Master Thesis in Marine Technology 2023

Deep sea mining vessel configuration study

NTNU

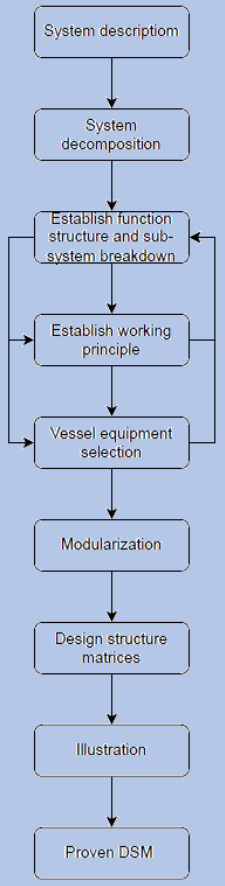
Kunnskap for en bedre verden

Background

The world is in a situation where green technologies and environmentally friendly development are crucial for the existence of the ecosystems as we know them. A considerable part of this technology development is based on rare earth elements (REE) and minerals. Until now, the only sources we have been able to mine have been on shore. These mines will eventually run out and there is not enough raw material on shore to sustain tomorrow's development. This is why we need to look for new places and ways of mining. The natural way forward is to utilize the opportunity of deep sea mining. Considerable amounts of REE have been discovered on the seabed in numerous locations. According to estimates, there are approximately 600 million tonnes of seafloor massive sulfides which contain 30 million tonnes of copper and zinc globally. All of these are found in the immediate vicinity of oceanic plate boundaries. To be able to mine these resources we need to develop specialized deep sea mining vessels. These vessels have to be both economical and environmentally sustainable.

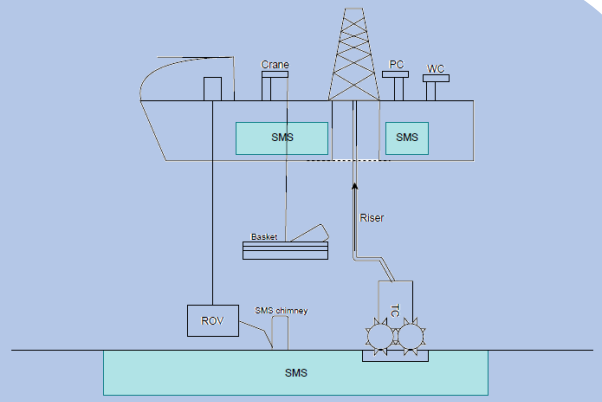
Approach

First, the function structure, on a basis from the system decomposition, with all its sub-functions is established. Then the working principles are needed. These two sections will together prove that the suggested way of conducting the mining is plausible. When this is established, the specialized vessel equipment selection is done. The equipment chosen is believed to be best suitable to accomplish the goal described in the main function - *transport SMS ore from the seabed to the surface*. While the selection is ongoing, the function structure and working principle are updated. When the needed equipment is chosen, the modularization is done. This is done with regard to need, function, and form. The next step is to make the design structure matrix. The matrix combines all components and the modules as well as described their dependencies. The DSM is then evaluated against the requirements for a successful DSM. Finally, when all dependencies are shown in the DSM.



Design structure matrix

For the making of a design structure matrix, one starts with the system boundaries. This is done to limit the scope of the system to be described. The system boundaries are limited to the deep sea mining vessel, the riser system, and the mining equipment located on the seabed. When the system boundaries are set, the individual components need to be identified. The focus of the DSM is not on all the minor sub-systems, but the major components. To be able to identify the equipment needed, a system decomposition was done. This is done to get a detailed insight into the tasks and functions that each system or component fulfills.

