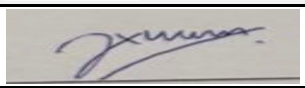
Temasek Polytechnic
School of Business

BLO2010 – Distribution Centre Management (AY2025/2026 Apr)

Group Project Report

Submitted By

Group Number:
Class: TC03

Name of Student	Signature
Chen Zehua	
Muhammad Zahid Bin Satar	
Lee Eng Rong	
Pon Jin Xuan	
ARSHAD MIRZA BIN AHMAD SOFHAN	

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- To achieve quality outputs from the AI tool, you should provide good prompt that is clear and specific. Be precise and provide context. Avoid asking open-ended questions.

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Introduction

TRAVEL PAL PTE LTD (TP) is a well-known E-commerce company which runs an online retail portal for school backpacks. It is currently looking for a new 3PL to help them set up and manage its new distribution centre (DC) in Singapore to serve its customers in the Southeast Asia region.

This proposal aims to fulfill TRAVEL PAL's requests such as projected growth and the goal of achieving a 95% service level every day. It will run on a "Pallet-In, Piece-Out" model, managing 30 SKUs of backpack inventory efficiently.

We have broken down the proposal into six parts. Using historical data to achieve 95% daily service level, resources and manpower planning, pricing, DC Layout, derived requirements and TRAVEL PAL's plans to expand into distributorship. The proposal follows TRAVEL PAL's business assumptions and volume pattern.

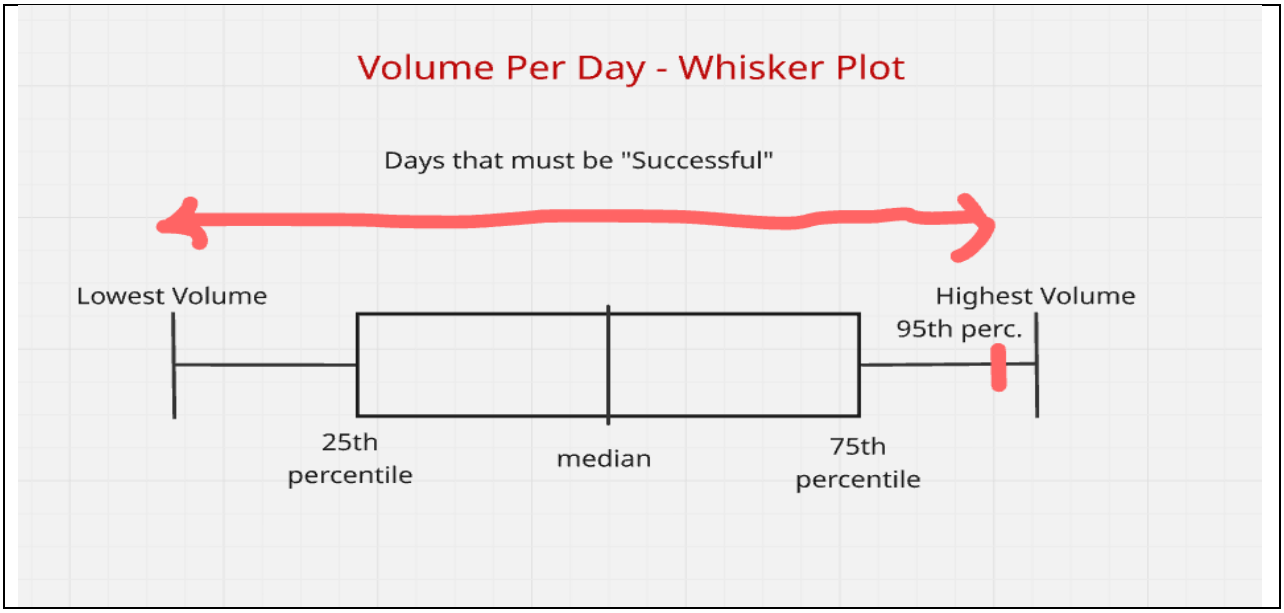
The proposal leverages advanced automation technologies, including an AutoStore system for storage operations, while maintaining flexibility to accommodate TRAVEL PAL's projected 10% annual growth rate over the five-year contract period.

This strategic partnership will position QUICK-QUICK LOGISTICS as TRAVEL PAL's preferred 3PL provider, demonstrating our capability to deliver sophisticated supply chain solutions that drive business growth and customer satisfaction in the Southeast Asian market.

A. To achieve a 95% daily service level, we analyzed TRAVEL PAL's historical volume data using Microsoft Excel

We used the 95th percentile of inbound, outbound and balance values to determine what volume achieves 95% success rate annually. TRAVEL PAL allow up to 5% of the days to be "unsuccessful". That means 95% of the days must be "successful". The 95th percentile value of inbound, outbound and balance for that year shows what values fulfill 95 percent of the days. For example, there are 100 days.

The value that fulfills 95 days is the 95th percentile value. 95th percentile means the value that is higher than 95 percent than rest of the data. Shown in the whisker plot below.



Operation	95th percentile value
IN	1920
OUT	1480
BAL	2802.5

Data Taken From TRAVEL PAL's historical data

B. Resources Planning

To achieve the 95% “Successful” days, we can use the 95th percentile volume for inbound e.g. 1920. However, that is **not practical** because of overstaffing. If we use the 95th percentile volume value, there will be many days when most of the staff have nothing to do. It’s because majority of the daily volumes is near the median. Hiring full timers to deal with 1920 vs 1560 volume has a huge difference in costs.

Median Volume (Inbound)	95th Percentile Volume (Inbound)
1560	1920

Inbound Activity (Daily Volume)

The value of inbound cartons is derived from TRAVEL PAL’s historical data. We took the median values of each month and took the max of those median values. This gets the middle value of the volume of each month while not causing understaffing. The median value is used as it reduces outliers. Each month is calculated to consider trends. For example, the lowest volume of backpacks for outbound is in November while the highest is in January, with *an increase of almost 50%!* This is explained by January being the start of the school year and school children ordering backpacks.

November (Outbound)	January (Outbound)
871	1368

Calculations:

Number of inbound cartons = 1560

Number of pallets = 1560 ÷ 12 = 130 (12 cartons in one pallet)

Number of backpacks = 1560 × 6 = 9360 (1 carton contains 6 pieces)

Number of Pallets (Forecasted growth) = $130 \times (1+0.1)^5 = 209.37 \approx 210$ pallets

Number of Cartons (Forecasted Growth) = $1560 \times (1+0.1)^5 = 2512.4 \approx 2513$

Number of Pieces (Forecasted Growth) = $9630 \times (1+0.1)^5 = 15074.4 \approx 15075$

Number of Working Hours = (1800hr – 0830hr) -1hr = 8.5 hours (minus 1 hour due to mandatory break time)

Inbound ACTIVITY (Manual)					
Task	UOM Per Task	Daily Volume per task	No. of working hours per shift	Standard Time (UOM per hour)	Estimated No. of Workers Required
Unload Full Pallets from container	Pallet	210	8.5	45	0.55
Move UOM to Inbound Working Area	Pallet	210	8.5	100	0.25
Inspect Pallet and sign POD	Pallet	210	8.5	120	0.21
Enter Cargo receiving data for pallet	Pallet	210	8.5	200	0.12
Break Shipping Cartons from pallet	Carton	2513	8.5	180	1.64
break Piece from shipping Carton	Piece	15075	8.5	300	5.91
Pasting of Licence Plate Number	Piece	15075	8.5	360	4.93
Move to Inbound Staging Area	Piece	15075	8.5	100	17.74
Putaway Piece	Piece	15075	8.5	180	9.85
Total Workers					41.19 ≈ 42
Supervisor					5

Automation

Since TP prefers automation, the automation manpower grid is used to decide the number of handlers and supervisors to be hired. The labour cost will be calculated based on that.

