Supply Chain Optimisation Considerations for Power Inverter

Authored & Presented by

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Presenter Bio

- 3rd year E&TC student at Cummins College of Engineering, Pune
- Department topper for 3 consecutive years
- Avid hackathon participant
- Previously an Intern at Twintech Control Systems Pvt Ltd, Pune
- Incoming Software Engineering Intern at Microsoft India
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Problem Statement

- Lead Time, Safety Stock, Minimum Order Quantities and ABC classification are key part parameters which form the basis of Materials Planning. Create a model which
    1. Takes into account the various factors in Supply Planning which contribute to these parameters
    2. Identifies the right method to re-calculate these parameters assuming there is current value of these parameters already defined but needs evaluation and optimization based on parameters identified in point(1) above
    3. Simulates the impact of the re-calculated parameters on Inventory levels
- The model can be built in excel or other analysis and visualization tools as per convenience, but should clearly outline the input, calculation process, simulation capabilities and stage wise output

The Market

The market research and analysis by marketing dept. suggests demand for two models with estimated volumes, features & target prices. Company initially considering Standard Model, Premium Model

Standard Model

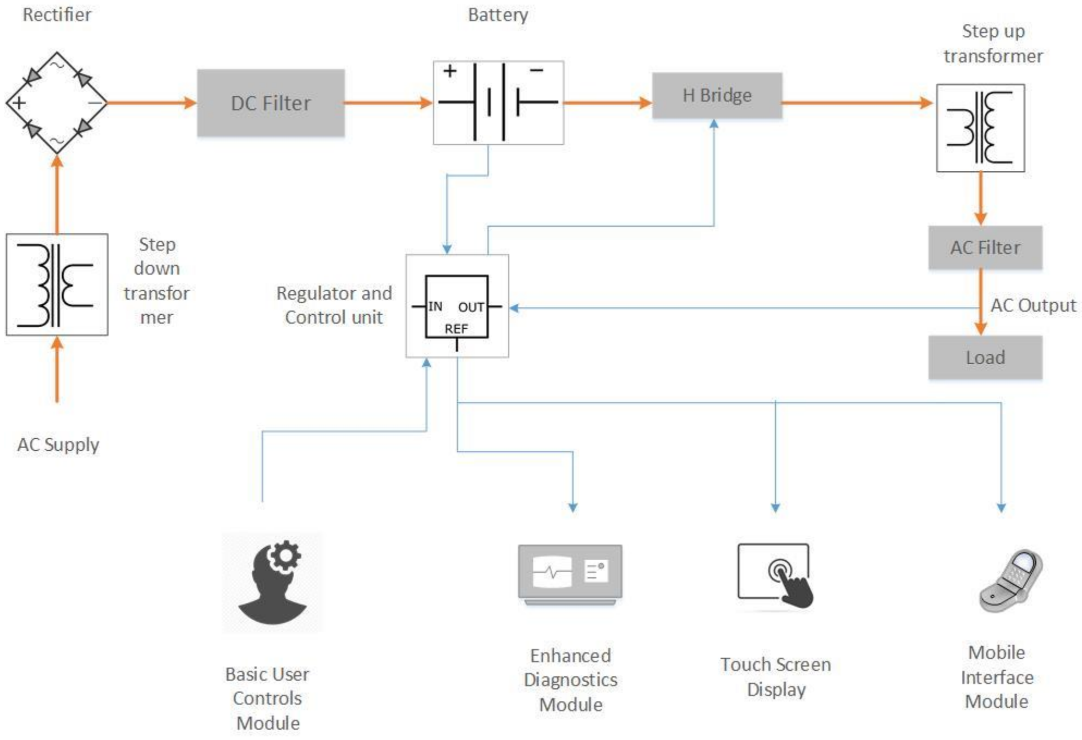
- Category workhorse budget model
- Quasi-sine-wave inverter
- Capacity = 900 VA
- Est. demand per month = 500
- Target price = Rs 10500

Premium Model

- Feature-rich top-tier model
- True-sine-wave inverter
- Capacity = 900 VA
- Est. demand per month = 100
- Target price = Rs 15000

