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*Case Study- Capacity allocation problem for
customer orders in K Company*

個案研討 K 公司客戶訂單產能配置問題



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Academic Year: Semester 2, 2010-2011



I. ABSTRACT

Nowadays, the environment of integrated-circuit (IC) high-tech industries is highly competitive. How to make quick responses and effective decisions is crucial to maintaining company's competitive advantages. Due to the highly expensive equipment and low profits in IC testing industry, most IC testing companies have no intension to purchase more test machines and expand testing capacity. Hence, how to provide a satisfactory capacity allocation plan using limited testing machines to meet customer orders demand is a challenging task. In order to make a capacity allocation plan timely and quickly, it is necessary to provide a set of formulas for measuring the required test machines given a batch of customer orders and analyze profitability and priority of different customers because test machines are limited and demand is changeable, as well as each customer order requires specific test machines and cycle times. For most IC testing companies, it is imperative to give a reply of available to promise for customer orders in order to manage better customer relationship and keep long-term cooperation.

In this case study, five criteria, including completion rate of customer order, contribution rate of total revenue, price of customer order, customer loyalty, and customer potential, for evaluating the profitability and priority of customers are proposed. Then Analytical Hierarchy Process (AHP) is used to analyze and rank priority for each customer.

Next, an order capacity allocation system is developed based on a set of formulas for measuring the required test machines given a batch of customer

orders and the obtained priority of customers along with the idea of available to promise (ATP) for IC testing industry. The development of this system also considers the limited conditions of capacity, such as test machine types, quantity, and product types, and customer orders available. The developed order capacity allocation system can comply with customer demand to provide available-to-promise information for sales and operations cooperation in addition to the quick response to customer demand.

The contributions of this case study are as follows:

- (1) Apply AHP methodology to prioritize customers using the proposed criteria;
- (2) Develop an order capacity allocation system to provide available-to-promise information.

Keywords: Analytical hierarchy process, Available to promise, Capacity measure, IC testing.

在現今這競爭激烈的半導體高科技產業環境裡，如何保持高度的靈敏度且快速的決策效率是維持競爭優勢的重要關鍵。由於半導體封裝測試產業的生產設備價格昂貴，加上這幾年半導體產品測試價格大幅滑落，大部份的半導體封裝測試公司不會任意新增測試機台以擴充測試產能。因此，如何充份利用現有的生產資源-測試機台-發揮最大效益，使得測試產能規劃更顯得有效益是相當重要的挑戰工作。由於測試機台產能的限制與產品的規格及訂單需求不一，有必要在短時間內將大量訂單精算出其所需要的測試機台數量，進而產生訂單產能最佳化配置。對客戶訂單能即時回覆承諾以落實客戶關係的管理及長期合作，是目前台灣半導體測試產業所面臨的問題之一。

在這個案中，以提升企業整體之效益、建立顧客夥伴關係為主要目標，提出評定客戶重要性之五項指標，包括：進貨達成率、佔整體營收比例、價格、客戶忠誠度及潛在性客戶，再利用層級分析法排序出客戶的優先順序與相對重要性。接著運用可允諾量的概念，針對半導體測試的特性，建立一個訂單產能精算與配置系統此一產能配置系統依據客戶重要性指標作為產能不足時訂單分配之參考，換言之，即根據現有產能，如：測試機台種類、數量、及各類產品適用的測試機台等等，以及所有客戶的訂單需求，完成訂單產能分配為目標，期望在客戶訂單的允諾回覆過程中能更可靠且快速。利用本個案中之訂單產能配置系統可以依據客戶的需求預測快速精算出可允諾量，提供公司產銷協調之需，同時通知客戶之可承諾訂單數量。本研究的貢獻有：

- (1) 應用層級分析法評估客戶重要性。
- (2) 建立一套訂單產能配置系統，快速提供在產銷協調時評估可允諾客戶訂單量之參考。

關鍵字：半導體測試、訂單允諾量、層級分析法、產能精算

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III. Company Profile

■ Company Founded	May 1, 1987
■ Paid-In Capital	NT\$ 12.8 Billion
■ Factories	Hsin-Chu (HQ) / Chu-Nan (Factories)
■ Sales Offices	U.S.A / Japan / Singapore (S.E.A.&EU)
■ Total Floor Space	3,277,945 Square ft (Dec. 31,2008)
■ Total Clean Room Space	1,444,982 Square ft (Dec. 31,2008)
■ Employees Numbers	4,500
■ IPO Listed in TSE	May 9, 2001