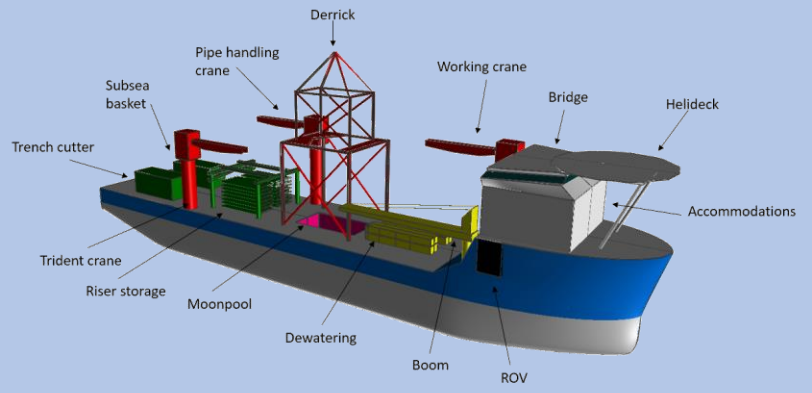


Components	NR.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38
Derrick	1	1		5	3	3	3			5									5														1			5	5		
Trident Crane	2		2				4	5			2	1							5	3																			
Pipe Handling Crane	3	5		3			5			5									5																			3	5		
Working Crane	4	3			4	5	5				5	2							5																					
Outside Work Area	5	3			5	5	5	3		4	4																													4	
Equipment Storage	6	3	4	5	5	5	6	5		5	5																													5	
Trench Cutter	7		5			3	5	7	5	5					2			5	5																			2		
Seabed Slurry Lift System	8							5	8	5					3			5																					4		
Riser	9	5		5		4	5	5	5	9									5																				4		5	4
Subsea Basket	10		2		4	5	5				10	5																													
ROV	11		1		2					5	11	5	5	5					5	4																				
ROV Hangar	12										5	12	5	5																										
Launch and Recovery system	13										5	5	13	5					5	5																				
Pilots Control Room	14										5	5	5	14					5																					
Cargo Hold	15						2	3							15	5																								
Cargo Hatches	16														5	16		5																						
Propulsion Power	17																	17		5												5						5		
Auxiliary Power	18	5	5	5	5		5	5		5		5	5		5			18		5	5	5	5	5	5					5		5	5	5		5	5		
Dynamic Positioning	19		3				5		5		4		5					5	19						5	5					2								
Cabins	20																	5		20	4	4	4	4															
Mess	21																	5		4	21	5	4	4															
Galley	22																	5		4	5	22	4	4															
Recreation Room	23																	5		4	4	4	23	4															
Washroom	24																	5		4	4	4	4	24															
Radar	25																	5	5						25	3	3	3	3											
ECDIS	26																	5	5						3	26	3	3											
Steering Console	27																								3	3	27	5											
Engine Control	28																5								3	3	5	28											
Communication Instruments	29																	5							3				29	5									
Safety Equipment	30																												5	30									
Helideck	31																		2												31								
Conveyor System	32														4	5		5														32	5	5					
Boom	33																	5														5	33	5					
Dewatering	34	1				4	2	4	4						4			5														5	5	34				5
Tanks	35																5	5																	35				
Storage	36																																			36			
Moonpool	37	5		3					5									5																			37	5	
Slurry Disposal System	38	5		5		4	5			4								5																				5	38	

In this case, the systems are broken down with regard to which part of the mining operation it contributes to. The DSM shows the level of interaction between the components, a numerical DSM. Different levels are represented with a numerical value of one through five.

Result

The final product for the DSM is a visualization of the deep sea mining vessel systems and their interactions. It is done to simplify the analysis and design of the vessel and to enable a better understanding of the interactions between the various components of the system in an intuitive way. Finally, the illustration of a low-detailed base for a deep sea mining vessel was made. The illustration is a theoretically well-founded basis for a mining vessel specially built for seafloor massive sulfide mining in the North sea.



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Key sources:

- Solheim, A. V., Brett, P. O., Agis, J. J. G., Erikstad, S. O., & Asbjørnslett, B. E. (2022). Technology Transfer in Novel Ship Design: A Deep Seabed Mining Study. 14th International Marine Design Conference (IMDC) 2022. https://doi.org/10.5957/IMDC-2022-240
- G. Pahl and W. Beitz, Engineering Design: A systematic Approach. Springer, 2007, vol. 3.