The Product

Block Diagram



Bill of Materials

Sr No	Assembly Name	Std/Prem/Both	Qty per Unit	Make/Buy	Target Unit Cost
1	Enclosure + Accessories	Both	1	Buy	295
2	Transformer1	Both	1	Buy	515
3	Transformer2	Both	1	Buy	520
4	Battery	Both	1	Buy	1,200
5	H Bridge	Both	1	Buy	1,500
6	Rectifier	Both	1	Buy	1,100
7	Filters	Both	2	Buy	150
8	Regulator & Control Assembly	Both	1	Make	1,100
9	Basic User Controls Module	Std	1	Make	900
10	Touchscreen display	Prem	1	Buy	655
11	Enhanced Diagnostics module	Prem	1	Make	1,030
12	Mobile interface module	Prem	1	Make	775

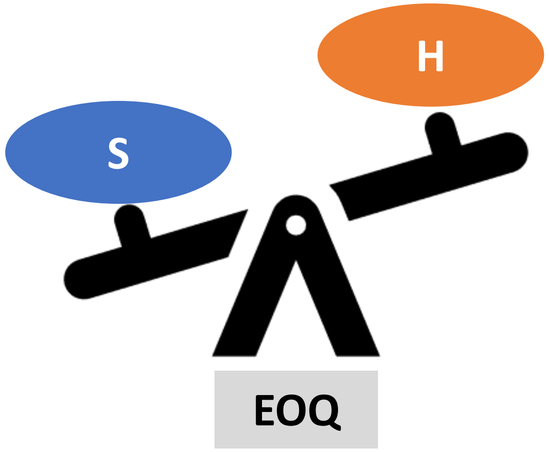
Comparative Supplier Data

								Supplier #1					Supplier #2					Supplier #3					Weighted Avg			
Sr No	Assembly Name	Std/Prem/Both	Qty per Unit	Qty per Yr (Std)	Qty per Yr (Prem)	Make/Buy	Target Unit Cost	Avg Lead Time (weeks)	Max Lead Time (weeks)	Lot Size	Quality Factor	Price	Avg Lead Time (weeks)	Max Lead Time (weeks)	Lot Size	Quality Factor	Price	Avg Lead Time (weeks)	Max Lead Time (weeks)	Lot Size	Quality Factor	Price	Lead Time	Lot Size	Quality Factor	Price
1	Enclosure + Accessories	Both	1	6000	1200	Buy	295	4	6	25		275	6	8	30		290	3	5	20		260				
2	Transformer1	Both	1	6000	1200	Buy	515	10	12	100		490	12	14	120		500	9	11	90		480				
3	Transformer2	Both	1	6000	1200	Buy	520	10	12	100		495	12	14	120		500	9	11	90		480				
4	Battery	Both	1	6000	1200	Buy	1,200	12	15	20		900	14	17	40		1000	11	14	15		850				
5	H Bridge	Both	1	6000	1200	Buy	1,500	16	21	250		1450	18	23	280		1500	15	20	225		1400				
6	Rectifier	Both	1	6000	1200	Buy	1,100	10	15	200		1050	12	17	250		1200	9	14	175		1000				
7	Filters	Both	2	12000	2400	Buy	150	8	10	75		100	10	12	120		125	7	9	60		87.5				
8	Regulator & Control Assembly	Both	1	6000	1200	Make	1,100																			
9	Basic User Controls Module	Std	1	6000		Make	900																			
10	Touchscreen display	Prem	1		1200	Buy	655																			
11	Enhanced Diagnostics module	Prem	1		1200	Make	1,030																			
12	Mobile interface module	Prem	1		1200	Make	775																			

Supplier Mix = Supplier #1 (40% volume); Supplier #2 (33% volume); Supplier #3 (27% volume)