K Company was founded in 1987 and has grown to become the World leader in developing and delivering test solutions. K Company is worth over 750 million USD off net asset and has 4 state-of-the-art facilities with over 4,500 employees located in Taiwan. To provide an immediate support to its customers, K Company also has regional offices throughout the world, covering **USA, Japan, Europe, China and Singapore.**

K Company is one of the world's largest testing houses. According to the most recent data from independent sources, K Company has been ranked in the top 3 of the world's leading suppliers in testing service.

The services currently available at K Company offer are: Testing Development Engineering , Wafer Probing , Pre-assembly and Final Test. K Company provides a broad range of testing platforms and the knowledge based

engineering resources that meets the needs of many of the leading semiconductor manufacturers, IDM and IC Design Houses. More than 1,000 dedicated engineers working with the most advanced automated test equipment provide unparalleled support and diversified applications. The services are available covers the full range of applications such as RF, Mixed-signal, Digital, Memory, LCD driver, CIS/CCD and SOC.

With a strong focus on IC Testing, K Company ensures that it leads the way in the highly competitive testing industry. K Company will be capable of achieving this goal by providing customers with cost-effective services and solutions using the very latest technology, experienced engineering teams and ensuring consistently high quality.



IV. IC Testing Service

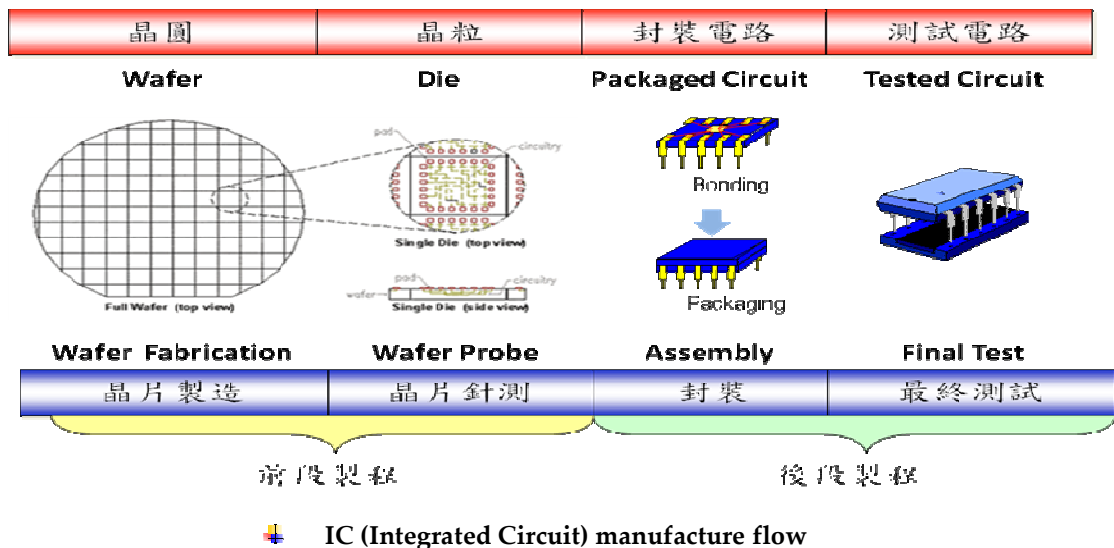
➤ Service in K Company

At K company's Final Test it perform 100% electrical testing as per customers parameters / test program with dedicated changeover kits for a wide range of IC package.

Capability at Final Test includes small packages to high pin count and covers the following form factors: PDIP, PLCC, full SOIC range – SOP, TSOP, TSSOP, MSOP, QFP, LQFP, TQFP, QFN , BGA , LGA , CSP , SIP and certain types of modules..

