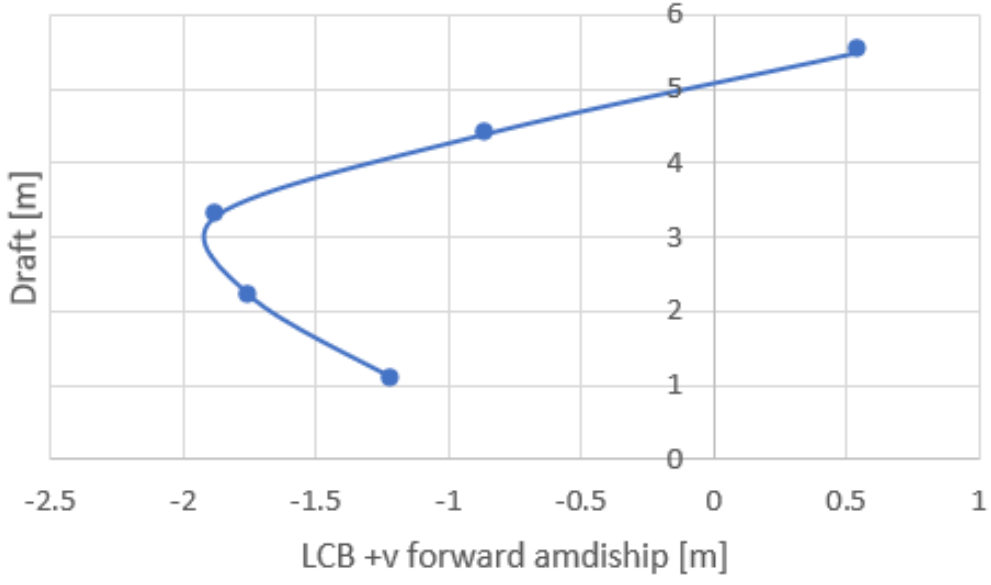
Hydrostatics

- **The section area curves and the Bonjean curves are plotted in “Offset Tables (working sheet)”, the derivations in “HS calculations” sheet.**
- **The section area curves at each water line and the Bonjean curves at each station reflect the change in the area throughout the ship length and draft respectively.**



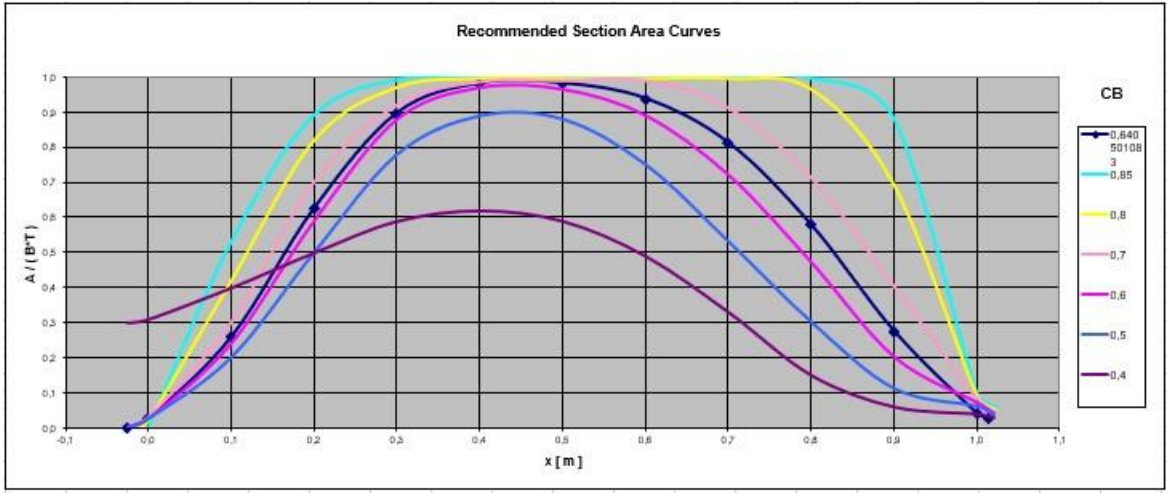
Sectional Area Curves

- **Check the C_B and LCB in the plots.**
- **These values must be in the required range for the type of ship being designed.**



