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Abstract/Summary:

Ship's General Arrangement Autocad drawing was converted into digital entity along with an automated csv output file which was then fed into a Web App. This has innovated the process of excel based manual Marine HVAC computation & optimisation process into an automatic Web App based results and drastically improved into few days effort from a fortnight required activity

Keywords: HVAC Digitalisation, Optimisation, Marine Acoustics, Interactive HVAC Web App

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Background: HVAC Computation Process when submitting to Technical Bid Proposals was scrutinized with respect to time consumed and extreme necessity was felt to meet stringent timelines while being technically competitive

Intent: To digitalise Ship General Arrangement (GA) Autocad drawing, automate manual pick up of compartment dimensions, generate csv file which in-turn was fed as input to Interactive HVAC Web App for results from background HVAC computations. Further Optimisation of HVAC Load by way of application of Fire, Thermal & Acoustic Insulation

Introduction:

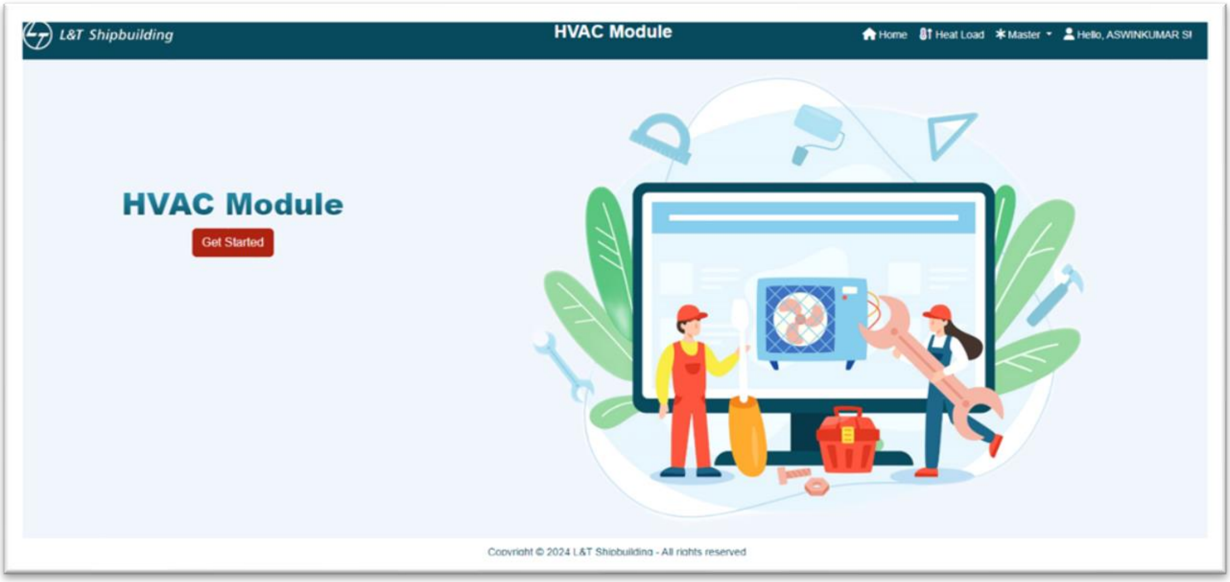
Ships are a system of systems and they are non-prototype based products wherein the exact Bill of Materials (BOM) & binding data emerges as the construction is concurrently progressing. Based on the binding data and the general arrangement of the Ship, we need to estimate capacity of the Air conditioning plant. Heat load calculation is a process of determining the capacity of the Air conditioning plant, Air Handling units and its respective items serving in the system. This calculation plays vital role in designing of the HVAC system. In L&T Shipbuilding we were carrying out heat load calculation for all the new building, Refit and bidding project (RFP & RFI) using semi automation excel sheet. This sheet was developed based on Naval Engineering standards and ISO standards.

Typically, for a medium range warship of 110 m, with 250 personnel on-board, would require about 15 working days to perform one round of HVAC Load Computations post preparation of the respective Ship's GA, which in turn is time taking. The extent of manual effort is considerable in picking up dimensions from the Autocad drawing, liable for creep of errors, to perform calculations in excel. This leads to rough estimation with margins making the effort, less competitive and varies basing on experience profile of the task performer

<u>Digitalisation:</u>

Currently we have digitalized the process of HVAC heat load calculation by developing a web Application for the same. Through this we have achieved complete digitalization of the process and hence HVAC heat load calculation is now process driven and many manual activities have been automated like fetching Compartment details and Insulation details from AutoCAD.