Inbound ACTIVITY (Automation)					
Task	UOM Per Task	Daily Volume per task	No. of working hours per shift	Standard Time (UOM per hour)	Estimated No. of Workers Required
Unload Full Pallets from container	Pallet	210	8.5	45	0.55
Move UOM to Inbound Working Area	Pallet	210	8.5	100	0.25
Inspect Pallet and sign POD	Pallet	210	8.5	120	0.21
Enter Cargo receiving data for pallet	Pallet	210	8.5	500	0.05
Break Shipping Cartons from pallet	Carton	2513	8.5	180	1.64
break Piece from shipping Carton	Piece	15074.3736	8.5	300	5.91
Pasting of Licence Plate Number	Piece	15074.3736	8.5	360	4.93
Move to Inbound Staging Area	Piece	15074.3736	8.5	600	2.96
Putaway Pieces into AutoStore	Piece	15074.3736	8.5	250	7.09
Total Workers					23.58 ≈ 24
Supervisor					3

Number of shifts per day

There will be 3 shifts per day:		
Shift 1: 8.30 am – 2.30 pm (6 hrs)	Shift 2: 10.30 am – 4.30 pm (6 hrs)	Shift 3: 12 pm – 6 pm (6 hrs)

6-hour shifts are implemented to avoid OT during normal volumes. If workers are required to OT during normal volumes, more staff will be needed for high volumes, which will cause the labour cost to be much higher.

The roster for the shifts will look like:

Worker Group	Mon	Tue	Wed	Thu	Fri	Sat	Sun
Group A (8) 8.30 - 2.30 pm	Work	Work	Work	Work	Work	Work	Rest
Group B (8) 10.30 am - 4.30 pm	Work	Work	Work	Work	Work	Work	Rest
Group 3 (8) 12 pm - 6 pm	Work	Work	Work	work	Work	Work	Rest

The roster below shows each shift for each supervisor.

Supervisor	Mon	Tue	Wed	Thu	Fri	Sat	Sun
Sup 1 (8.30am - 2.30pm)	Work	Work	Work	Work	Work	Work	OFF
Sup 2 (10.30am – 4.30pm)	Work	Work	Work	Work	Work	Work	OFF
Sup 3 (12pm - 6pm)	Work	Work	Work	Work	Work	Work	OFF

Labour Cost

Fully-Loaded Cost per Handler = 2000 × 1.6 = 3200

Total Handler Cost – Inbound = 3200 × 24 = 76800

Expected number of Supervisors = 3

Fully-Loaded Cost per Supervisor = 2800 × 1.6 = 4480

Total Supervisor Cost – Inbound = 4480 × 3 = 13440

Total Labour Cost – Inbound =13440 + 76800 = 90240

Inbound Activity (High Volume)

Number of inbound cartons = 1920

Number of pallets = 1920 ÷ 12 = 160 (12 cartons in one pallet)

Number of backpacks = 1920 × 6 = 11520 (1 carton contains 6 pieces)

Number of Pallets (Forecasted growth) = $160 \times (1+0.1)^5 = 257.682 \approx 258$ pallets

Number of Cartons (Forecasted Growth) = $1920 \times (1+0.1)^5 = 3092.18 \approx 3093$

Number of pieces (forecasted growth) = $11520 \times (1+0.1)^5 = 18553.1 \approx 18554$

Number of working hours = 1800hr – 0830hr -1hr =8.5

Manual

Inbound ACTIVITY (Manual)					
Task	UOM Per Task	Daily Volume per task	No. of working hours per shift	Standard Time (UOM per hour)	Estimated No. of Workers Required
Unload Full Pallets from container	Pallet	258	8.5	45	0.67
Move UOM to Inbound Working Area	Pallet	258	8.5	100	0.30
Inspect Pallet and sign POD	Pallet	258	8.5	120	0.25
Enter Cargo receiving data for pallet	Pallet	258	8.5	200	0.15
Break Shipping Cartons from pallet	Carton	3093	8.5	180	2.02
Break Piece from shipping Carton	Piece	18554	8.5	300	7.28
Pasting of Licence Plate Number	Piece	18554	8.5	360	6.06
Move to Inbound Staging Area	Piece	18554	8.5	100	21.83
Putaway Piece	Piece	18554	8.5	180	12.13
Total Workers					50.70 ≈ 51
Supervisor					6

Automation

Inbound ACTIVITY (Automation)					
Task	UOM Per Task	Daily Volume per task	No. of working hours per shift	Standard Time (UOM per hour)	Estimated No. of Workers Required
Unload Full Pallets from container	Pallet	258	8.5	45	0.67
Move UOM to Inbound Working Area	Pallet	258	8.5	100	0.30
Inspect Pallet and sign POD	Pallet	258	8.5	120	0.25
Enter Cargo receiving data for pallet	Pallet	258	8.5	500	0.06
Break Shipping Cartons from pallet	Carton	3093	8.5	180	2.02
break Piece from shipping Carton	Piece	18554	8.5	300	7.28
Pasting of Licence Plate Number	Piece	18554	8.5	360	6.06
Move to Inbound Staging Area	Piece	18554	8.5	600	3.64
Putaway Pieces into AutoStore	Piece	18554	8.5	250	8.73
Total Workers					29.02 ≈ 30
Supervisor					3

During high volumes, workers are to work 8 hours per day. In addition, 5 part time staffs are to be hired. The number of shifts remain as 3.

Number of OT hours = (8 × 6) – 44 = 4 hours

Fully-Loaded Cost per Handler = 2000 × 1.6 = 3200

Monthly OT Cost per Handler = (2000 × 12) ÷ (52 × 44) × 1.5 × 1.17 × (4 hours per week × 4 weeks) = 294.55

Total Handler Cost – Inbound = (3200 + 294.55) × 24 = 83869.20

Expected number of Supervisors = 3

Fully-Loaded Cost per Supervisor = 2800 × 1.6 = 4480

Monthly OT Cost per Supervisor = (2800 × 12) ÷ (52 × 44) × 1.5 × 1.17 × (4 hours per week × 4 weeks) = 412.36

Total Supervisor Cost – Inbound = (4480 + 412.36) × 3 = 14677.08

Total Temporary Staff Cost – Inbound = 15 × 6hrs × 5 staff = 450

Total Labour Cost – Inbound = 83869.20 + 14677.08 + 450 = 98996.28

The roster for the shifts will look like:

Worker Group	Mon	Tue	Wed	Thu	Fri	Sat	Sun
Group A (6) 8.30 - 4.30 pm	Work	Work	Work	Work	Work	Work	Rest
Group B (6) 9.30 am - 5.30 pm	Work	Work	Work	Work	Work	Work	Rest
Group 3 (6) 10 am - 6 pm	Work	Work	Work	work	Work	Work	Rest
Part timers (5) 12 pm – 6 pm	Work	Work	Work	Work	Work	Work	Rest

The roster below shows each shift for each supervisor.

