Department of Industrial Systems Engineering and Management
IE3100M Systems Design Project AY 2021/2022

Optimize Planning and Scheduling of Gas Cylinders for Wilhelmsen

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COMPANY BACKGROUND

- Wilhelmsen is an extensive global maritime company providing imperative products and services to commercial ships and the maritime industry, along with supplying crew and technical management to the largest and most complex vessels ever to sail.
- Wilhelmsen operates on a global exchange business model involving the rental of gas cylinders to ship owners who require the gas cylinders on board to run their operations

PROBLEM DESCRIPTION

- There is an inadequate establishment of gas cylinders to purchase, as well as an inefficient global distribution of these new cylinders across all warehouses. There are many factors to consider such as the minimum service level at each warehouses, estimated operational loss and scrap rate, expected return quantity, current availability at each warehouses and gas refilling factories, gross profit, purchase cost, and annual budget at the start of the year.
- Wilhelmsen faced difficulty in obtaining accurate level of minimum stock for each gas cylinder types in their respective warehouses. This was due to factors such as lead time to refill the gas cylinders, demand level of each gas cylinders at each warehouses, and quantity of buffer stock required.

OBJECTIVE

- Develop an interactive dashboard to accurately plan the number of new gas cylinders of each type to purchase as well as their optimal distribution across the warehouses globally
- Provide Wilhelmsen with the optimal reorder point for each gas cylinder across the warehouses in order for them to reshuffle the gas cylinders along the shipping lines efficiently

METHODOLOGY

Problem Identification
Identify problems that the company is currently facing regarding current operations

→ **Information Gathering**
Gathered through stakeholders' engagement and included current practices by the company, company's requirements and practical limitations

→ **Root Cause Identification**
Aspects like man, machine, management, method and process

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Data Gathering and Developing of Solution Approach
Solution is aligned with Wilhelmsen's current operations so that the solution model can be easily integrated into their current practices

← **Mathematical Model Building**
Formulation of mathematical model to derive optimal solutions

← **Model Testing and Implementation**
Made improvements to the model based on results and feedback from our model solution

LONG TERM PLANNING

Optimizing Actual Quantity of each Gas Cylinder Type to be Purchased

Using VBA Macro to automate extraction of all the input factors into Dashboard from data:

- Last 12 months' demand at minimum service level based on sales made and sales lost incurred
- Current availability of gas cylinders at each warehouse and gas refilling factory
- Expected returned quantity from customers
- Average gross profit of each gas cylinder type

Using Excel Solver to optimize the actual quantity of each type to purchase based on given variables:

- Purchase cost of each gas cylinder type
- Average gross profit of each gas cylinder type
- Ideal number of each gas cylinder type to purchase
- Minimum quantity of each gas cylinder type to purchase
- Annual budget

Gas Cylinders	Average Gross Profit	Cost of Cylinder	No. of New Cylinders to Purchase	Minimum Quantity to Purchase	Actual Quantity to Purchase	Annual Budget	
A-40	146	310	4073	2036	2036	2500000	
A-5	94	100	135	67	67		
C-27	203	160	955	477	831		
C-9	91	100	2524	1262	1262		
E-10	126	70	299	149	299		
E-50	330	190	425	212	425		
H-40	329	160	139	69	139		
M-10	146	70	365	182	365		
M-50	309	190	50	25	50		
MOX-2	123	100	15	7	7		
MOX-40	317	100	334	167	334		
MOX-5	145	100	193	96	192		
N-10	228	70	280	140	280		
N-50	329	190	1717	858	1717		
O-40	121	160	11372	5686	5686		
O-5	72	60	238	119	119		
R-12	607	40	181	90	181		
R-56	2275	120	921	460	921	Gross Profit to Maximise =	4682044
SG-10	942	70	146	73	146	Budget Constraint =	2500000
						Actual Quantity	

Optimizing Distribution of Newly Purchased Gas Cylinder across all Warehouses Globally

Objective:

Maximize Profit = Total Sales Revenue - Total Refilling Cost

Constraints:

Distributed quantity ≤ Demanded quantity across each warehouse (1)

Total distributed quantity of each type = Total purchased quantity of each type (2)

- A Python Script was written to execute the above mathematical model, outputting the optimized distribution of the newly purchased gas cylinders across the warehouses in an Excel workbook
- **Pulp** (Python module package) was utilised to create the Python Script

SHORT TERM PLANNING

Optimise Wilhelmsen's inventory and ensuring optimal reshuffling of gas cylinders among the warehouses to meet the demand at each port without going out of stock by setting an Optimal Reorder Point for each gas cylinder type in their respective warehouses

- Replenishment Policy: decisions regarding when to reorder and how much to reorder

Replenishment Policy

Continuous Review Policy
- Inventory is continuously traced, and an order for a lot is placed when the inventory declines to the reorder point

Periodic Review Policy
- Inventory status is observed at regular periodic intervals, and an order is placed to raise the inventory level to a specified threshold

For our project, we have adopted the **Periodic Review Policy:**

Reorder Point = Demand during lead time + Safety stock

Lead Time	Time taken to get the respective gas cylinders refilled and readied in the warehouse to meet the demand at the port
Safety Stock	Inventory held in the event where demand exceeds expectations, and to help avoid any stock outs. This extra stock is held to counter uncertainties as well.