Sectional Area Curves

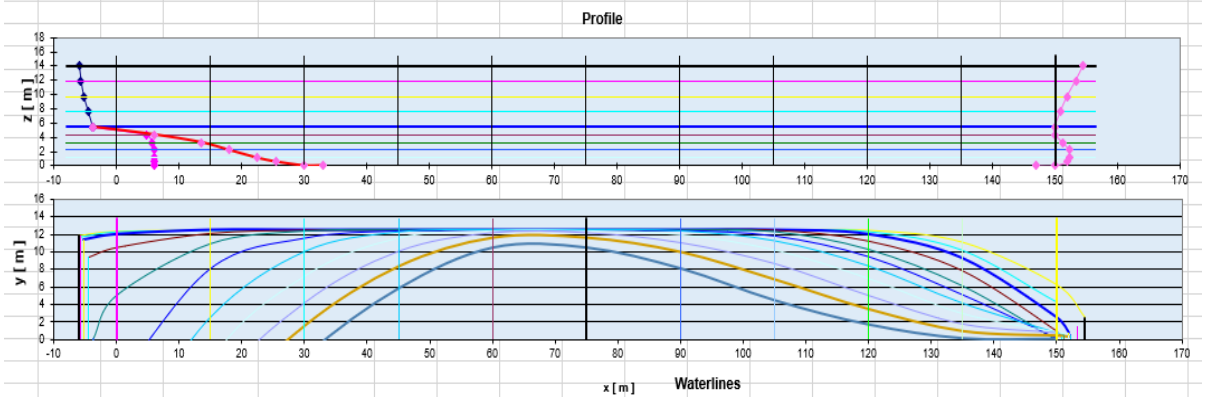
- **The SAC curve plotted must be checked with the recommended curves, refer to “Recommended SAC” sheet.**
- **If the SAC at DWL is not appropriate, changes must be made to the Offset Tables sheet to have the fair form.**



Hull Lines

- **After the SAC is correct, the offset tables and the plots of lines plan and hydrostatics need to be checked again. They are plotted by the dimensional table which depends on the Non-dimensional table. The axes should be adjusted accordingly.**

					Water Line half breadths (m)												
		Stern-profile		CL-	Fr 0	Fr 1	Fr 2	Fr 3	Fr 4	Fr 5	Fr 6	Fr 7	Fr 8	Fr 9	Fr 10	Bau-profile	
	x	x	y	buttock	0	13,5	27	40,5	54	67,5	81	94,5	108	121,5	135	x	y
Upper Dk	14,00	-5,4	11,875	0	12,375	12,5	12,5	12,5	12,5	12,5	12,5	12,5	12,5	11,125	6,25	139,05	2,5
WL 8	11,875	-5,13	11,75	0	12,3375	12,5	12,5	12,5	12,5	12,5	12,5	12,5	12,375	10,25	4,375	137,97	1,5
WL 7	9,75	-4,725	11,375	0	12	12,5	12,5	12,5	12,5	12,5	12,5	12,5	12	9,25	2,5	136,755	0,75
WL 6	7,625	-4,05	9,375	0	10,5	12,125	12,5	12,5	12,5	12,5	12,5	12,5	11,25	7,875	1	135,81	0,25
CWL	5,5	-3,375	0	-3,375	5	10,875	12,3125	12,5	12,5	12,5	12,5	12,25	10,25	6,125	0	135	0
WL 4	4,4	4,32	0	5,4	-5	8,125	11,625	12,4625	12,5	12,5	12,5	11,875	9,5	5,125	0,125	135	0
WL 3	3,3	5,13	0	12,15	-12,5	2,5	10	12,25	12,5	12,5	12,375	11,25	8,375	4,125	0,75	136,08	0,5
WL 2	2,2	5,4	0	16,2	-25	-2,5	7,25	11,625	12,4375	12,4375	12	10,25	7	3	0,875	137,025	0,625
WL 1	1,1	5,4	0	20,25	-25	-6,25	4,125	10	12,125	12,125	11	8,625	5	1,75	0,75	137,025	0,5
WL 1/2	0,55	5,4	0	22,95	-25	-8,75	1,625	8,375	11,625	11,625	10	6,875	3,5	1	0,5	136,755	0,375
WL 1/10	0	5,4	0	27	-25	-12,5	-1,875	5,875	10,5	10,5	8,125	4,5	1,75	0,1875	0,125	135	0,0125
Flat Batta	0	5,4	0	29,7	-25	-12,5	-2,5	5,625	10	10	7,875	4,375	1,625	0,125	0	132,3	0
CL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0



