The Use of Simulation for Clothing Manufacturing Executives; A Case Study.

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Abstract: This paper describes the use of a spreadsheet based monte-carlo simulation tool to model a Melbourne based clothing manufacturer's key inventory decisions for their AS/RS warehouse management system

Keywords: *Warehouse; Simulation; Automatic Storage Retrieval System*

1. INTRODUCTION

This paper is based on a consultancy to improve the productivity of a warehouse for a large Australian based clothing manufacturer in Melbourne. The company is private, managed by its founder and is an important manufacturing supplier to the textile clothing industry in Australia. The company has over 10,000 stock keeping units (SKU's) and maintains a large inventory of finished suits, pants and shirts in one large warehouse facility in suburban Melbourne.

A few years ago, the company invested in a state-of-the-art automatic storage and retrieval system (AS/RS) involving a carousel, conveyor system for hanging garments. Garments are hung on racks that are then fixed onto a conveyor system that transports the rack of garments to a vertical hanging carousel storage system located in the roof of the warehouse. The system cost several million dollars and has a capacity for storing about 30,000 individual SKU's. It has significantly improved the space utilisation of the warehouse but the picking productivity of the system remains low, about 40 to 50 SKU's per hour. Manual picking systems in the hanging racks on the floor of the warehouse have pick rates of 140 to 160 SKU's per hour. The AS/RS system uses random storage for inventory and the problem, on analysis, was that a substantial portion of the 30,000 SKU's were slow moving, effectively clogging up the AS/RS system and slowing downing the retrieval/ picking process.

This paper reports on a monte-carlo, spreadsheet based simulation to show senior managers the consequences of keeping slow stock in the carousel system and suggesting to them the need for reprogramming the system from random allocation to a zonal location system, with fast moving stock located in carousel aisles closest to the picking station.

2. LITERATURE REVIEW

A review of the literature on AS/RS systems indicated that this problem was well researched. Although the subject has been studied since the early 1970's, the text of Tomkins and White (1984) provides a good review of the basic principles and more recent papers by Eben-Chaime and Pliskin (1997), Tang and Chew (1997), Kosfeld (1998) and Dallari et.al (2000) consider different operating strategies using both analytical methods and simulation approaches. The suggested simulation approach by Tomkins and White using a monte-carlo methodology was adopted for the analysis of this case.

3. METHODOLOGY

There are many papers and texts on monte-carlo simulation using various discrete simulation packages, for example, see Dilworth (2000). In this paper a spreadsheet-based approach was used because it was relatively transparent, quick and easy to develop. The software used for the simulation was Microsoft Excel 2000, which is now ubiquitous in business in Australia. The grid structure of the spreadsheet was used to model the actual layout of the carousel system with each cell representing a trolley rack of the carousel system. The carousel model layout is given in figure 1.

Pick station

	racks														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
rows															
1	1	16	31	46	61	76	91	106	121	136	151	166	181	196	211
2	226	241	256	271	286	301	316	331	346	361	376	391	406	421	436
3	451	466	481	496	511	526	541	556	571	586	601	616	631	646	661
4	676	691	706	721	736	751	766	781	796	811	826	841	856	871	886
5	901	916	931	946	961	976	991	1006	1021	1036	1051	1066	1081	1096	1111
6	1126	1141	1156	1171	1186	1201	1216	1231	1246	1261	1276	1291	1306	1321	1336
7	1351	1366	1381	1396	1411	1426	1441	1456	1471	1486	1501	1516	1531	1546	1561
8	1576	1591	1606	1621	1636	1651	1666	1681	1696	1711	1726	1741	1756	1771	1786
9	1801	1816	1831	1846	1861	1876	1891	1906	1921	1936	1951	1966	1981	1996	2011
10	2026	2041	2056	2071	2086	2101	2116	2131	2146	2161	2176	2191	2206	2221	2236
95	21151	21166	21181	21196	21211	21226	21241	21256	21271	21286	21301	21316	21331	21346	21361
96	21376	21391	21406	21421	21436	21451	21466	21481	21496	21511	21526	21541	21556	21571	21586
97	21601	21616	21631	21646	21661	21676	21691	21706	21721	21736	21751	21766	21781	21796	21811
98	21826	21841	21856	21871	21886	21901	21916	21931	21946	21961	21976	21991	22006	22021	22036
99	22051	22066	22081	22096	22111	22126	22141	22156	22171	22186	22201	22216	22231	22246	22261
100	22276	22291	22306	22321	22336	22351	22366	22381	22396	22411	22426	22441	22456	22471	22486

Figure 1: Plan of carousel layout using a spreadsheet framework.