Operating temperature at final test can range from -55°C to 150°C and performed in class 100 for CCD/CIS and class 10K for all packages.

➤ What is IC Testing Service?



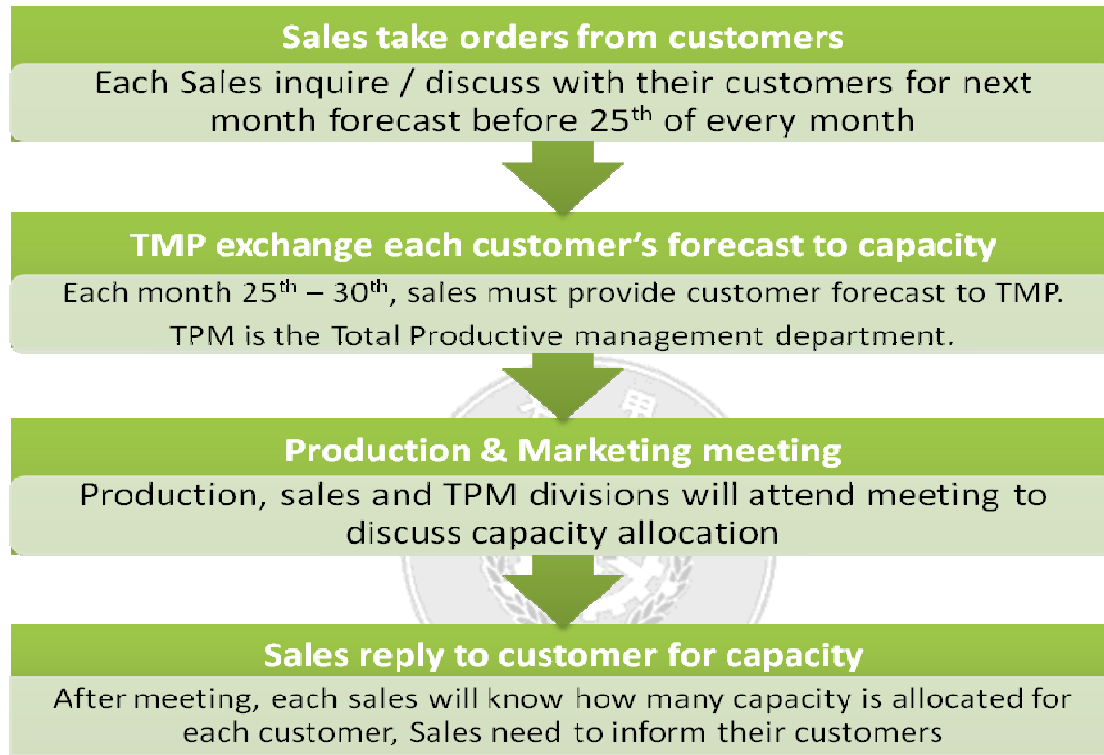
After packaged each piece of IC in order to double confirm and check its electrical function, it needs to do IC testing (Final testing), such as function 、 speed 、 power consumption 、 thermal energy scatter and so on attributes.

Basically, it follows each customer specification and test program to overall test / exam its products. The Purpose is to examine IC quality if conform to customer specification and then according to the testing result to classify each IC into different grade, (ex: grade A 、 grade B 、 grade C....and downgrade). After final testing, customer can setup IC selling price according as different IC grade. Therefore, IC testing is the essential manufacture process and indispensable.



V. Customer orders (Capacity) allocation problems

➤ Customer order processing flow



At K Company, every month sales have to discuss with their customer to inquire the next month orders before 25th every month. K company internal calls “forecast”. After each sale provides the forecast to TPM (the Total Productive management department) and then TPM will exchange all customer orders into capacity according to different type of testers. On beginning of each month, K Company will held a production and marketing meeting to discuss capacity allocation for each customer order. In this meeting, production managers 、 production planners 、 sales managers 、 account sales and TPM all will attend the meeting to have a conclusion. After the meeting, each sales will know how many

capacity is be allocated for each customer. Therefore sales have to inform and reply his/her customer for how many orders that K Company will take.