EVALUATION OF SOLUTIONS

	Current Operation	Solution Design
Total Cost	$2,499,740	$2,500,000
Total Gross Profits	$4,674,396	$4,682,044

Comparison of Gross Profits from the Quantity Purchased

	Current Operation	Solution Design
Total Gross Profits	$3,145,502	$3,413,712

Comparison of Gross Profits from the Distribution of New Gas Cylinders

FUTURE WORK

- **Optimize Reshuffling of Gas Cylinders**

Through clustering of warehouses and subsequently obtaining the distances between all warehouses

- **Reorder Level**

Determines the top up quantity of gas cylinders from one warehouse to another, which must be done in an efficient and effective manner by taking into consideration target quantity, current quantity and forecasted demand at each warehouse.

ACHIEVEMENTS/OUTCOMES

Short Term Solution

- Constructed a table detailing the reorder point for each gas cylinder type at each warehouse

Site	A-40	A-5	C-27	C-9	E-10	E-50	H-40	M-10	M-50	MOX-2	MOX-40	MOX-5	N-10	N-50	O-40	O-5	R-12	R-56	SG-10
AAD-Adelaide	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	0	0	1
ABJ-Abidjan	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	1
ABN-Brisbane	11	1	0	11	2	2	0	0	0	1	1	0	1	3	26	1	1	9	
ABR-Aberdeen	22	2	4	0	3	4	0	0	2	0	0	0	1	5	42	3	7	4	
ADH-Andhra Pradesh	8	0	0	0	0	0	0	0	0	0	0	0	0	0	18	0	0	1	
AES-Aalesund	3	1	3	2	1	2	0	0	0	0	0	0	0	3	7	2	1	1	
AFM-Fremantle	11	1	0	4	1	1	0	0	1	1	0	0	2	2	23	1	3	5	
AKL-Auckland	6	1	0	5	1	1	0	0	0	0	1	0	1	2	21	1	4	6	

Long Term Solution

- Constructed a Dashboard that optimizes the purchase of new gas cylinders of each type and their distribution across the warehouses

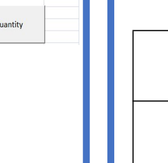
Site	A-40	A-5	C-27	C-9	E-10	E-50	H-40	MOX-2	MOX-40	MOX-5	M-10	M-50	N-10	N-50	O-40	O-5	R-12	R-56	SG-10
AAD-Adelaide	33	0	0	0	0	0	0	4	2	0	0	0	0	15	76	0	0	14	0
ABJ-Abidjan	70	0	0	0	0	0	0	0	0	0	0	0	0	0	139	0	0	12	3
ABN-Brisbane	278	16	0	279	44	46	0	49	33	0	0	13	26	75	665	37	0	121	19
ABR-Aberdeen	291	26	47	0	42	52	0	0	0	0	6	24	0	139	547	42	170	115	0
ADH-Andhra Pradesh	199	0	0	0	0	0	0	0	0	0	0	0	0	7	459	0	0	27	0
AES-Aalesund	89	39	86	53	35	41	0	0	0	0	0	1	0	89	174	49	0	0	1
AFM-Fremantle	195	13	0	69	9	11	0	40	13	13	0	12	31	40	401	16	82	89	0
AKL-Auckland	152	27	0	133	20	23	0	22	32	16	0	0	20	46	361	32	0	71	0
ALG-Algeciras	1497	113	98	113	136	342	0	0	0	0	22	429	69	350	3142	182	222	450	0
AMB-Melbourne	296	28	0	249	27	21	1	18	38	0	0	0	0	125	598	47	0	0	0
ASY-Sydney	256	70	517	1662	132	121	6	19	89	0	0	72	0	176	598	97	0	202	0
AUG-Augusta	66	5	0	0	0	6	0	0	0	0	0	0	0	34	144	10	0	18	0
BAR-Bari	137	13	14	28	0	0	0	0	0	0	0	0	0	20	265	12	21	30	0
BBY-Maharashtra	204	0	0	0	0	0	0	0	0	0	0	0	0	17	437	0	0	40	0

Generate

Clear

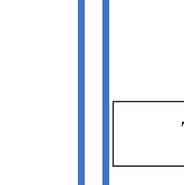
KEY SKILL SETS

Operations Research



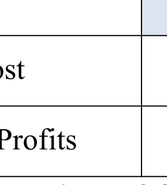
Supply Chain Modelling

Python Programming

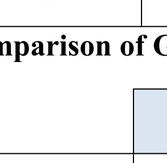


Cost Analysis and Management

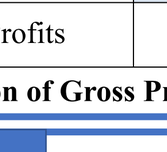
KEY TAKEAWAYS/BENEFITS



- **Project and stakeholder management** are important in determining the root causes of problems that Wilhelmsen face regarding current operations



- **Formulation of mathematical models** has to be clear and well-defined in order to optimize planning and scheduling of gas cylinders



- **Inventory management** is imperative in obtaining accurate level of minimum stock for each gas cylinder types in their respective warehouses