Program scripts are used to automate the fetching of dimensions from the Ship's General Arrangement which acts as an input to the web application, thereby reducing the manual intervention & resulting in increased productivity and efficiency.



The complex task of digitalization & automation was split into smaller tasks before being integrated in order to map the task software coding requirements while inherently embedding the skills associated for optimised results. The Algorithm and the process of defining digital form of autocad GA and then automating manual process was first applied on a 25T Tug GA drawing with success while it identified limitations of the process software. Then the coding requirements was again was split into smaller algorithms

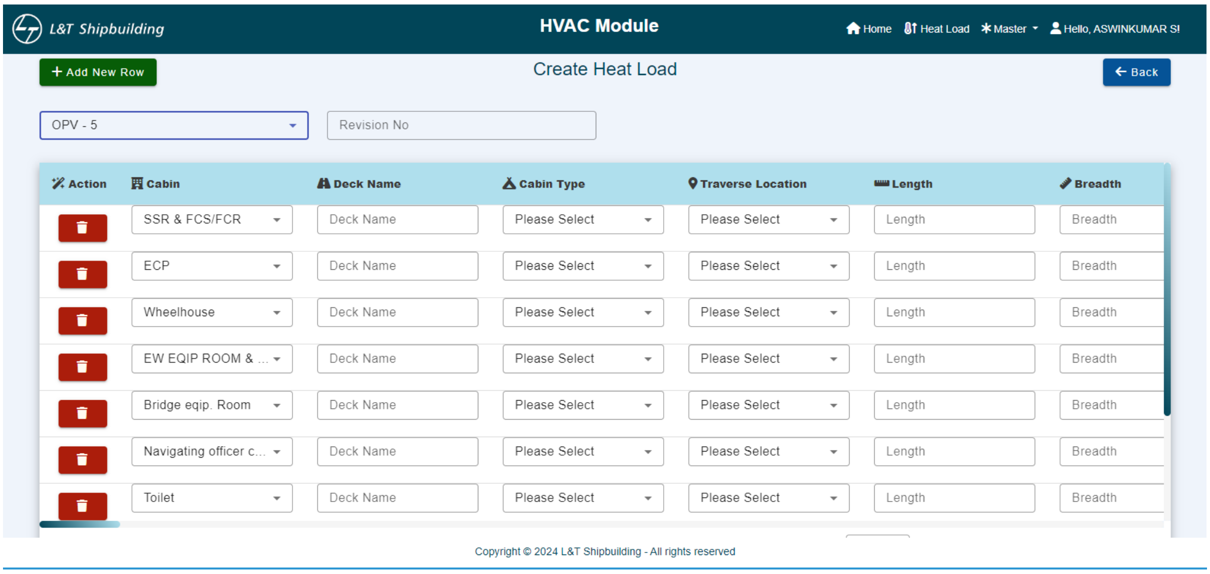


Figure-1: Partial Extract of Input Autocad GA

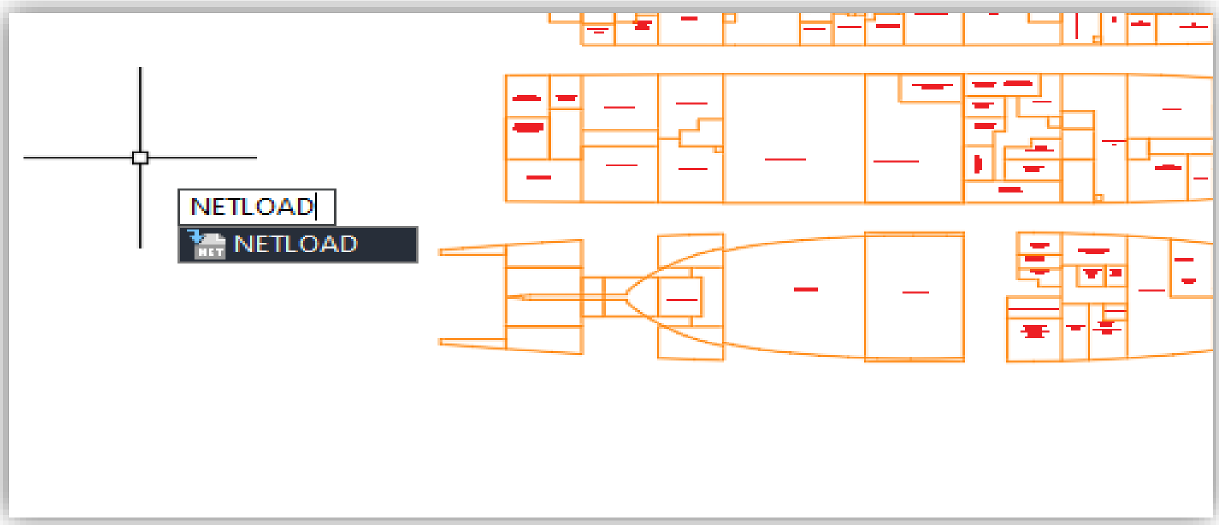
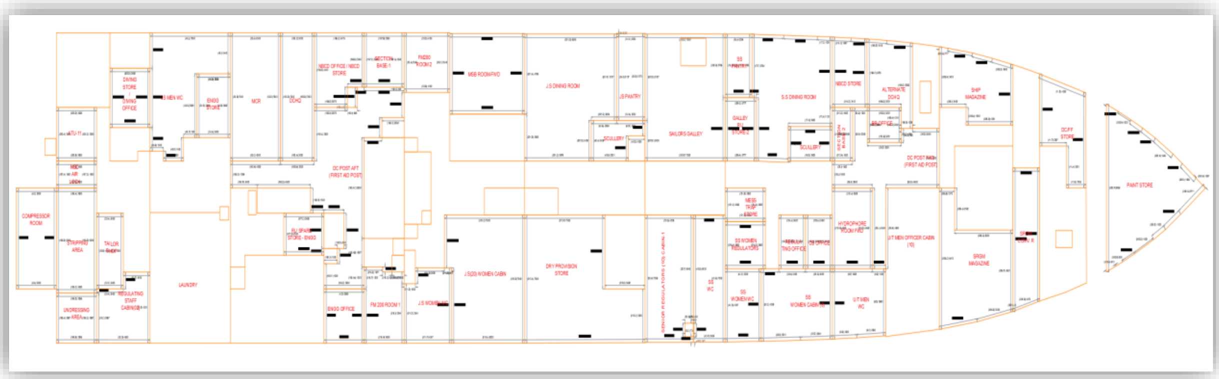