The rows of the spreadsheet represent the aisles of the carousel. Each aisle has space for 15 hanging rack units. Thus the columns are numbered from 1 to 15 with each cell location representing a rack with hanging garments. The capacity of an individual rack (cell) varies from 15 suits to 30 pairs of pants. In this case the cells are numbered in steps of 15 representing the location of individual SKU's on each rack. There are 100 aisles in the system, so the rows of the spreadsheet are numbered from 1 to 100. So for example, a suit with SKU 21,258 would be located in row 95, column 8 with a cell starting number of 21,256. Thus in order to pick item 21,258 the carousel system would have to move 7 racks out of the way on the conveyor system before moving rack 21,256 to the pick station which is located near cell number 1 (row 1, column 1). The capacity of the model system for this case is 22,473 SKU's (22,468+15garments).

The distance travelled in the system for an individual item on a rack is easily given by a Manhattan Metric. Each rack is approximately 1 metre long and each aisle is about 1 metre wide. Hence the dimensions of the carousel system being modelled are 100 metres long by 15 metres deep.

The key assumptions in the simulation model are that SKU's are located randomly though the carousel system (which they are under current procedures) and the distribution of SKU's by individual order is given in figure 2. The distribution of SKU's by order size is based on analysis of about 90,000 orders from the warehouse management system over 2002.

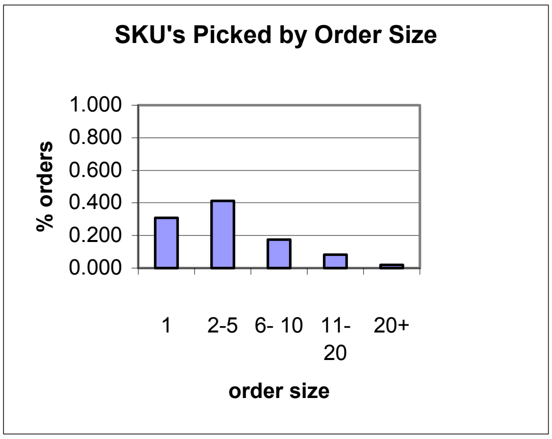

Figure 2: SKU's per Order in 2002.

This shows that one third of orders required only one SKU per order and 40% required between 2 to 5 SKU's per order. Thus the majority of orders (70%) contained only a few picks per order.

The model structure is summarised in Table 1 and Figure 3.

The AS/RS system runs between 4 and 6 trolley racks per minute. Thus, knowing the position of a trolley it is possible to calculate how long it will take to retrieve the SKU's for an order. The system may be operated as either dual or single cycle depending upon whether the pick station has SKU's available for storage as well as retrieval (picking). For this analysis only picking activity was modeled.

Table 1: Simulation Model Steps

Step	Activity
1	Generate random number (uniformly distributed) between 1 and 22,473 (number of SKU's).
2	Identify row and column location of rack
3	Generate random number
4	Use cumulative to distribution of order size to determine number of picks (figure 2)
5	Estimate movement distance to select SKU's based on row/column location
6	Estimate pick time

Each row of the spreadsheet is effectively an order for a single day. Figure 3 shows a simulation of 200 orders (see Step 1 in figure 3) where total movements of trolley racks is 15908 metres or 2651 minutes (at 6 trolley racks/ minute movement speed). This was generated by 975 SKU's. The pick rate was 22.1 SKU's per hour. A very simple macro was then generated to run the spreadsheet simulation model for 100 "days". The total distances, travel times and pick rates were then recorded row by row for each run in another summary worksheet.

The simulation spreadsheet in figure 3 uses Excel vlookup commands where the lookup table is headed "Lookup Table for Warehouse". In step 1, rack location is a uniformly distributed random number (between 1 and 22473) that corresponds to an SKU location in the warehouse lookup table. This allows the simulation to then locate the row and column position of the rack in the warehouse. Step 4 is used to determine how many SKU's are picked from that particular rack according to the distribution in figure 2.