Supervisor	Mon	Tue	Wed	Thu	Fri	Sat	Sun
Sup 1 (8.30am - 4.30pm)	Work	Work	Work	Work	Work	Work	OFF
Sup 2 (9.30am – 5.30pm)	Work	Work	Work	Work	Work	Work	OFF
Sup 3 (10pm - 6pm)	Work	Work	Work	Work	Work	Work	OFF

Inbound Activity (Low Volume)

Number of inbound cartons = 240

Number of pallets = 240 ÷ 12 = 20 (12 cartons in one pallet)

Number of backpacks = 240 × 6 = 1440 (1 carton contains 6 pieces)

Number of Pallets (Forecasted growth) = $20 \times (1+0.1)^5 = 32.21 \approx 33$ pallets

Number of Cartons (Forecasted Growth) = $240 \times (1+0.1)^5 = 386.52 \approx 387$

Number of pieces (forecasted growth) = $1440 \times (1+0.1)^5 = 2319.13 \approx 2320$

Number of working hours = 1800hr – 0830hr -1hr =8.5

Inbound ACTIVITY (Manual)					
Task	UOM Per Task	Daily Volume per task	No. of working hours per shift	Standard Time (UOM per hour)	Estimated No. of Workers Required
Unload Full Pallets from container	Pallet	33	8.5	45	0.09
Move UOM to Inbound Working Area	Pallet	33	8.5	100	0.04
Inspect Pallet and sign POD	Pallet	33	8.5	120	0.03
Enter Cargo receiving data for pallet	Pallet	33	8.5	200	0.02
Break Shipping Cartons from pallet	Carton	387	8.5	180	0.25
break Piece from shipping Carton	Piece	2320	8.5	300	0.91
Pasting of Licence Plate Number	Piece	2320	8.5	360	0.76
Move to Inbound Staging Area	Piece	2320	8.5	100	2.73

Putaway Piece	Piece	2320	8.5	180	1.52
Total Workers					6.34 ≈ 7
Supervisor					1

Automation

Inbound ACTIVITY (Automation)					
Task	UOM Per Task	Daily Volume per task	No. of working hours per shift	Standard Time (UOM per hour)	Estimated No. of Workers Required
Unload Full Pallets from container	Pallet	33	8.5	45	0.09
Move UOM to Inbound Working Area	Pallet	33	8.5	100	0.04
Inspect Pallet and sign POD	Pallet	33	8.5	120	0.03
Enter Cargo receiving data for pallet	Pallet	33	8.5	500	0.01
Break Shipping Cartons from pallet	Carton	387	8.5	180	0.25
break Piece from shipping Carton	Piece	2320	8.5	300	0.91
Pasting of Licence Plate Number	Piece	2320	8.5	360	0.76
Move to Inbound Staging Area	Piece	2320	8.5	600	0.45
Putaway Pieces into AutoStore	Piece	2320	8.5	250	1.09
Total Workers					3.63 ≈ 4
Supervisor					1

Handlers

During low volumes, there will not be shifts. 3 workers will work 8.5 hours for 3 days. There will only be 2 groups of workers, resulting in total of 6 workers for that week. There will only be one shift per day.

This is what the roster will look like:

Worker Group	Mon	Tue	Wed	Thu	Fri	Sat	Sun
Group A (4) 8.30 - 6 pm	Work	Work	Work	Rest	Rest	Rest	Rest
Group B (4) 8.30 - 6 pm	Rest	Rest	Rest	Work	Work	Work	Rest

Labour Cost (Handlers)

Fully-Loaded Cost per Handler = 2000 × 1.6 = 3200

Total Handler Cost – Inbound = 3200 × 8 = 25600

Supervisors

During low volumes, there will also not be shifts for supervisors. We will only need 2 supervisors to cover the 6 days. Each supervisor is required to work 8.5 hours for 3 days.

This is what the roster will look like.

Supervisor	Mon	Tue	Wed	Thu	Fri	Sat	Sun
Sup 1 (8.30am – 6pm)	Work	Work	Work	Rest	Rest	Rest	OFF
Sup 2 (8.30am - 6pm)	Rest	Rest	Rest	Work	Work	Work	OFF

Labour Cost (Supervisor)

Expected number of Supervisors = 2

Fully-Loaded Cost per Supervisor = 2800 × 1.6 = 4480

Total Supervisor Cost – Inbound = 4480 × 2 = 8960

Total Labour Cost

Total Labour Cost – Inbound = 8960 + 25600 = 34560

Outbound Activity (Daily Volume)

Number of inbound cartons = 1369 × 6 = 8122 (since the excel data provided is carton equivalent, ×6 because one carton has 6 pieces for inbound, while one carton has one piece for outbound)

Number of pieces = 8122

Number of shipping packages = 8122

Forecasted Growth = $8122 \times (1+0.1)^5 = 13223.9 \approx 13224$

Since outbound is supposed to operate for 24 hours for 7 days, split into 2 shifts (12 hours each)

Number of working hours = 12 – 1 = 11

Manual

Outbound ACTIVITY (Manual)					
Task	UOM Per Task	Daily Volume per task	No. of working hours per shift	Standard Time (UOM per hour)	Estimated No. of Workers Required
Store Piece ; pick Piece	Piece	13224	11	150	8.01
check piece	Piece	13224	11	300	4.01
Update Location Information - Piece	Piece	13224	11	200	6.01
Move to Outbound Working Area	Piece	13224	11	100	12.02
check piece	Piece	13224	11	300	4.01
piece - Packed into carton and labeling	Piece	13224	11	80	15.03

carton - secure into shipping package and	Carton	13224	11	80	15.03
enter cargo packing data for shipping package	Carton	13224	11	200	6.01
move to outbound staging area	Carton	13224	11	100	12.02
hand shipping package to freight forwarder	Carton	13224	11	360	3.34
Total Workers					85.49 ≈ 86
Supervisor					9

Automation

Outbound ACTIVITY (Automation)					
Task	UOM Per Task	Daily Volume per task	No. of working hours per shift	Standard Time (UOM per hour)	Estimated No. of Workers Required
pick piece from autostore	Piece	13224	11	250	4.81
check piece	Piece	13224	11	500	2.40
Update Location Information - Piece	Piece	13224	11	500	2.40
Move to Outbound Working Area	Piece	13224	11	500	2.40
check piece	Piece	13224	11	600	2.00
piece - Packed into carton and labeling	Piece	13224	11	80	15.03
carton - secure into shipping package and	Carton	13224	11	80	15.03
enter cargo packing data for shipping package	Carton	13224	11	400	3.01

move to outbound staging area	Carton	13224	11	500	2.40
hand shipping package to freight forwarder	Carton	13224	11	360	3.34
Total Workers					52.83 ≈ 53
Supervisor					6

Number of shifts per day (Daily Volume)

There will be 4 shifts per day:			
Shift 1: 6.30 am – 6.30 pm	Shift 2: 6.30 pm – 6.30 am	Shift 3: 6.30 am – 6.30 pm	Shift 4: 6.30 pm – 6.30 am

The roster for the shifts will look like:

Worker Group	Mon	Tues	Wed	Thurs	Fri	Sat	Sun	Days Worked
1 (10) 6.30 am - 6.30pm	✓	✓	✓	✓	✗	✗	✗	4
2(10) 6.30 am - 6.30pm	✗	✗	✗	✗	✓	✓	✓	3
3(16) 6.30 pm - 6.30 am	✓	✓	✓	✓	✗	✗	✗	4
4(17) 6.30 pm - 6.30 am	✗	✗	✗	✗	✓	✓	✓	3
Supervisor	**Mon**	**Tues**	**Wed**	**Thurs**	**Fri**	**Sat**	**Sun**	**Days Worked**
Supp 1 (6.30 am - 6.30pm)	✓	✓	✓	✓	✗	✗	✗	4
Supp 2 (6.30 am - 6.30pm)	✗	✗	✗	✗	✓	✓	✓	3
Supp 3 and 4 (6.30 pm - 6.30 am)	✓	✓	✓	✓	✗	✗	✗	4
Supp 5 and 6 (6.30 pm - 6.30 am)	✗	✗	✗	✗	✓	✓	✓	3

Since its working hours per day is 12, adopt 4-3-3-4 arrangement.