EOQ: Pillar #1 of Material / Inventory Planning

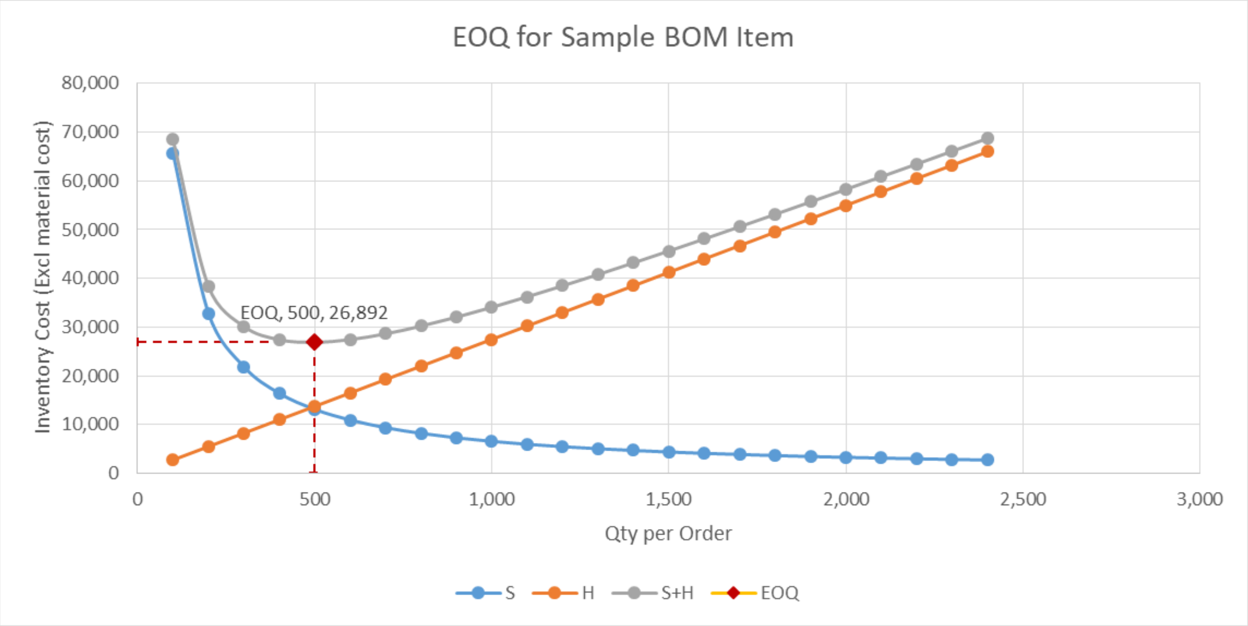
- EOQ = Economic Order Quantity
- Two prime cost components of Material / Inventory Strategy
  - Ordering Costs (S)
  - Holding Costs (H)
- Too many orders of smaller qty reduce inventory hence Holding Costs (H) but increase per order transaction costs (Ordering Costs, S)
- Too few orders of large qty reduce Ordering Costs (S) but increase inventory hence Holding Costs (H)
- Strategy: Balance S & H so total inventory costs are minimum (excl. Material Costs)



EOQ Simulation on a sample part (Inverter Enclosure Assembly)

EOQ for Sample BOM Item			
Q	**S**	**H**	**S+H**
	65,712	2,750	68,462
100	65,712	2,750	68,462
200	32,856	5,500	38,356
300	21,904	8,250	30,154
400	16,428	11,000	27,428
500	13,142	13,750	26,892
600	10,952	16,500	27,452
700	9,387	19,250	28,637
800	8,214	22,000	30,214
900	7,301	24,750	32,051
1,000	6,571	27,500	34,071
1,100	5,974	30,250	36,224
1,200	5,476	33,000	38,476
1,300	5,055	35,750	40,805
1,400	4,694	38,500	43,194
1,500	4,381	41,250	45,631
1,600	4,107	44,000	48,107
1,700	3,865	46,750	50,615
1,800	3,651	49,500	53,151
1,900	3,459	52,250	55,709
2,000	3,286	55,000	58,286
2,100	3,129	57,750	60,879
2,200	2,987	60,500	63,487
2,300	2,857	63,250	66,107
2,400	2,738	66,000	68,738

D	2,400	Demand
C	275	Unit material cost
h	0.2	Carrying cost as % of material cost
s	2,738	Order cost per order
Q	100	Units qty in an order
S	65,712	Total ordering cost
H	2,750	Total holding cost
S+H	68,462	Total inventory cost (excl material cost)



EOQ Mathematical Expression:

EOQ = (2 x Demand x Order Cost / Holding Cost) ^ 1/2

EOQ can be used to simulate:

- Supplier mix for various components in multi-vendor sourcing strategy
- Inward goods rejection ratio from various suppliers
- MOQs enforced by suppliers

and their impact on overall costs of materials operation and planning

EOQ Simulation w/ Multi-Supplier Mix (Calculations & Data Table)