Figure -2 : Typical Output of Automated Dimensions in white colour:



Validation of Digitalisation: The application results on 25 Tug General Arrangement drawing was scrutinized by comparing manual lifting of dimensions as a test case. Initially errors cropped up at the compartment corners with certain errors because of it picking up the 3D references. Then the requirement to have intersecting corners was resolved by intervention of compartment wise definition which is also coded to be automatic and resides in a separate layer within the digital entity of the GA. Thus finally the GA was automatically populating dimensions and converting into input data csv file

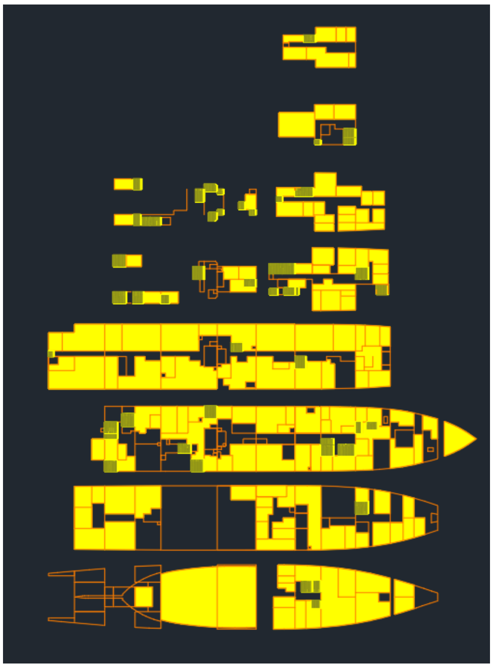
Scaling to Actual Digital model: Then the methodology was scaled to apply in-house on a typical about 100m Warship GA autocad drawing. Then it yielded 100% successful results which were extensively manual verified.