Rotate every week	4-3-3-4	Also applies to supp

Week 1	group 1 and 3 work 4 days, rest 3 days	group 2 and 4 work 3 days, rest 4 days
week 2	group 1 and 3 work 3 days, rest 4 days	group 2 and 4 work 4 days, rest 3 days
week 3	group 1 and 3 work 4 days, rest 3 days	group 2 and 4 work 3 days, rest 4 days
week 4	group 1 and 3 work 3 days, rest 4 days	group 2 and 4 work 4 days, rest 3 days

Labour Cost

Fully-Loaded Cost per Handler = 2000 × 1.6 = 3200

Total Handler Cost – Outbound = 3200 × 53 = 169600

Expected number of Supervisors = 6

Fully-Loaded Cost per Supervisor = 2800 × 1.6 = 4480

Total Supervisor Cost – Outbound = 4480 × 6 = 26880

Total Labour Cost – Outbound =169600+ 26880 = 196840

Outbound Activity (High Volume)

Number of inbound cartons = 1865 × 6 = 11190 (since the excel data provided is carton equivalent, ×6 because one carton have 6 pieces for inbound, while one carton has one piece for outbound)

Number of pieces = 11190

Number of shipping packages = 11190 Forecasted Growth = $11190 \times (1+0.1)^5$ = 18021.6 ≈ 18022

Since outbound is supposed to operate for 24 hours for 7 days, split into 2 shifts (12 hours each)

Number of working hours = 12 – 1 = 11

Manual

Outbound ACTIVITY (Manual)					
Task	UOM Per Task	Daily Volume per task	No. of working hours per shift	Standard Time (UOM per hour)	Estimated No. of Workers Required
Store Piece ; pick Piece	Piece	18022	11	150	10.92
check piece	Piece	18022	11	300	5.46
Update Location Information - Piece	Piece	18022	11	200	8.19
Move to Outbound Working Area	Piece	18022	11	100	16.38
check piece	Piece	18022	11	300	5.46
piece - Packed into carton and labeling	Piece	18022	11	80	20.48
carton - secure into shipping package and	Carton	18022	11	80	20.48
enter cargo packing data for shipping package	Carton	18022	11	200	8.19
move to outbound staging area	Carton	18022	11	100	16.38
hand shipping package to freight forwarder	Carton	18022	11	360	4.55
Total Workers					116.51 ≈ 117
Supervisor					12

Automation

Outbound ACTIVITY (Automation)					
Task	UOM Per Task	Daily Volume per task	No. of working hours per shift	Standard Time (UOM per hour)	Estimated No. of Workers Required
pick piece from autostore	Piece	18022	11	250	6.55

check piece	Piece	18022	11	500	3.28
Update Location Information - Piece	Piece	18022	11	500	3.28
Move to Outbound Working Area	Piece	18022	11	500	3.28
check piece	Piece	18022	11	600	2.73
piece - Packed into carton and labeling	Piece	18022	11	80	20.48
carton - secure into shipping package and	Carton	18022	11	80	20.48
enter cargo packing data for shipping package	Carton	18022	11	400	4.10
move to outbound staging area	Carton	18022	11	500	3.28
hand shipping package to freight forwarder	Carton	18022	11	360	4.55
Total Workers					72.00
Supervisor					8

Workers to need to 4 more hours per week during high volumes. In addition, we will need to hire 2 more supervisors.

*4-3-3-4

• 1st Week : Work 5 days, and Rest 2 days → 48 hours + 4 = 52 hours

• 2nd Week : Work 4 days, and Rest 3 days → 36 hours + 4 = 40 hours

• Average weekly working hours = 46 hours

Number of OT hours = 46 – 44 = 2 hours

Fully-Loaded Cost per Handler = 2000 × 1.6 = 3200

Monthly OT Cost per Handler = (2000 × 12) ÷ (52 × 44) × 1.5 × 1.17 × (2 hours per week × 4 weeks) = 147.27

Total Handler Cost – Outbound = (3200 + 147.27) × 72 = 241003.44

Expected number of Supervisors = 8

Fully-Loaded Cost per Supervisor = 2800 × 1.6 = 4480

Total Supervisor Cost – Outbound = 4480× 8 = 35840

Total Labour Cost – Outbound = 241003.44 + 35840= 276843.44

The roster for the shifts will look like:

Worker Group	Mon	Tues	Wed	Thurs	Fri	Sat	Sun	Days Worked
1 (10) 6.30 am - 6.30pm	✓	✓	✓	✓	✓ (8.30 am – 12.30 pm)	✗	✗	5
2(10) 6.30 am - 6.30pm	✗	✗	✗	✓ (8.30 am – 12.30 pm)	✓	✓	✓	4
3(16) 6.30 pm - 6.30 am	✓	✓	✓	✓	✓ (4.30 pm – 8.30 pm)	✗	✗	5
4(17) 6.30 pm - 6.30 am	✗	✗	✗	✓ (4.30 pm – 8.30 pm)	✓	✓	✓	4

Supervisor	Mon	Tues	Wed	Thurs	Fri	Sat	Sun	Days Worked
Supp 1 (6.30 am - 12.30pm)	✓	✓	✓	✗	✓ (8.30 am – 2.30 pm)	✗	✗	4
Supp 2 and 3 (6.30 pm - 6.30am)	✓	✓	✓	✓ (2.30 pm – 6.30pm)	✗	✗	✗	4
Supp 4 (6.30 am - 6.30 pm)	✗	✗	✗	✓	✓	✓	✓	3
Supp 5 and 6 (6.30 pm – 6.30 am)	✗	✗	✗	✗	✓	✓	✓	3
Supp 7 (12.30 pm – 6.30 pm)	✓	✓	✓	✓ (8.30 am – 2.30 pm)	✓ (2.30 pm – 8.30 pm)	✗	✗	4
Supp 8 (6.30 pm – 6.30 am)	✗	✗	✗	✓	✓ (2.30 pm – 8.30 pm)	✗	✗	2

Outbound Activity (Low Volume)

Number of inbound cartons = 603 × 6 = 3618 (since the excel data provided is carton equivalent, ×6 because one carton have 6 pieces for inbound, while one carton has one piece for outbound)

Number of pieces = 3618

Number of shipping packages = 3618

Forecasted Growth = $3618 \times (1+0.1)^5 = 5826.83 \approx 5827$

Since outbound is supposed to operate for 24 hours for 7 days, split into 2 shifts (12 hours each)

Number of working hours = 12 – 1 = 11

Manual

Outbound ACTIVITY (Manual)					
Task	UOM Per Task	Daily Volume per task	No. of working hours per shift	Standard Time (UOM per hour)	Estimated No. of Workers Required
Store Piece ; pick Piece	Piece	5827	11	150	3.53
check piece	Piece	5827	11	300	1.77
Update Location Information - Piece	Piece	5827	11	200	2.65
Move to Outbound Working Area	Piece	5827	11	100	5.30
check piece	Piece	5827	11	300	1.77
piece - Packed into carton and labeling	Piece	5827	11	80	6.62
carton - secure into shipping package and	Carton	5827	11	80	6.62
enter cargo packing data for shipping package	Carton	5827	11	200	2.65
move to outbound staging area	Carton	5827	11	100	5.30
hand shipping package to freight forwarder	Carton	5827	11	360	1.47
Total Workers					37.67 ≈ 38
Supervisor					4