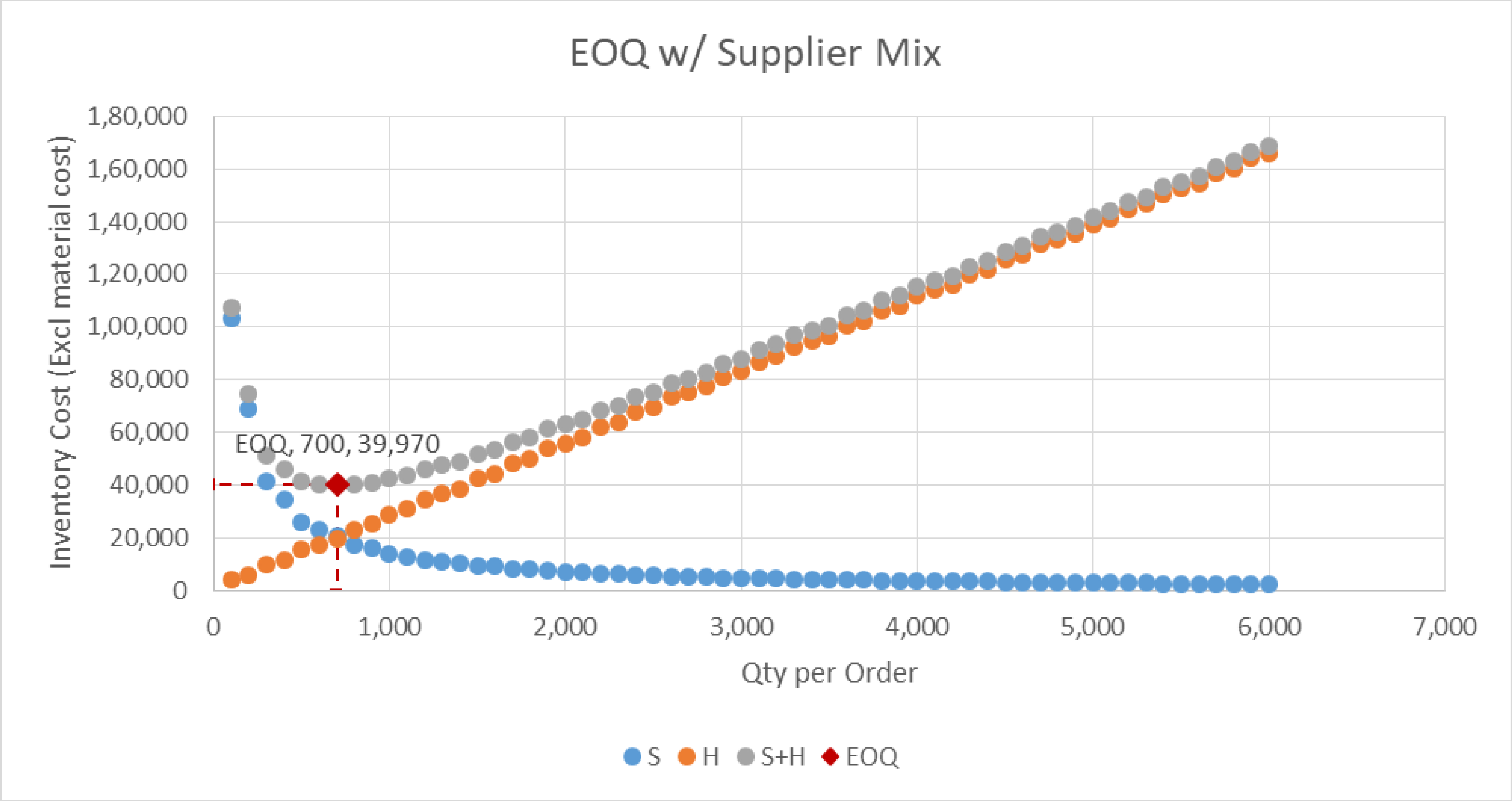
EOQ w/ Supplier Mix			
Q	S	H	S+H
	1,03,286	3,863	1,07,148
100	1,03,286	3,863	1,07,148
200	68,857	5,794	74,651
300	41,314	9,657	50,971
400	34,429	11,588	46,016
500	25,821	15,450	41,272
600	22,952	17,382	40,334
700	20,657	19,313	39,970
800	17,214	23,176	40,390
900	15,890	25,107	40,997
1,000	13,771	28,970	42,741
1,100	12,911	30,901	43,812
1,200	11,476	34,763	46,240
1,300	10,872	36,695	47,567
1,400	10,329	38,626	48,955
1,500	9,390	42,489	51,878