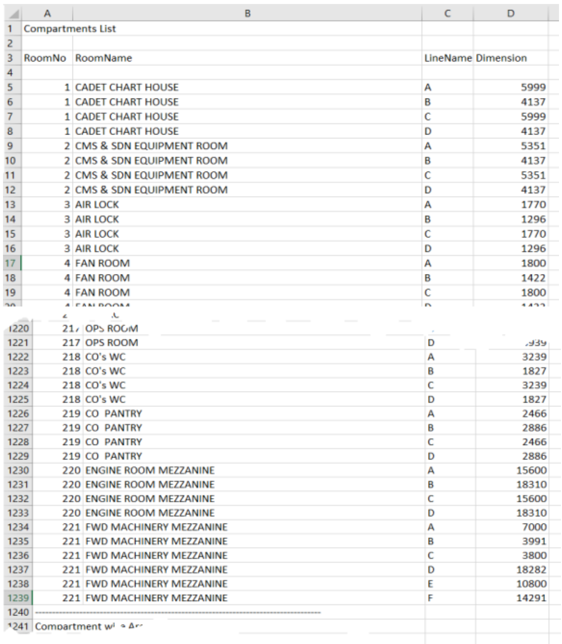
Results: (a) Digitalisation & Automation images are presented below

Figure-3 below : Compartment Identification

Figure-4 : Exported CSV Data

A handy csv file which can be given as input to Web app is observed to be 100% error free





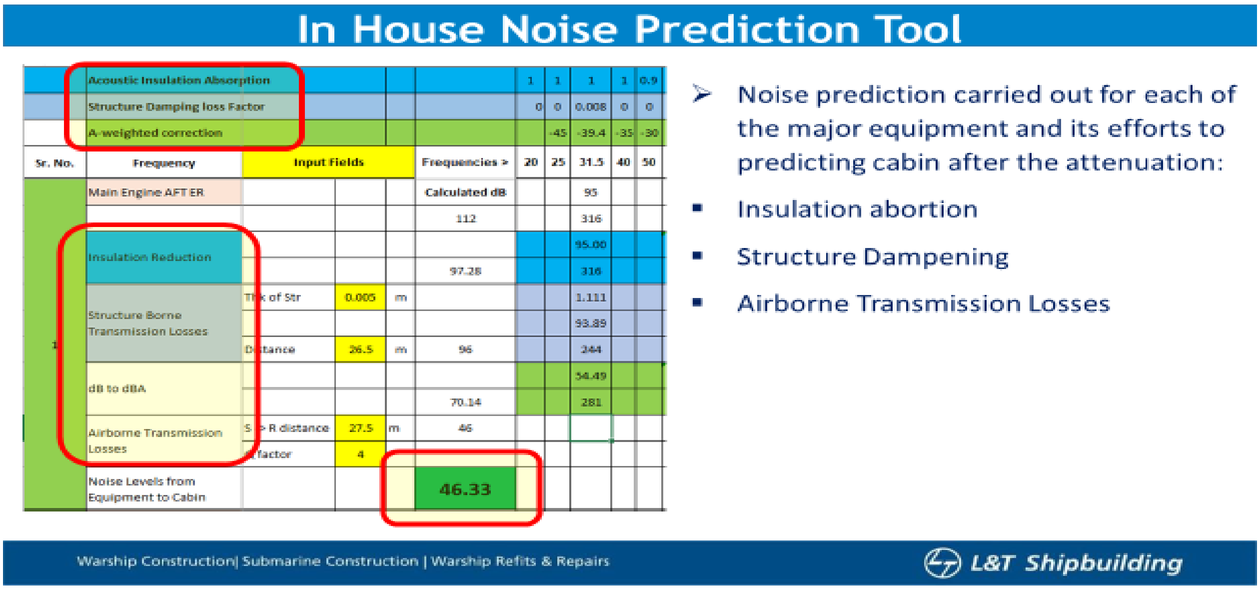
	A	B	C	D
1	Compartments List			
2				
3	RoomNo	RoomName	LineName	Dimension
4				
5	1	CADET CHART HOUSE	A	5999
6	1	CADET CHART HOUSE	B	4137
7	1	CADET CHART HOUSE	C	5999
8	1	CADET CHART HOUSE	D	4137
9	2	CMS & SDN EQUIPMENT ROOM	A	5351
10	2	CMS & SDN EQUIPMENT ROOM	B	4137
11	2	CMS & SDN EQUIPMENT ROOM	C	5351
12	2	CMS & SDN EQUIPMENT ROOM	D	4137
13	3	AIR LOCK	A	1770
14	3	AIR LOCK	B	1296
15	3	AIR LOCK	C	1770
16	3	AIR LOCK	D	1296
17	4	FAN ROOM	A	1800
18	4	FAN ROOM	B	1422
19	4	FAN ROOM	C	1800
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1220	[illegible]	OPS ROOM	[illegible]	[illegible]
1221	217	OPS ROOM	D	[illegible]
1222	218	CO's WC	A	3239
1223	218	CO's WC	B	1827
1224	218	CO's WC	C	3239
1225	218	CO's WC	D	1827
1226	219	CO PANTRY	A	2466
1227	219	CO PANTRY	B	2886
1228	219	CO PANTRY	C	2466
1229	219	CO PANTRY	D	2886
1230	220	ENGINE ROOM MEZZANINE	A	15600
1231	220	ENGINE ROOM MEZZANINE	B	18310
1232	220	ENGINE ROOM MEZZANINE	C	15600
1233	220	ENGINE ROOM MEZZANINE	D	18310
1234	221	FWD MACHINERY MEZZANINE	A	7000
1235	221	FWD MACHINERY MEZZANINE	B	3991
1236	221	FWD MACHINERY MEZZANINE	C	3800
1237	221	FWD MACHINERY MEZZANINE	D	18282
1238	221	FWD MACHINERY MEZZANINE	E	10800
1239	221	FWD MACHINERY MEZZANINE	F	14291
1240	---			
1241	Compartment w[illegible]			