Automation

Outbound ACTIVITY (Automation)					
Task	UOM Per Task	Daily Volume per task	No. of working hours per shift	Standard Time (UOM per hour)	Estimated No. of Workers Required
pick piece from autostore	Piece	5827	11	250	2.12
check piece	Piece	5827	11	500	1.06
Update Location Information - Piece	Piece	5827	11	500	1.06
Move to Outbound Working Area	Piece	5827	11	500	1.06
check piece	Piece	5827	11	600	0.88
piece - Packed into carton and labeling	Piece	5827	11	80	6.62
carton - secure into shipping package and	Carton	5827	11	80	6.62
enter cargo packing data for shipping package	Carton	5827	11	400	1.32
move to outbound staging area	Carton	5827	11	500	1.06
hand shipping package to freight forwarder	Carton	5827	11	360	1.47
Total Workers					23.28 ≈ 24
Supervisor					3

Handlers

This is what the roster will look like:

Worker Group	Mon	Tues	Wed	Thurs	Fri	Sat	Sun	Days Worked

1 (6) 6.30 am - 6.30pm	✓	✓	✓	✓	✗	✗	✗	4
2(6) 6.30 am - 6.30pm	✗	✗	✗	✗	✓	✓	✓	3
3(6) 6.30 pm - 6.30 am	✓	✓	✓	✓	✗	✗	✗	4
4(6) 6.30 pm - 6.30 am	✗	✗	✗	✗	✓	✓	✓	3

Since its working hours per day is 12, adopt 4-3-3-4 arrangement.

Rotate every week	4-3-3-4	Also applies to supp
Week 1	group 1 and 3 work 4 days, rest 3 days	group 2 and 4 work 3 days, rest 4 days
week 2	group 1 and 3 work 3 days, rest 4 days	group 2 and 4 work 4 days, rest 3 days
week 3	group 1 and 3 work 4 days, rest 3 days	group 2 and 4 work 3 days, rest 4 days
week 4	group 1 and 3 work 3 days, rest 4 days	group 2 and 4 work 4 days, rest 3 days

Labour Cost (Handlers)

Fully-Loaded Cost per Handler = 2000 × 1.6 = 3200

Total Handler Cost – Outbound = 3200 × 24 = 76800

Supervisors

This is what the roster will look like.

Supervisor	Mon	Tues	Wed	Thurs	Fri	Sat	Sun	Days Worked
Supp 1 (6.30 am - 6.30pm)	✓	✓	✓	✓	✗	✗	✗	4
Supp 2 (6.30 am - 6.30pm)	✗	✗	✗	✗	✓	✓	✓	3
Supp 3 (6.30 pm - 6.30 am)	✓	✓	✓	✓	✗	✗	✗	4
Supp 4 (6.30 pm - 6.30 am)	✗	✗	✗	✗	✓	✓	✓	3

Rotate every week	4-3-3-4	Also applies to supp
Week 1	Supp 1 work 4 days, rest 3 days	Supp 2 work 3 days, rest 4 days
week 2	Supp 2 work 4 days, rest 3 days	Supp 1 work 3 days, rest 4 days
week 3	Supp 3 work 4 days, rest 3 days	Supp 4 work 4 days, rest 3 days
week 4	Supp 4 work 4 days, rest 3 days	Supp 3 work 4 days, rest 3 days

Labour Cost (Supervisor)

Expected number of Supervisors = 4

Fully-Loaded Cost per Supervisor = 2800 × 1.6 = 4480

Total Supervisor Cost – Outbound = 4480 × 4 = 17920

Total Labour Cost

Total Labour Cost – Outbound = 17920 + 76800 = 94720

C. Pricing

Inbound (Daily Volume)

Forecasted growth = $130 \times (1+0.1)^5 = 209.37 \approx 210$ pallets

Monthly Volume = 210 × 6 days × 4 weeks = 5040

Labour Cost - Inbound = $90240

Applied OH = 50000 ÷ 2 = $25000

Total Cost – Inbound = 90240 + 25000 = $115240

Selling Rate – Inbound = (115240 ÷ 5040) × 1.2 = $27.44 per pallet

Inbound (High Volume)

Number of Pallets (Forecasted growth) = $160 \times (1+0.1)^5 = 257.682 \approx 258$ pallets

Monthly Volume = 258 × 6 days × 4 weeks = 6192

Labour Cost - Inbound = $98996.28

Applied OH = 50000 ÷ 2 = $25000

Total Cost – Inbound = 98996.28 + 25000 = $123996.28

Selling Rate – Inbound = (123996.28 ÷ 6192) × 1.2 = $24.03 per pallet

Inbound (Low Volume)

Number of Pallets (Forecasted growth) = $20 \times (1+0.1)^5 = 32.21 \approx 33$ pallets

Monthly Volume = 33 × 6 days × 4 weeks = 792

Labour Cost - Inbound = $34560

Applied OH = 50000 ÷ 2 = $25000

Total Cost – Inbound = 34560 + 25000 = $59560

Selling Rate – Inbound = (59560 ÷ 792) × 1.2 = $90.24 per pallet

Outbound (Daily Volume)

Forecasted Growth = $8122 \times (1+0.1)^5 = 13223.9 \approx 13224$

Monthly Volume = 13224 × 7 days × 4 weeks = 370272

Labour Cost - Outbound = $43840

Applied OH = 50000 ÷ 2 = $25000

Total Cost – Outbound = 196840 + 25000 = $221840

Selling Rate – Outbound = (221840 ÷ 370272) × 1.2 = $0.60 per piece

Outbound (High Volume)

Forecasted Growth = $11190 \times (1+0.1)^5 = 18021.6 \approx 18022$

Monthly Volume = 18022 × 7 days × 4 weeks = 504616

Labour Cost - Outbound = $276843.44

Applied OH = 50000 ÷ 2 = $25000

Total Cost – Outbound = 276843.44 + 25000 = $301843.44

Selling Rate – Outbound = (301843.44 ÷ 504616) × 1.2 = $0.71 per piece

Outbound (Low Volume)

Forecasted Growth = $3618 \times (1+0.1)^5 = 5826.83 \approx 5827$

Monthly Volume = 5827 × 7 days × 4 weeks = 163156

Labour Cost - Outbound = $94720

Applied OH = 50000 ÷ 2 = $25000

Total Cost – Outbound = 94720 + 25000 = $119720

Selling Rate – Outbound = (119270 ÷ 163156) × 1.2 = $0.88 per piece

Storage (Daily Volume)

Forecasted growth = (2122 cartons × 6 pieces) × $(1+0.1)^5$ = 20505.01 ≈ 20506 pieces

Monthly Volume = 20506 × 7 days × 4 weeks = 574168

Total amount of capital investment = $800000

Monthly desired cash flow = 800000 × $(1 + 0.05)^5$ ÷ 5 ÷ 12 = $17017.09

Selling Rate – Storage = (17017.09 ÷ 574168) × 1.2 = $0.04 per piece

Storage (High Volume)

Forecasted growth = (4064 cartons × 6 pieces) × $(1+0.1)^5$ = 39270.68 ≈ 39271 pieces

Monthly Volume = 39271 × 7 days × 4 weeks = 1099588

Total amount of capital investment = $800000

Monthly desired cash flow = 800000 × $(1 + 0.05)^5$ ÷ 5 ÷ 12 = $17017.09

Selling Rate – Storage = (17017.09 ÷ 1099588) × 1.2 = $0.02 per piece

Storage (Low Volume)

Forecasted growth = (123 cartons × 6 pieces) × $(1+0.1)^5$ = 1188.56 ≈ 1189 pieces