D	6,000	Demand
C	276	Wtd Avg Unit material cost
h	0.2	Carrying cost as % of material cost
s	2,410	Order cost per order
MOQ	70	Blended Avg MOQ
n	70	# of orders
Q	100	Units qty in an order
QM	140	Qty rounded to multiple of MOQ

S	1,03,286	Total ordering cost (D/QM*s)
H	3,863	Total holding cost ((QM/2)*C*h)
S+H	1,07,148	Total inventory cost (excl material cost)

Supplier #1	0.4	Supplier Mix for an Item
Supplier #2	0.33	
Supplier #3	0.27	
Total	1	

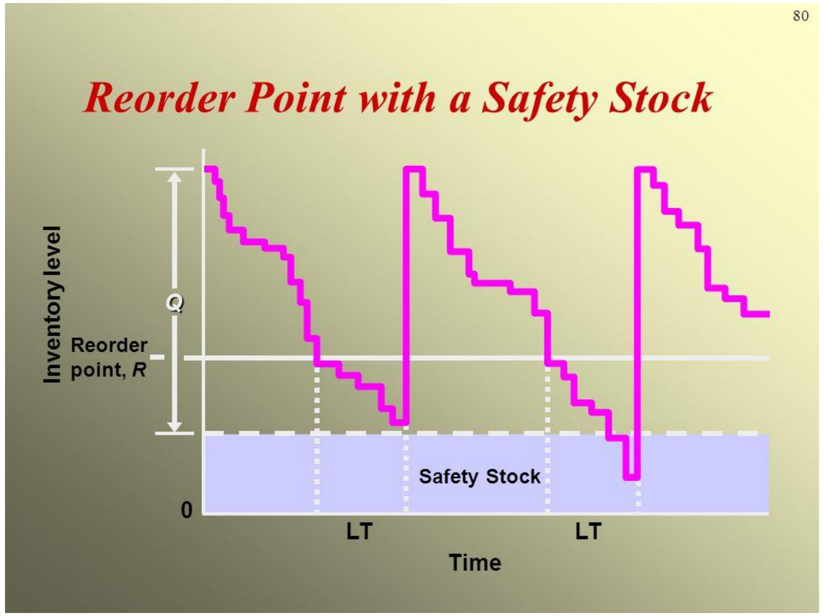
EOQ Simulation w/ Multi-Supplier Mix (Chart with EOQ)



ROP: Pillar #2 of Material / Inventory Planning (Re-Order Point)

- ROP allows company to address demand fluctuation, variation / impact of lead times and need for safety stock to avoid stock-out situations as also abnormal input material rejections
- Mathematical expression of ROP:

  ROP = Average usage per period x lead time + safety stock
- ROP strategy can be adopted for single item or collection / combination of multiple items that are used in the product
- MOQ & EOQ also affect ROP amongst other factors (e.g. rejection ratio)
- ROP can be used to automatically generate & process order(s) to supplier(s)