Optimisation of HVAC Load through Addition of Fire, Thermal & Acoustic Insulation to boundaries

Boundaries of each of the compartments are defined to have Fire insulation in accordance with Class/Statutory Guidelines. Next Compartment boundaries are populated with Thermal insulation. In this, careful addition of thermal insulation, at exposed areas, at likely condensation areas, is done. All of above telescopically reduces HVAC load.

Then, a detailed Noise levels prediction on-board ship to meet the habitability demand of the compartment and the crew comfort is done using In-house Noise Prediction tool based on SNAME & ABS methodology.

The process involves each of the major equipment and its contribution to actual cabin noise after taking into account the attenuation due to Insulation, Structure borne transmission loss, Dampening factors and Transmission Loss

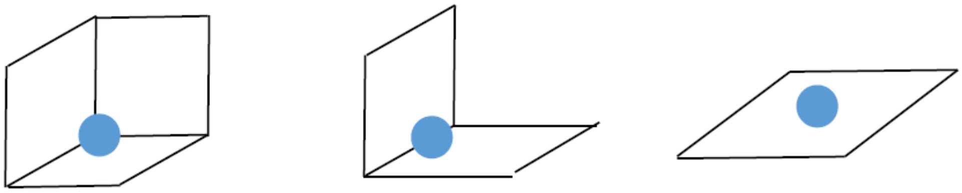


Airborne Sound Transmission Loss of Typical Ship and Offshore Unit Panels *(1 April 2019)*

Material	*Thickness mm*	*Octave Band Center Frequency, Hz*								
		31.5	*63*	*125*	*250*	*500*	*1k*	*2k*	*4k*	*8k*
Steel	6	16	22	26	31	36	40	37	42	51
Aluminum	6	7	13	19	25	28	34	30	32	42
Thermal insulation board	25	0	0	0	0	2	9	18	27	35
Fiberglass board	25	0	0	0	0	0	2	4	7	11

As shown in Appendix 1, Figure 1, for a source located in the center of the source room, Q is 2. For a source located against to a bulkhead, Q is 4. For a source located in the corner of the source room, Q is 8.