➤ **Issue 1 - Sales can't promise customer orders immediately**

In this customer order processing flow, it has 3 problems. First problem is that when customer inquire or replace orders to K Company, sales can't reply customer for capacity immediately. Because each month, Sales inquire / discuss with their customers for next month forecast before 25th and provide forecast to TPM. K Company internal has to wait for TPM to exchange the customer orders into capacity. TPM have to according to each type tester's characteristics and IC testing time to figure out each customer's forecast into capacity (tester quantity), and then discuss the capacity allocation in the production & marketing meeting. It takes about 1 week or even longer.

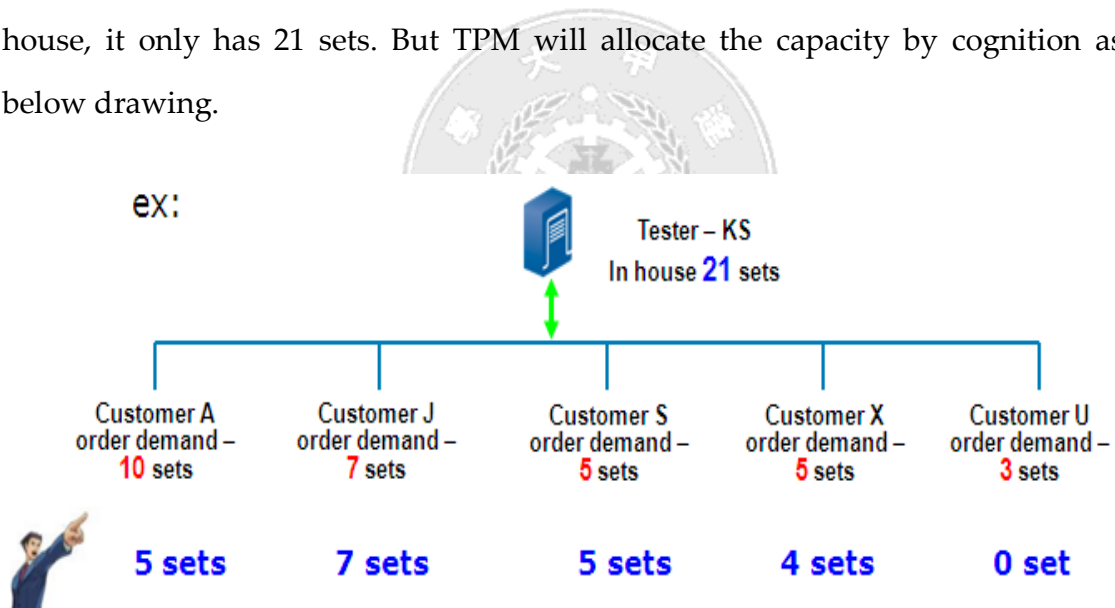
- ◆ Below table shows all customer orders' capacity demand monthly. In house sets mean each type tester that K Company has. For red number in customer order demand, it means the in house tester quantity (capacity) less than customer orders demand. Therefore, in production & marketing meeting will discuss how to allocate customer orders.

Tester	J7	KS	KW	PK	PKII	T35	T36	T65	T71	T77	T81	T82	T85	T88	V2	TOTAL
In house Sets	1	21	3	11.5	22	12	3.5	26	14	3	25	3	5	4	13	153.00
Customer order demand (sets)	0.43	30	0.43	0.51	12	1.49	1.49	26.8	7.07	1.17	15.5	2.22	7.06	1.16	6.97	94.15

➤ **Issue 2 - Capacity allocation unfair**

Another problem happens in production & marketing meeting. In the meeting, if capacity of some testers are over booking (as above table), it need to decide which customer can get the capacity. Normally, production & Sales divisions all have right to discuss how to allocate overbooking issue. But the problem is TPM division always subjective to decide the capacity allocation by his/her cognition. Even sales director can't oppose to say NO.