ROP Calculation & Simulation Data Table

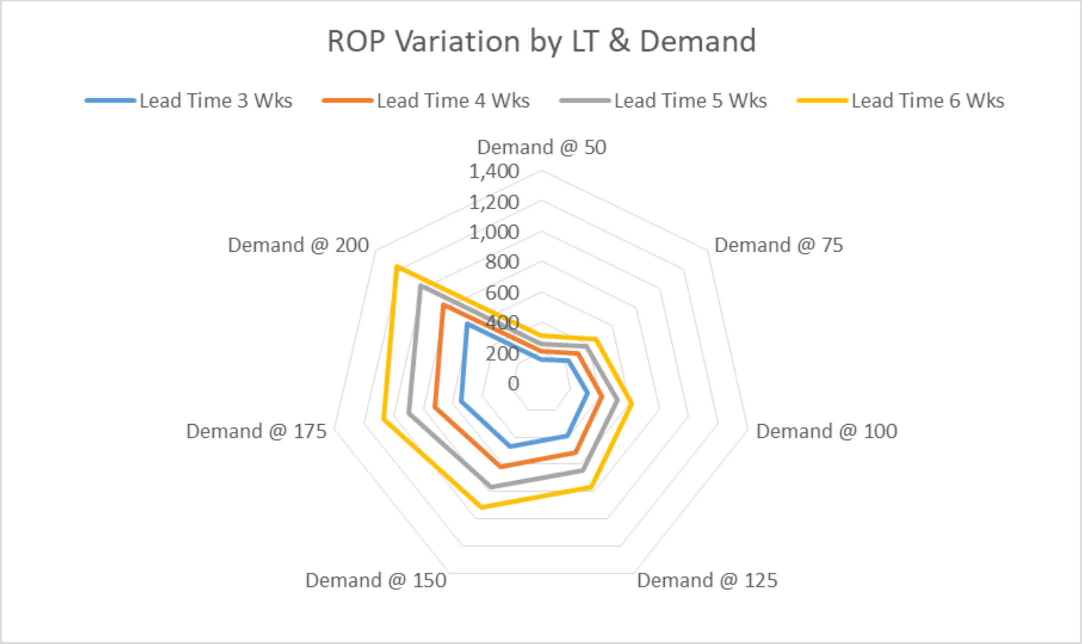
- Table and the chart model variability of average LT and average demand
- Other supplier parameters are assumed held constant
- Base case parameters w/ safety stock level shown in adj table
- Modelled for single supplier but can be extended to multi-supplier system

Enclosure + Accessories ROP	
Lead Time (Wks)	4
Safety Stock (12% of Demand)	15
Avg Demand (per Wk)	125
ROP	515

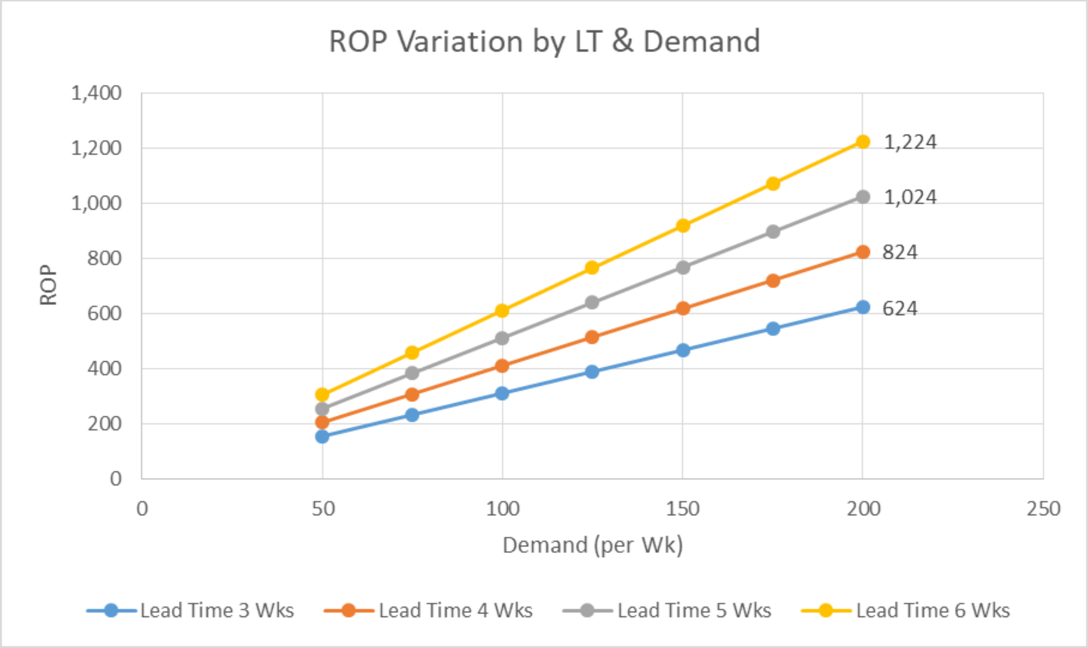
	ROP	**Lead Time (Wks)**			
	515	**3**	**4**	**5**	**6**
Demand (per Wk)	**50**	156	206	256	306
	75	234	309	384	459
	100	312	412	512	612
	125	390	515	640	765
	150	468	618	768	918
	175	546	721	896	1,071
	200	624	824	1,024	1,224