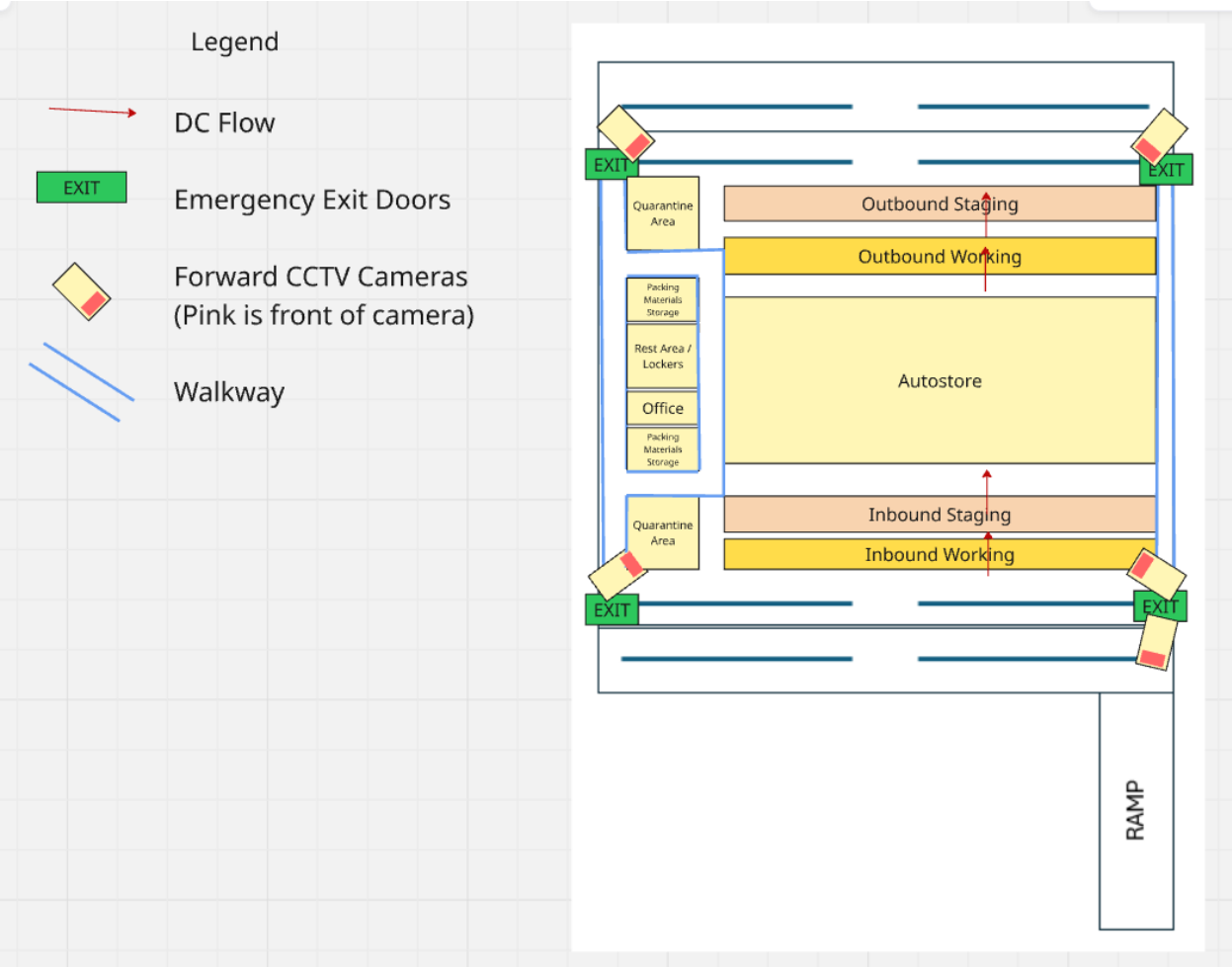
Monthly Volume = 1189 × 7 days × 4 weeks = 33292

Total amount of capital investment = $800000

Monthly desired cash flow = 800000 × $(1 + 0.05)^5$ ÷ 5 ÷ 12 = $17017.09

Selling Rate – Storage = (17017.09 ÷ 33292) × 1.2 = $0.61 per piece

D. The following is the proposed sketch for the DC Layout



Planning Methodology:

The DC will be an I shape flow. We will be using Auto Store for the storage system. There is a high number of backpacks flowing, and I shape reduces confusion as there is a clear separation between inbound and outbound. Compared to “U shape” which is more error prone due to its compact design and unclear separation between inbound and outbound operations.

There’s no need for a U shape design forward picking is not needed with Auto Store. It’s more scalable due to the simplistic design of a straight through flow, and it’s better suited for automation, e.g. conveyers can be easily integrated due to the predictable path of a straight line.

Emergency exits at each corner allow easy navigation and accessibility from anywhere in the Distribution Center. Even if you don't know where the emergency exit is, you will run into one as long as you try to exit the DC.

Cameras at each corner to capture traffic into and out from the DC. The emergency exits are vulnerable as they can be used to sneak out of the DC. Hence, each exit has a camera monitoring it's in and out traffic. The camera outside captures high traffic, as it's the main entrance and exit for goods, and vehicles arrive there providing valuable information in the case of accidents or theft.

There are no cameras in the Auto Store because it's surrounded by four walls, compartmentalized by bins, and operated by a robot. There are records in the system when goods are picked or put away.

The pedestrian walkway allows easy access and provides return paths throughout the DC to many different areas. It helps to reduce chances of accidents between pickers and vehicles when handlers are in motion.

FIFO Requirement

Auto Store performs FIFO by using its software to track the timestamps of items stored in each bin and retrieve the oldest stock first. Since bins are stacked vertically, the system may need to move upper bins to access older inventory below, a process known as "digging."

Storage Height

The maximum height is 14m as the ceiling is 14m. Only the storage area may exceed it unlike working and staging areas. Auto Store is usually 4-6 meters high, so there is no need to worry about its height. However, there is no information on the backpack's dimensions so we can't derive the number of bins for the Auto Store

MHE Charging Station

There is no MHEs, hence no charging station required for it.

E. Derived Requirements

Note: Instead of using Maximum Capacity (95th Percentile) to calculate requirements. The max volume is used, as using Maximum Capacity could result in insufficient storage space which could lead to delays, and it acts as a buffer of 20 – 30%. That is a low price to pay relative to the risks and issues delays poses.

Number of Dock Doors required

Assumptions:

a. Only inbound is needed, as outbound is handled by freight forwarder. Shipping Carton is handed over to Freight Forwarder. Hence, no outbound dock door.

Outbound Activity	• Outbound function expected to open 24-hour, 7-day-per-week.
	• Daily orders generated in 3 batches daily
	  • 1st Batch printed at 0700hr; to be completed by 1300hr of the same day (25% of daily volume)
	  • 2nd Batch printed at 1300hr; to be completed by 1900hr of the same day (25% of daily volume)
	  • 3rd Batch printed at 1900hr; to be completed by 0700hr of the next morning (50% of daily volume)
	• Labels for "Destination Address" to be pasted on the Outbound Shipping Carton before handing over to the Freight Forwarder.
	• Estimated number of Freight Forwarder's Pick-up for whole working day : 80 trucks