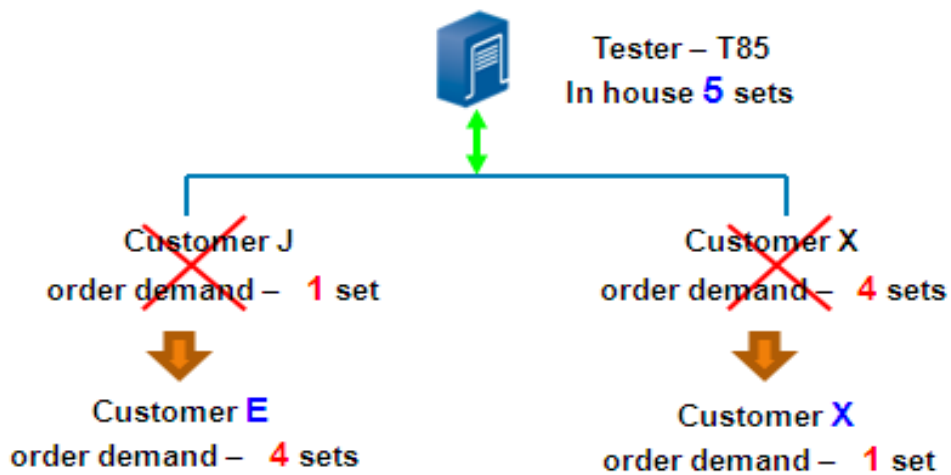
For example, all of customer orders demand 30 sets of KS tester, but in house, it only has 21 sets. But TPM will allocate the capacity by cognition as below drawing.



➤ **Issue 3 - Plunder / Rob capacity problem**

Some customers don't follow the rule to booking capacity, 1 or 2 customers often don't provide the forecast so that sales can't book the capacity for them.

For example, when customer E wants capacity in the middle of month, they always call executive director of Company K directly to request the capacity. And then an executive director gives an order to Company K internal to make capacity for customer E. (As below drawing shows)

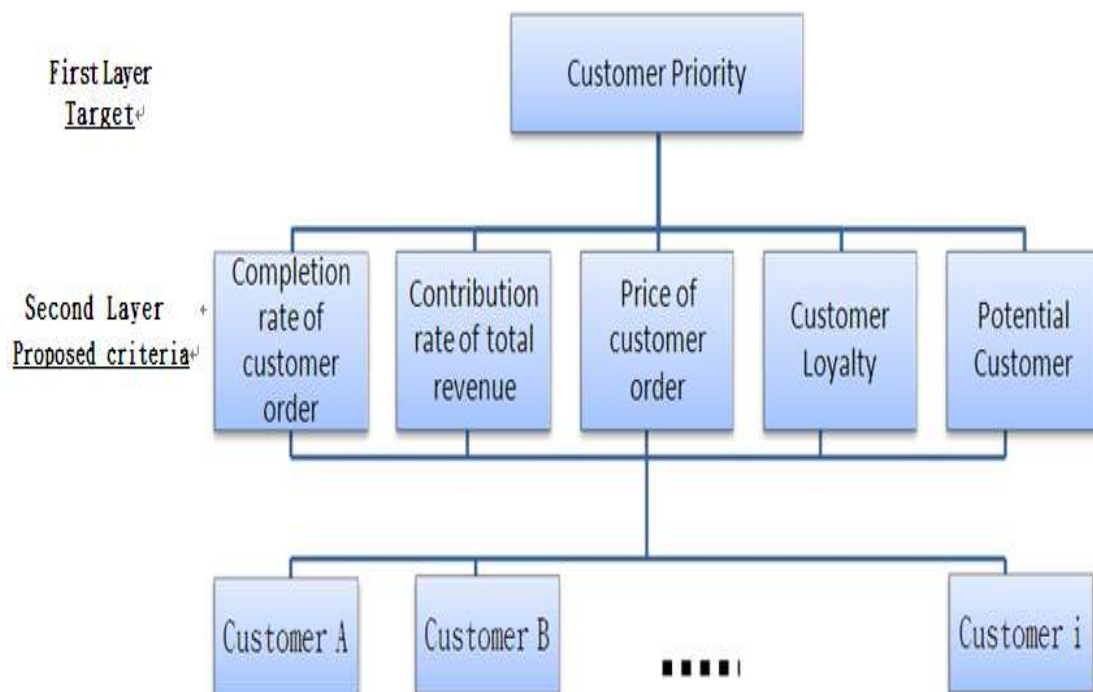


VI. Suggestions / Solutions

➤ Step 1: Rank priority for each customer

Firstly, list down all customers and then use Analytical Hierarchy Process (AHP) to analyze and rank priority for each customer.