FIGURE 1
Directivity Factors Q



Q=8 Q=4 Q=2

$$L_p = L_W - 20\log r + 10\log[Q] - 11 \quad \text{dB} \qquad (r \text{ in m})$$

where

L_p = sound pressure level at receiver point, in dB

L_W = sound power level of the source, in dB

r = distance between the acoustic center of the noise source and the receiver, in m (ft)

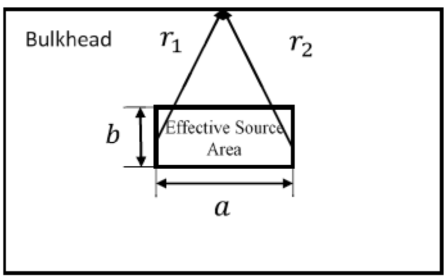
$$L_{\Sigma} = 10 \cdot \log_{10}\left(10^{\frac{L_1}{10}} + 10^{\frac{L_2}{10}} + \cdots + 10^{\frac{L_n}{10}}\right) \text{ dB}$$

Combining of Decibels of each of the Equipment

Sl.no	Major Equipment	dBA	Antilog
2	ME Aft ER	46.33	42953.64268
3	Gear Box AFT ER	48.41	69357.85717
4	DG AFT ER -1	47.56	56954.97011
5	DG AFT ER -2	44.55	28477.48506
6	ME FWD ER	56.57	454076.5817
7	Gear Box FWD ER	55.93	391343.9741
8	DG FWD ER -1	56.52	448708.2544
9	DG FWD ER -2	56.52	448708.2544
10	Propeller -1	44.20	26330.23743
11	Propeller -2	44.20	26330.23743
12	Fire Pump Fwd ER	26.28	424.2319177
13	Fire Pump Aux	37.28	5349.889664
14	ER Supply Fan -1	36.85	4840.863465
15	ER Supply Fan -2	36.85	4840.863465
16	ER Supply Fan -3	36.85	4840.863465
17	ER Supply Fan -4	36.85	4840.863465
18	ATU nearby	43.46	22203.52767
19	AC Plant Fwd ER	35.63	3653.827392
20	AC Plant Aux	42.66	18430.20572
21	AC CW/SW Pump Fwd ER	25.18	329.9183435
22	AC CW/SW Pump Aux	31.06	1277.38015
23	Ref Plant	36.05	4029.18304
			2068303.112
			63.156
			63.156 dBA

Comput

Source Room Layout



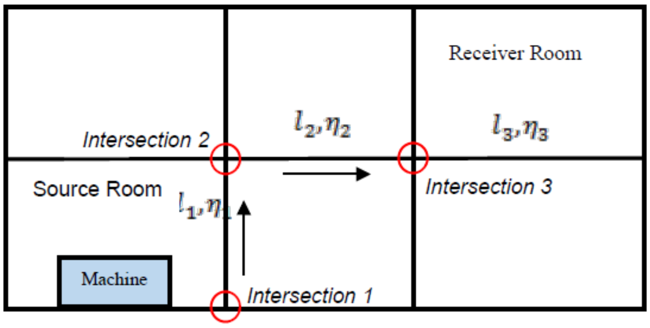


FIGURE 1
Directivity Factors Q

$$TF_{path} = \Delta L_a + \Delta L_d + TL_{inter} \quad \text{dB}$$

where

ΔL_a = transmission loss in the source room, in dB

ΔL_d = transmission loss caused by structure damping, in dB

TL_{inter} = transmission loss caused by intersections, in dB

$$L_p = L_W - 20\log r + 10\log[Q] - 11 \quad \text{dB} \qquad (r \text{ in m})$$

where

L_p = sound pressure level at receiver point, in dB

L_W = sound power level of the source, in dB

r = distance between the acoustic center of the noise source and the receiver, in m (ft)

Q = directivity factor of the source [1]

Results: Test cases of Optimisation results yielded 10% to 15% optimisation basing on the various insulation considerations above. The results compared successfully with earlier computations which were using excel tool when verified on two projects

It is concluded that :

(a) A quick computation Web App with csv file input, Autocad digitalised entity, and automation of manual effort innovate a time efficient solution and becomes handy tool during Bid stage

(b) During contract operation stage, optimisation of HVAC Load in accordance with provisions of Standards, present an optimised and competitive bidding process

References:

a) SNAME Guidelines
b) ABS Guide on Noise