Hydrostatics calculations

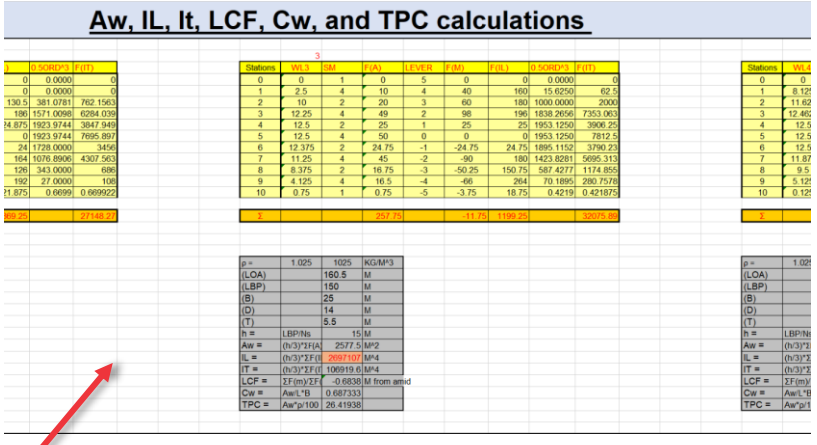
- **“HS calculations” sheet is used for calculating the hydrostatics of the vessel and plotting the hydrostatics curves as a function of ship draft.**
- **You should not edit any data in this sheet**
- **The main particulars and offset table in this sheet are linked with the dimensions you entered previously**

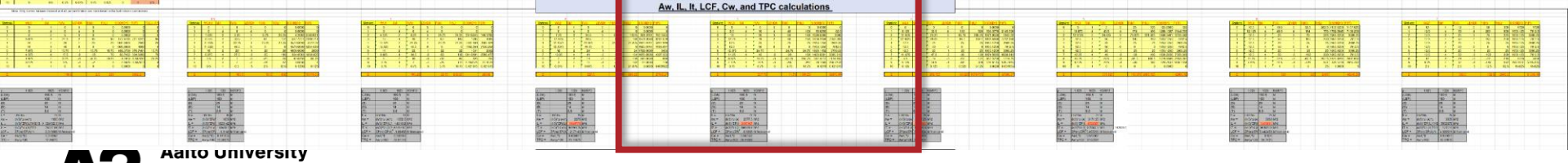
Length overall (LOA)	160.5	m
Length between perpendiculars (LBP)	150	m
Breadth molded (B)	25	m
Depth molded to main deck (D)	14	m
Draft to load waterline (T)	5.5	m

	Waterlines (Half breadths)								
stations	0	0.5	1	2	3	4	5 WL	6	7
0	0	0	0	0	0	0	5	10.5	12
1	0	0	0	0	2.5	8.125	10.875	12.125	12.5
2	0	1.625	4.125	7.25	10	11.625	12.3125	12.5	12.5
3	5.625	8.375	10	11.625	12.25	12.4625	12.5	12.5	12.5
4	10	11.625	12.125	12.4375	12.5	12.5	12.5	12.5	12.5
5	10	11.625	12.125	12.4375	12.5	12.5	12.5	12.5	12.5
6	7.875	10	11	12	12.375	12.5	12.5	12.5	12.5
7	4.375	6.875	8.625	10.25	11.25	11.875	12.25	12.5	12.5
8	1.625	3.5	5	7	8.375	9.5	10.25	11.25	12
9	0.125	1	1.75	3	4.125	5.125	6.125	7.875	9.25
10	0	0.5	0.75	0.875	0.75	0.125	0	1	2.5