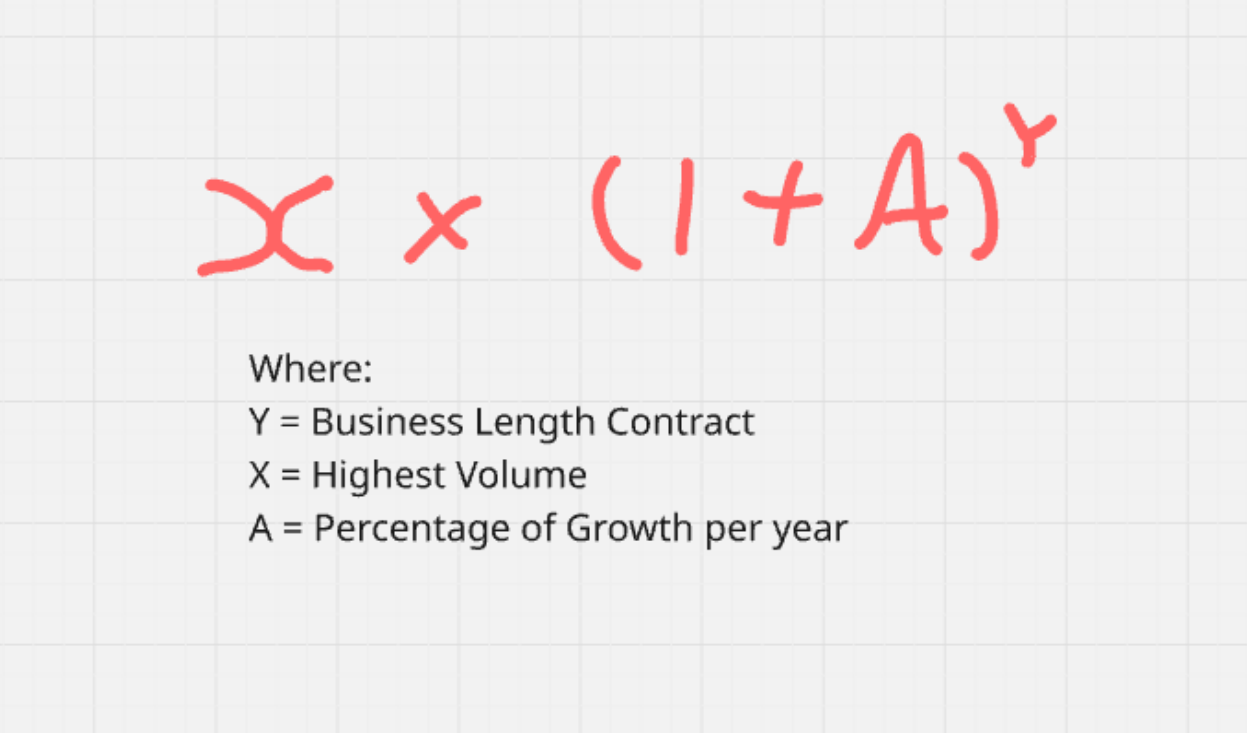
b. 1 dock door per 1 handler, for highest efficiency as there is no confusion and bottlenecks
c. Highest volume of cartons is 2400, according to TRAVEL PAL's historical data
d. Growth is 10% per annum, length of contract is 5 years

Calculations:

Step 1: Find Highest Volume of Cartons While Accounting For Growth

The Highest Volume of Cartons and Growth must be accounted for, as dock doors cannot be easily expanded or changed.

Derived Formula:



Hence, 2400 * $(1+0.1)^5$ = 3866 cartons (rounded up)

Step 2: Find Number of Containers

Derived Formula to Get Containers from Cartons:

Each full pallet has 12 cartons max. Hence, amt of pallets = amt of cartons/12

Each container has 20 pallets max. Hence, amt of containers = amt of pallets/20

Formula for Number of Containers = ((Cartons / 12) / 20)

Using the highest volume of cartons for calculation while accounting for growth will make the container account for growth and peak volume as well.

Using the highest volume of cartons while accounting for growth. Therefore, number of containers is ((3866 / 12) / 20) = 17 (rounded up)

Step 3: Find Time Taken to Unload Each Container

Each container has 20 pallets. Each handler unloads 45 pallets per container every hour, according to the productivity guidelines. Assuming there's one handler.

Productivity Guideline – INBOUND

Process Category	Task	Productivity per man-hour	UOM	Activity	Remarks
Receiving	Unload Full Pallets from container	45	Pallet	R1, R4, R6	Manual / Auto

Hence, time taken to finish unloading each container (measured by hours). It's calculated by pallets per container / pallets unloaded every hour. It takes 20/45 hours, which is roughly 0.44 hours.

Step 4: Calculate number of docks

Derived Formula:

(Inbound Containers * Time Taken to Unload Each Container) / Working Hours Per Day

Containers = 16 (Accounts for growth and peak volume, in step 1 and 2)

Time Taken to Unload Each Container (measured by hours) = 0.44 hours

Working Hours Per Day = 8.5 hours.

(16 * (20/45)) / 8.5 = 1 (rounded up).

In conclusion, the **number of docks required is 1 dock** accounting for growth and peak volume. Outbound cartons are handed over to freight forwarder so there is no need for outbound dock doors.

Area of Working Space and Staging Space (for both Outbound and Inbound)

Staging Spaces

Assumptions:

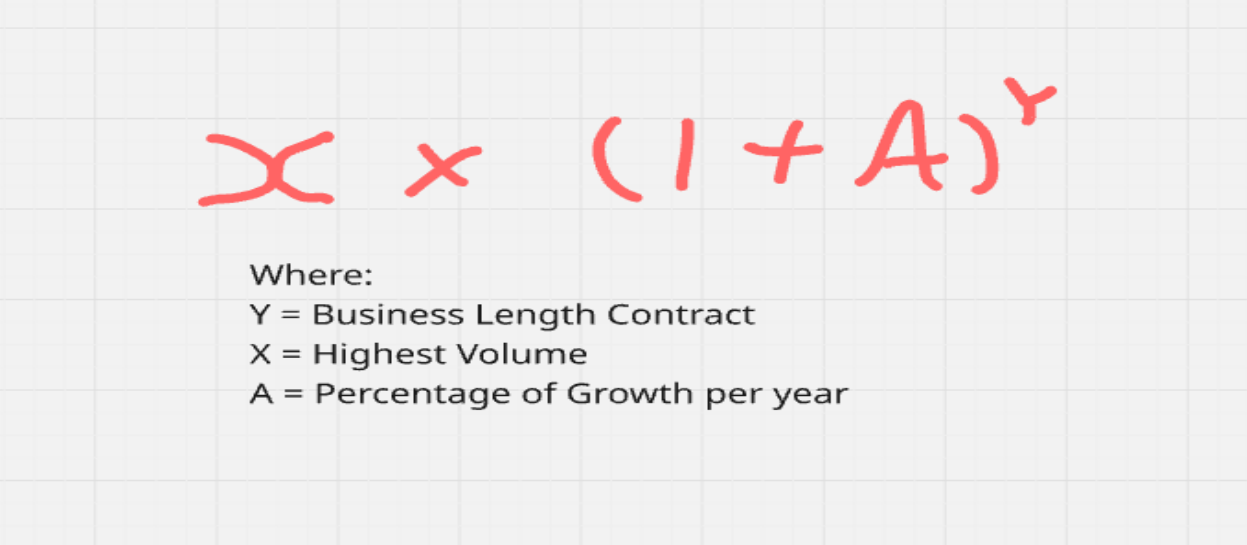
a. Pallet dimensions are 1.2m x 1.1m
b. Factor for Access Aisle is 60%
c. Staging Space handles 30% of shift volume

Calculations:

Step 1: Find Highest Outbound Cartons Volume While Accounting for Growth

The Highest Volume of Cartons and Growth must be accounted for, as space allocations cannot be easily expanded or changed.