Second, apply AHP methodology to prioritize customers by using 5 proposed criteria. And the 5 proposed criteria are including: completion rate of customer order, contribution rate of total revenue, price of customer order, customer relationship, and potential customers, for evaluating the profitability and priority of customers are proposed.

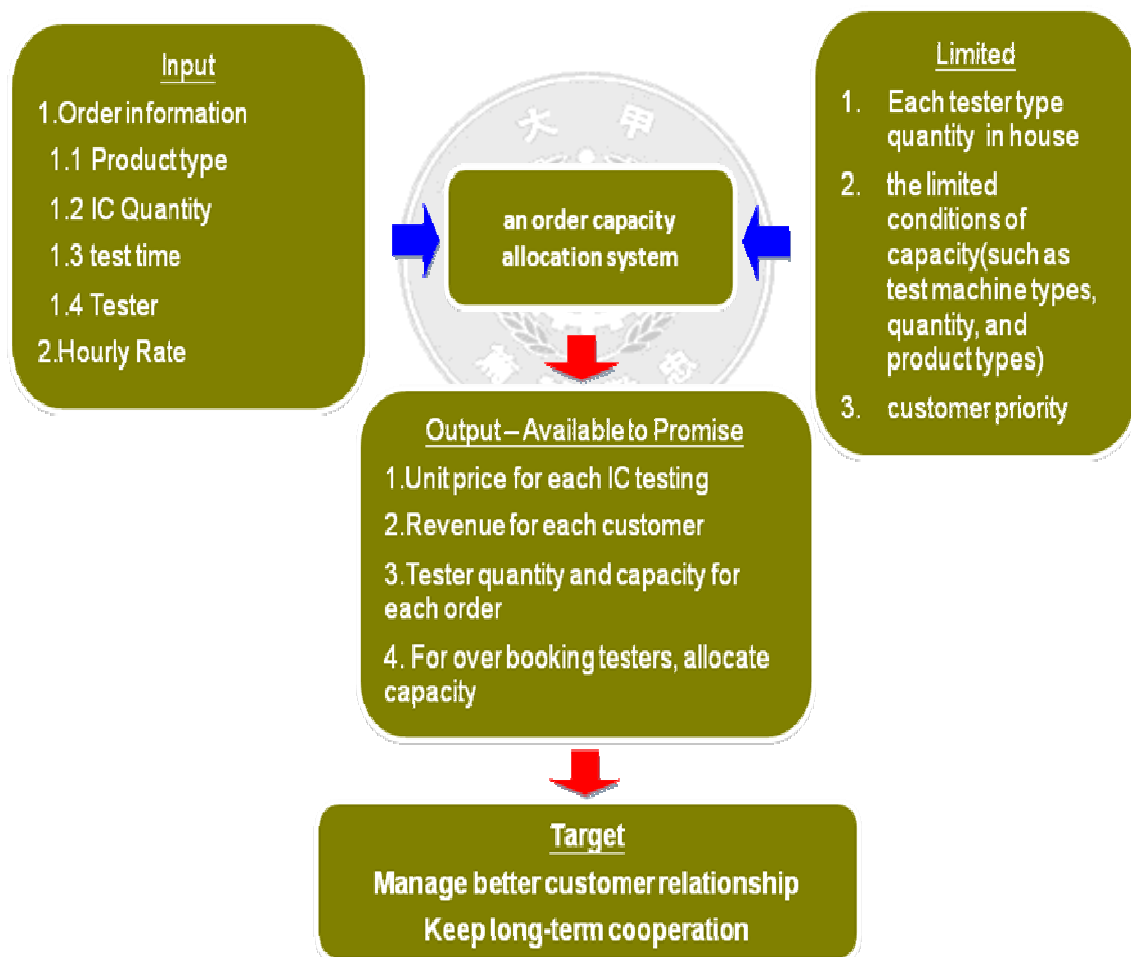


After the evaluating by AHP methodology, it can know the priority of customers. It shows as following:

Customer	Synthetic Weight	Customer priority
S	0.178	1
U	0.152	2
M	0.117	3
I	0.106	4
T	0.093	5
F	0.090	6
O	0.087	7
A	0.076	8
C	0.074	9
J	0.028	10

➤ **Step 2: Develop an order capacity allocation system**

Use Access software to develop an customer orders capacity allocation system and it must some limited rule, such as each tester type quantity in house、the limited conditions of capacity and customer priority to be the rule of exchange and allocate customer orders. And the structure of a customer orders capacity allocation system as following:



■ The main page of a customer orders capacity allocation system



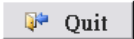
■ Customer order query

Package Type	Tester	Test Time	Unit Price	Next Month Forecast	Tester Demand	Next Month Revenue	After Next Month Forecast	After Next
FAA064L	T71	230	NT\$3.51	150,000	0.30	NT\$527,083	150,000	
FAA064L	T71	173	NT\$2.64	400,000	0.60	NT\$1,057,222	380,000	
FAA064L	T71	115	NT\$1.76	950,000	0.95	NT\$1,669,097	950,000	
LAA064L	T71	1094	NT\$16.71	25,000	0.24	NT\$417,847	25,000	
LAA064L	T71	86	NT\$1.31	100,000	0.07	NT\$131,389	100,000	
LAA064L	T71	144	NT\$2.20	100,000	0.13	NT\$220,000	100,000	
LAA064L	T71	132	NT\$2.02	120,000	0.14	NT\$242,000	120,000	
LAA064L	T71	230	NT\$3.51	200,000	0.40	NT\$702,778	200,000	
TSOP148L	T71	86	NT\$1.31	380,000	0.28	NT\$499,278	380,000	
TSOP148L	T71	144	NT\$2.20	650,000	0.81	NT\$1,430,000	650,000	
TSOP148L	T71	144	NT\$2.20	1,550,000	1.94	NT\$3,410,000	1,600,000	
YBK048L	T71	144	NT\$2.20	200,000	0.25	NT\$440,000	200,000	
YBK048L	T71	86	NT\$1.31	300,000	0.22	NT\$394,167	300,000	
YBK048L	T71	86	NT\$1.31	400,000	0.30	NT\$525,556	390,000	

■ Customer Orders Capacity Analysis

Tester	Sets (In house)	Customer	Synthetic Weight	Tester Demand (Sets)	Tester Allocation
J7					
	1	S	0.178	0.47	0.47
Surplus Testers: 0.53			Total Tester Demand: 0.47		
KW					
	3	S	0.178	0.43	0.43
Surplus Testers: 2.57			Total Tester Demand: 0.43		
PK					
	12	S	0.178	0.36	0.36
		B	0.027	0.15	0.15
Surplus Testers: 11.49			Total Tester Demand: 0.51		
PKII					
	22	S	0.178	4.67	4.67
		M	0.117	0.32	0.32
		T	0.093	5.54	5.54
		E	0.027	0.45	0.45
		R	0.027	1.02	1.02
Surplus Testers: 9.99			Total Tester Demand: 12.01		
T35					
	12	S	0.178	0.82	0.82
		T	0.093	0.27	0.27
		J	0.028	0.01	0.01
		R	0.027	0.38	0.38
Surplus Testers: 10.51			Total Tester Demand: 1.49		

Case Study- Capacity allocation problem for customer orders in K Company


T82				
	3			
		U	0.152	2.22
				2.22
Surplus Testers:	0.78		Total Tester Demand:	2.22
<hr/>				
T88				
	4			
		I	0.106	0.64
		R	0.027	0.37
		K	0.027	0.16
Surplus Testers:	2.84		Total Tester Demand:	1.16
<hr/>				
V2				
	13			
		C	0.074	6.97
Surplus Testers:	6.03		Total Tester Demand:	6.97
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■ Insufficient Capacity(overbooking) Analysis