Simulation of ROP Variation w/ LT & Demand

Radar Chart



Scatter Chart



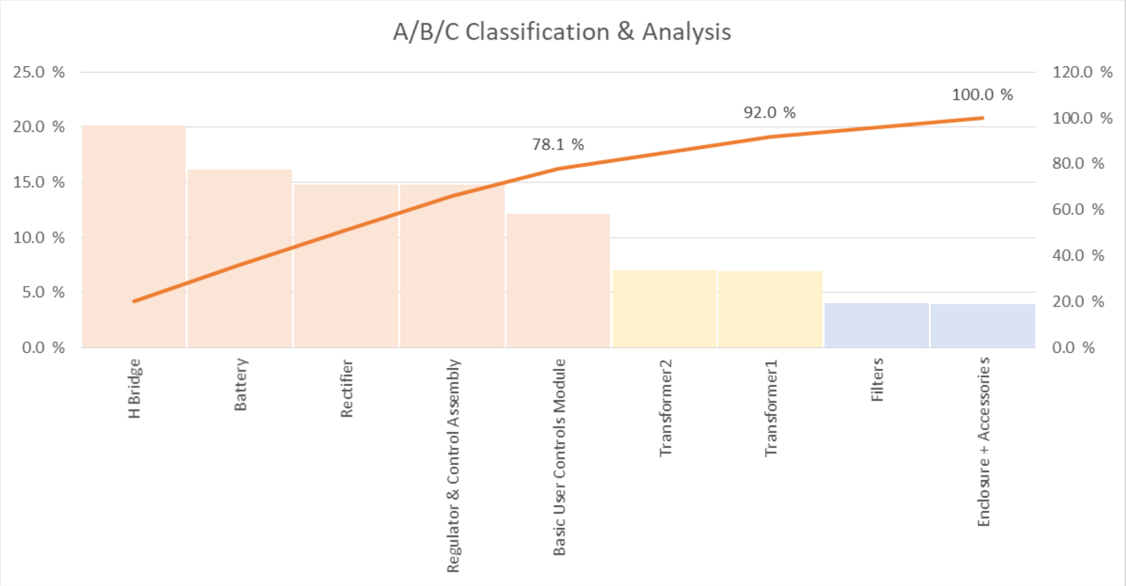
ABC Classification: Pillar #3 of Material Planning

- Method in which inventory is divided into three categories, i.e. A, B, and C in descending value

1. ‘A’ rank: High-value components with fewer manufacturers; ~80% of the annual inventory value
2. ‘B’ rank: moderate criticality items; not as critical as rank ‘A’ items nor as trivial as rank ‘C’ items; ~10% to 15% of the annual inventory value
3. ‘C’ rank: Commodity items w/ abundant suppliers at competitive price; ~5% to 10% of the annual inventory value

ABC Analysis: Pillar #3 of Material Planning

Sr No	Assembly Name	Qty per Unit	Qty per Yr	Target Unit Cost	Total Target Cost	Cost Weight %	A/B/C Classification	Cumulative %
5	H Bridge	1	6,000	1,500	9,000,000	20.2 %	A	78.1 %
4	Battery	1	6,000	1,200	7,200,000	16.2 %	A	
6	Rectifier	1	6,000	1,100	6,600,000	14.8 %	A	
8	Regulator & Control Assembly	1	6,000	1,100	6,600,000	14.8 %	A	
9	Basic User Controls Module	1	6,000	900	5,400,000	12.1 %	A	
3	Transformer2	1	6,000	520	3,120,000	7.0 %	B	13.9 %
2	Transformer1	1	6,000	515	3,090,000	6.9 %	B	
7	Filters	2	12,000	150	1,800,000	4.0 %	C	8.0 %
1	Enclosure + Accessories	1	6,000	295	1,770,000	4.0 %	C	
	Total				**44,580,000**	**100.0 %**		



Conclusion

Advantages

- Data-driven models & simulations help map out best-case & worst-case scenarios that help organisations plan for operational consequences
- This allows for far better approach than the ad-hoc materials planning
- Much efficient & cost-effective
- Eliminates / reduces human biases
- Well-informed, rational decision-making
- Simplicity if models managed well

Limitations

- Models & simulations rely on high-quality data; garbage in → garbage out
- Models outline large variety of outcomes but not necessarily all
- Model complexity grows with large number of variables
- Requires skilled supply-chain analyst

Thank you for your attention

Happy to take any questions…

Reference Material

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