Hydrostatics calculations

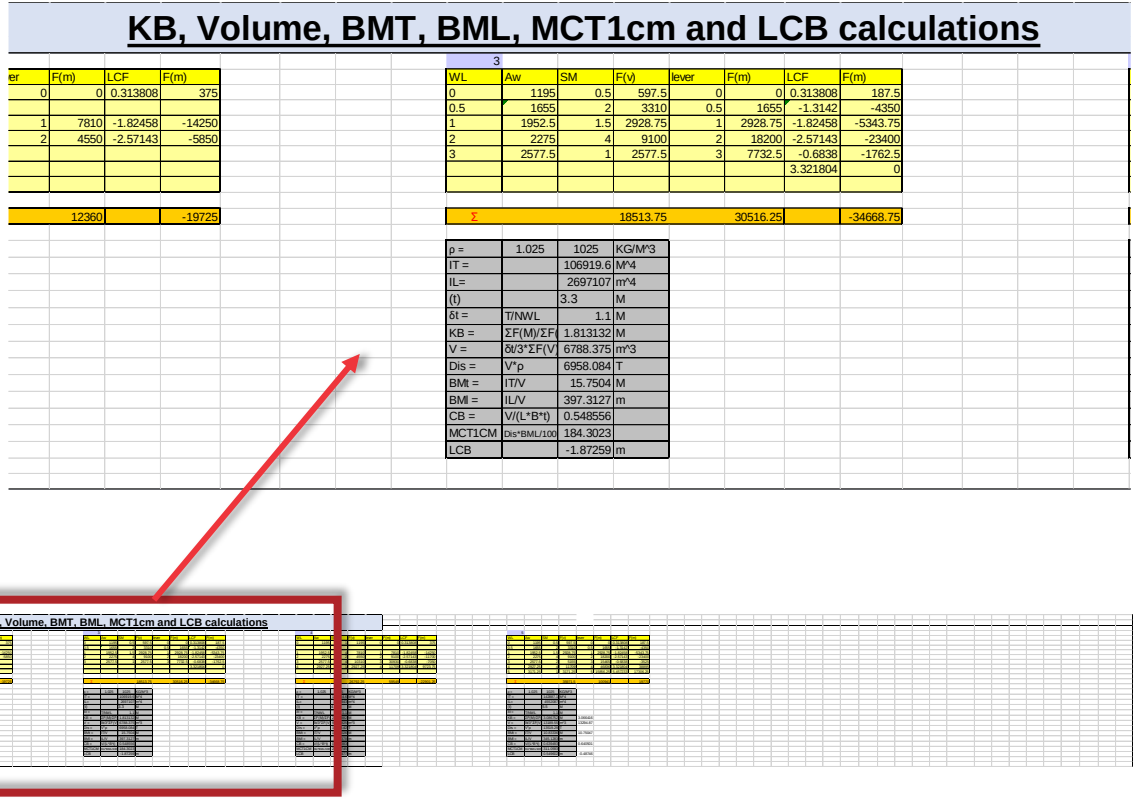
- **Here we integrate the half breadth coordinates using Simpson 1/3 rule to obtain the area of water lines, KB, I_L, I_T, LCF and TPC. at each water line.**