Modelling alternate layouts was accomplished by limiting the random allocation to restricted portions of figure 1. A simulation was conducted where 50% of the warehouse closest to the pick station were used for picking and then another simulation using the nearest one third of the warehouse to the pick station.

Figure 3 is a part of the spreadsheet layout for the current random location system. It shows the design of the main worksheet, that simulates a single day's orders.

4. RESULTS

The results are presented in Figure 4. They show that the current strategy of randomly locating stock through the 22, 473 locations results in simulated pick rates between 60 and 80 SKU's per hour. If the active stock is segmented to half the storage system nearest the pick station, productivity rises to between 100 and 120 units per hour. If the active stock is further segmented to just the nearest third of the warehouse, rates further increase to between 160 and 200 units per hour.

An analysis of the inventory in the AS/RS warehouse showed that a large amount of stock was very slow moving, with inventory turns less than two. For some lines in excess of two years demand was stored in the carousel system.

Lookup Table for warehouse

Rack Number	Row	Column
1	1	1
16	1	2
31	1	3
46	1	4
61	1	5
22411	100	10
22426	100	11
22441	100	12
22456	100	13
22471	100	14
22486	100	15

Order number	random number (rack location)
1	2067
2	8869
3	6018
4	365
5	20719
199	12148
200	7861

Row	Aisle (rack)	Distance to travel metres
10	3	13
40	7	47
27	12	39
2	10	12
93	2	95
54	15	69
35	15	50

Total distance travelled, metres 15908

Total time minutes 2651

random number	order size
0.66993	3
0.60564	3
0.2219	1
0.45365	3
0.00096	1
0.5375	3

Total picks 975

Pick rate 22.1

SKU's/ order Cumulative dist.	
0	1
0.309	3
0.722	7
0.897	15
0.979	30
1	

See Figure 2

Figure 3: Excel worksheet, one run of monte-carlo simulation

5. CONCLUSIONS

The simulation has confirmed that given the existing order pattern and location of substantial slow moving stock in the AS/RS warehouse system the current random storage of SKU’s is resulting in low picking productivity. The simulated pick rates of the current system (60 to 80 picks/ hour) approximate the low actual pick rates being experienced by the warehouse (40 to 50 picks per hour). More detailed modelling would be required to more closely replicate the real world, but the results indicate order of magnitude improvements that could be expected if the current operating procedures are changed.

Alternate storage procedures that segment faster moving inventory closer to the pick station will significantly increase the productivity. The simulation also shows the importance of culling the slow moving stock from the AS/RS system and block stacking it using different processing/ picking procedures. These may include shifting slow moving SKU’s to static hanging systems or in extreme cases, quitting the stock.

The use of a simple and transparent simulation using Excel allows senior executives to use the model and test out various strategies. In this way it may improve their confidence to undertake different inventory management strategies and procedures with their AS/RS carousel system.

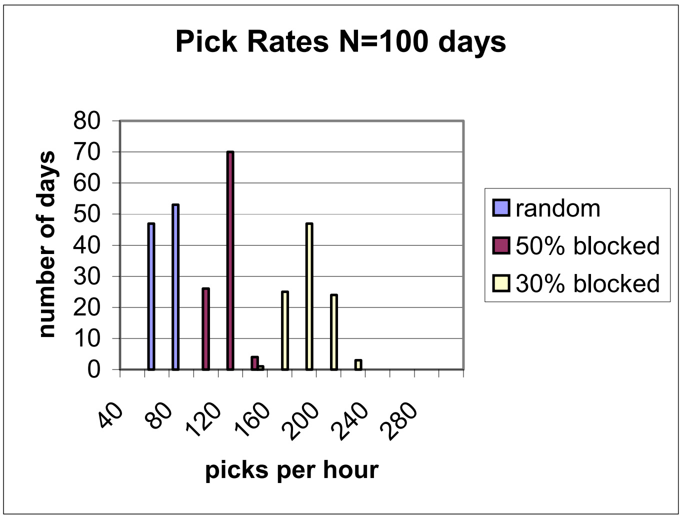

Figure 4: Simulated pick rates for 3 storage strategies

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