不足之機台數之所有客戶分析 的樣本

Insufficient Capacity Analysis

Tester	Sets (In house)	Customer	Synthetic Weight	Priority	Total Tester Demand	Tester Demand (Accumulative Total)	Tester Allocation
KS							
	7						
S			0.178	1	7.09	7.09	7.00
M			0.117	3	0.48	7.57	0.00
D			0.027	11	2.27	9.85	0.00
			Insufficient Tester Sets: -2.85		Total Tester Demand Sets: 9.85		
T65							
	26						
S			0.178	1	15.01	15.01	15.01
M			0.117	3	9.11	24.12	9.11
T			0.093	5	1.21	25.33	1.21
F			0.090	6	1.10	26.43	0.67
J			0.028	10	0.07	26.50	0.00
H			0.027	11	0.30	26.81	0.00
			Insufficient Tester Sets: -0.81		Total Tester Demand Sets: 26.81		
							
T85							
	7						
U			0.152	2	5.02	5.02	5.02
I			0.106	4	0.44	5.46	0.44
Q			0.027	11	1.61	7.06	1.54
			Insufficient Tester Sets: -0.06		Total Tester Demand Sets: 7.06		

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VII. Conclusion

- The developed order capacity allocation system can comply with customer demand to provide available-to-promise information for sales and operations cooperation in addition to **the quick response to customer demand**.
- Through an order capacity allocation system, it can make a capacity allocation plan **timely**、**quickly** and **fair**.
- Reply the available to promise for customer orders that can **manage better customer relationship** and **keep long-term cooperation**.



VIII. Suggestions / Solutions by Group Discussion

Beside the suggestions in above chapters, for these issues, we also discussed in class and had 3 groups to provide recommendations and solutions for these problems. Which as following:

➤ Group 1

For problem 1, it can setup software to calculate customer orders into capacity automatic.

For problem 2 & 3, it can use 80/20 principle to sift the most important customers, because only 20% customers occupy the majority of revenue for the company. Therefore, when allocating the capacity, these 20% customers have priority to get the capacity.

If customer who is not in these 20%, it can't get the capacity without booking or providing the forecast on time.

➤ Group 2

If neglect the reality, for these 3 issues, we can follow the Pareto principle (also known as the 80-20 rule) which group 2 mentioned to handle.

Whatever to sort customers into: VIP / good relationship / general / unclear condition or bad reputation, for limited orders, or sales all be responsible for coordinating. These can be the methods to handle or process the capacity allocation and then to get the maximum profit.

But today the problems in practice are:

- (1) In hot season, tester's capacity is full and production planner is also allocating the capacity to maximum.
- (2) The test demand which not be fulfilled in the market can't support the testing house to increase testers/capacity.
- (3) Customers can't find second source (second vendor)

Therefore, in this cycle, production planners / division is seeking the capacity allocation in hot season, not the revenue.

Because the company revenue is hard to increase, sales division can't follow the general sales promotion strategy to coordinate the business between customers and production line. And it results in sales can't get the profit for K company.

So, when sales get orders, all needs to follow production planners' rule – “production full run” to be prerequisite to get company profit in hot season.

And for “capacity allocate unfair” issue is also have to be put after “capacity full run”, that is because the production planner's power is bigger than sales division and customers. And this is hard to change in semiconductor industry.

However, for Plunder / Rob capacity problem, it may affect the full-run production. This needs to consider, but if company top managers request production to dispatch/reschedule to meet production full run. That also is hard to change in this industry.

➤ **Group 3**

For issue 1 & 2, it can follow first in and first out rule to allocate the capacity. Therefore, the capacity allocation will be fair for all customers.

For Issue 3: Plunder / Rob capacity problem: Sales persons do forecast for those companies who have the bad record not providing forecast to K Company.

Sales representatives check the orders with their customers. If there is any volume increase or decrease, even cancel the orders. Contact with customers weekly, not monthly base. In peak season, the capacity is tight, check with customers every day.

Sales department keeps record; they should have some flexibility allow them set the testing priority for their customers. After all, sales department know more about their customers not the other departments.