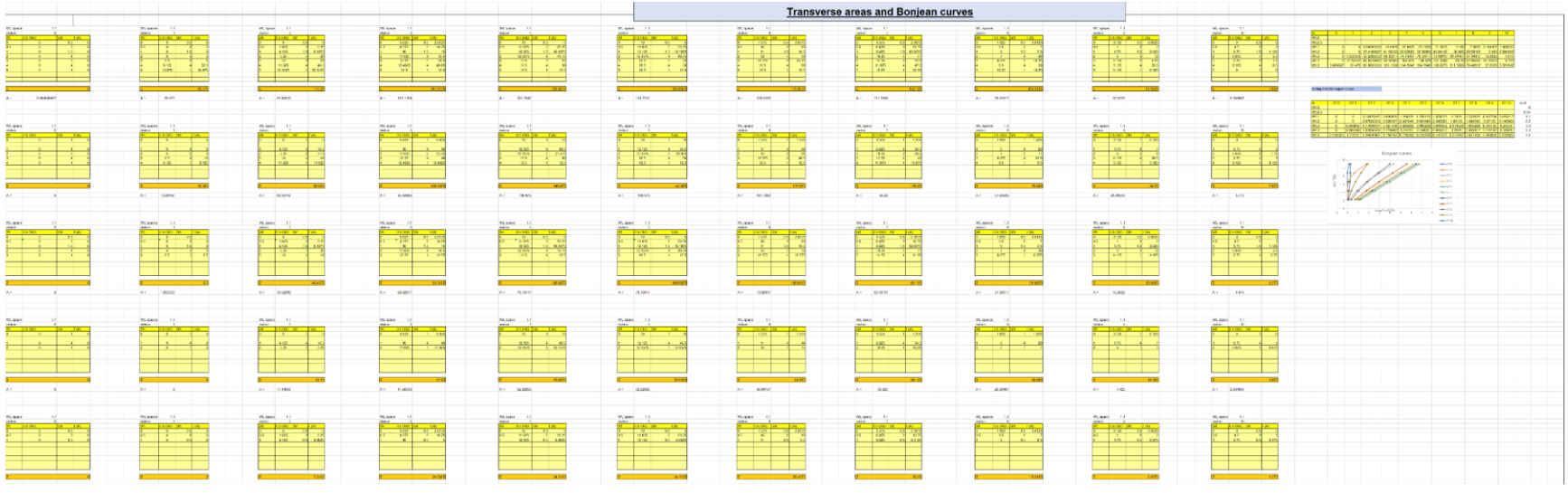
Hydrostatics calculations

- Here we integrate the water line areas using Simpson 1/3 rule to obtain the ship displacement, BM_T, BM_L, C_B, MCT_{1cm} and LCB at each draft.



Bonjean curves

- **This part aims to define the transverse areas at each station and draft. This data will be used to draw the Bonjean curves.**



Bonjean curves

- **The table contains the transverse area at each station and water line**

A	0	1	2	3	4	5	6	7	8	9	10
WL0	.	.	.	.	.	.	.	.	.	.	.
WL0.5	.	.	.	.	.	.	.	.	.	.	.
WL1	0	0	3.89583333	18.0125	25.1625	25.1625	21.5875	14.85	7.5625	2.154167	1.008333
WL2	0	0	17.4166667	41.98333	52.02083	52.02083	46.84167	36.025	20.99167	7.425	2.841667
WL3	0	1.833333	35.5208333	68.42917	79.70417	79.70417	73.92917	59.49167	37.90417	15.2625	4.675
WL4	0	13.29167	60.5916667	95.58083	106.975	106.975	101.1083	85.25	57.65833	25.48333	5.775
WL5	3.666667	35.475	85.9833333	123.1358	134.7042	134.7042	128.8375	111.5583	79.42917	37.8125	5.591667

- **The table above should be scaled to draw the Bonjean curves on the profile plot.**
- **Enter the appropriate scale factor and check the Bonjean curves plot**

Scale factor	10	Enter the scale factor									
A	ST 0	ST 1	ST 2	ST 3	ST 4	ST 5	ST 6	ST 7	ST 8	ST 9	ST 10
WL0	0	0	0	0	0	0	0	0	0	0	0
WL0.5	0	0	0.19479167	0.900625	1.258125	1.258125	1.079375	0.7425	0.378125	0.107708	0.050417
WL1	0	0	0.38958333	1.80125	2.51625	2.51625	2.15875	1.485	0.75625	0.215417	0.100833
WL2	0	0	1.74166667	4.198333	5.202083	5.202083	4.684167	3.6025	2.099167	0.7425	0.284167
WL3	0	0.183333	3.55208333	6.842917	7.970417	7.970417	7.392917	5.949167	3.790417	1.52625	0.4675
WL4	0	1.329167	6.05916667	9.558083	10.6975	10.6975	10.11083	8.525	5.765833	2.548333	0.5775
WL5	0.366667	3.5475	8.59833333	12.31358	13.47042	13.47042	12.88375	11.15583	7.942917	3.78125	0.559167

Bonjean curves

- **The scaled transverse areas (actual value /scale factor) are used to plot the Bonjean curves.**
- **The actual values are used to plot the SACs at each waterline.**