Derived Formula:



Inbound Volume Cartons = 2400 (from TRAVEL PAL's historical data highest inbound volume)

Hence, $2400 * (1+0.1)^5 = 3866$ cartons (rounded up, one piece per carton)

Outbound Volume Cartons = 1865 (from TRAVEL PAL's historical data)

Hence, $1865 * (1+0.1)^5 = 3004$ cartons (rounded up, one piece per carton)

Step 2: Get amount of pallets at any point of time

Staging spaces expected to hold 30% of Shift volume at any point in time

Each full pallet has 12 cartons max. Hence, amt of pallets = amt of cartons/12. Daily volume is shift volume for inbound as there is only one shift.

Inbound shift pallet volume: 3866 / 12 = 323 (rounded up)

323 is inbound pallet shift volume. Hence, 323 * 0.3 = 97 pallets (rounded up)

16 Outbound Shipping Cartons is equivalent to 1 pallet space

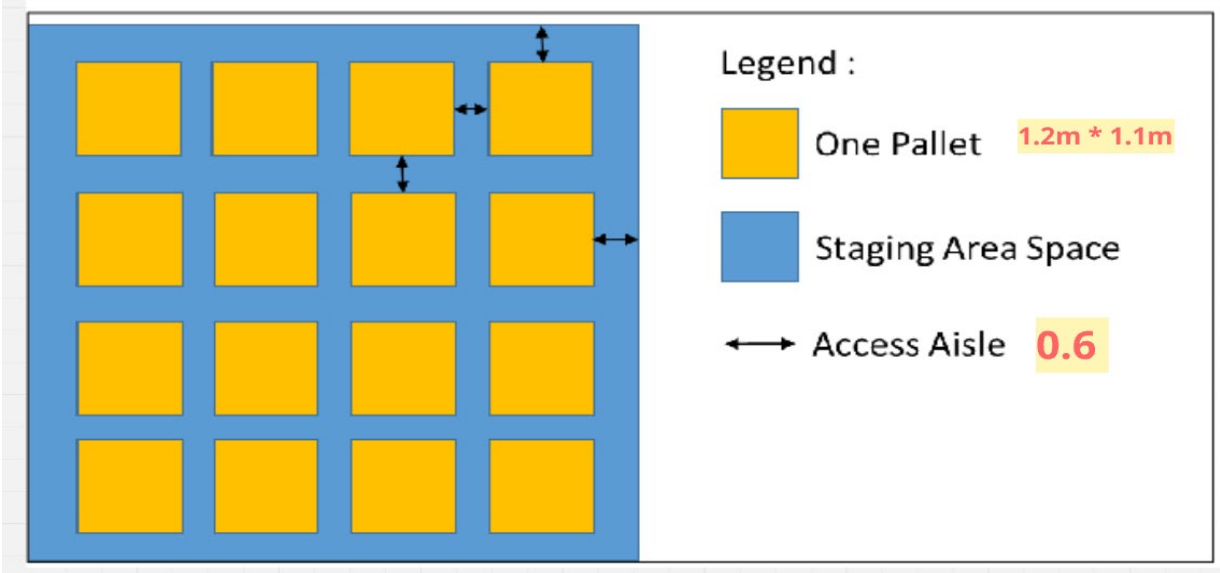
Outbound daily pallet volume: 3004 cartons / 16 = 188 pallets (rounded up)

There are 2 x 12 hours shifts. Hence, each shift handles 188 / 2 = 94 pallets (rounded up)

94 is outbound pallet shift volume. Hence, 94 * 0.3 = 29 pallets (rounded up)

Step 3: Calculate staging area space

The dimension of a pallet is 1.2m x 1.1m. Hence, the area of one pallet: 1.2 * 1.1 = 1.32 m^2
Access Aisle for Staging Space = 60%



The formula is taken from the course material. It calculates the amount of space for staging area while accounting for aisle access.

The formula to determine the space for Staging Area is :

- **Inbound / Outbound Staging Area**
  = Area of One Pallet ×
  Target No. of Pallets Received or Shipped at a point in time ×
  (1 + Factor for Access Aisle)

In conclusion,

Inbound Staging Area Space: 1.32 * 97 * (1+0.6) = 205 m^2 (rounded up)

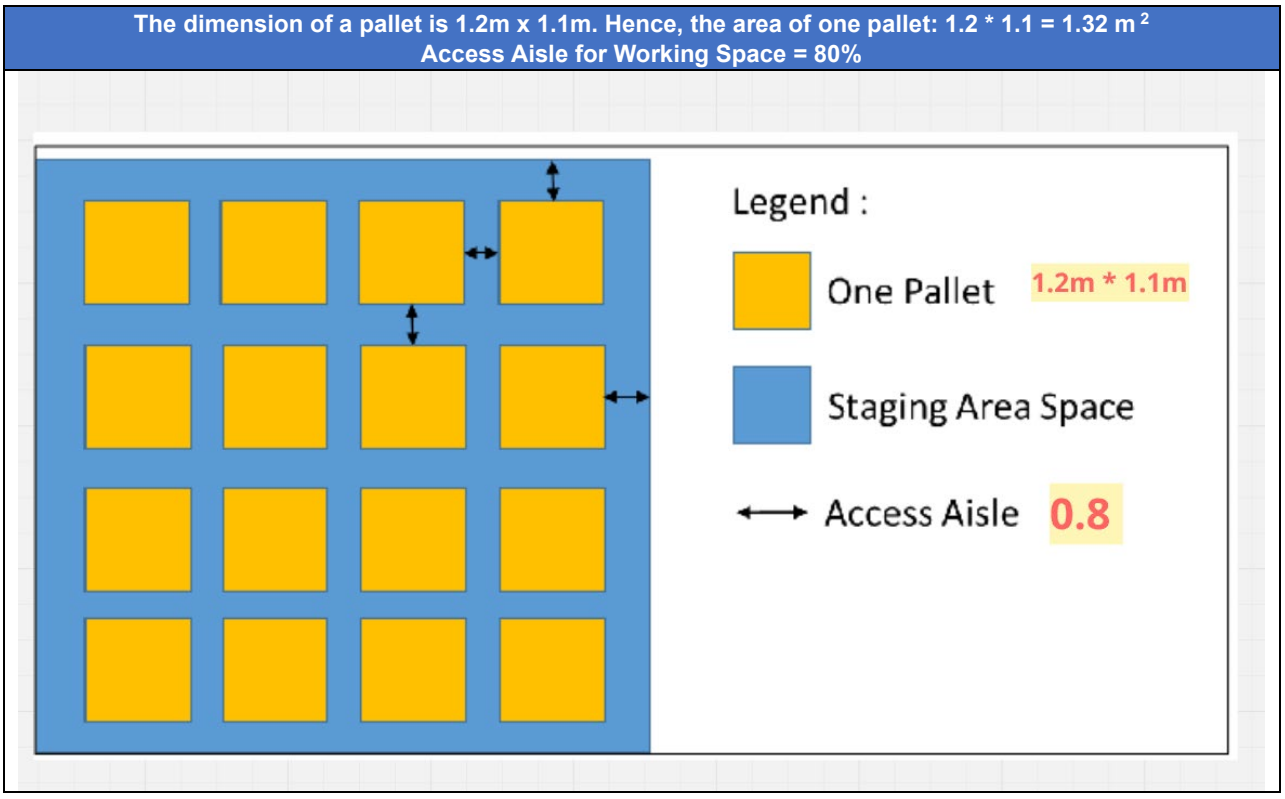
Outbound Staging Area Space: 1.32 * 29 * (1+0.6) = 62 m^2 (rounded up)

Working Spaces

Using assumptions, and calculations derived from staging space calculation above, and the following.

Assumptions:

Access Aisle for Working Space = 80%



The formula is taken from the course material. It calculates the amount of space for working area while accounting for aisle access.

- **Inbound / Outbound Working Area**

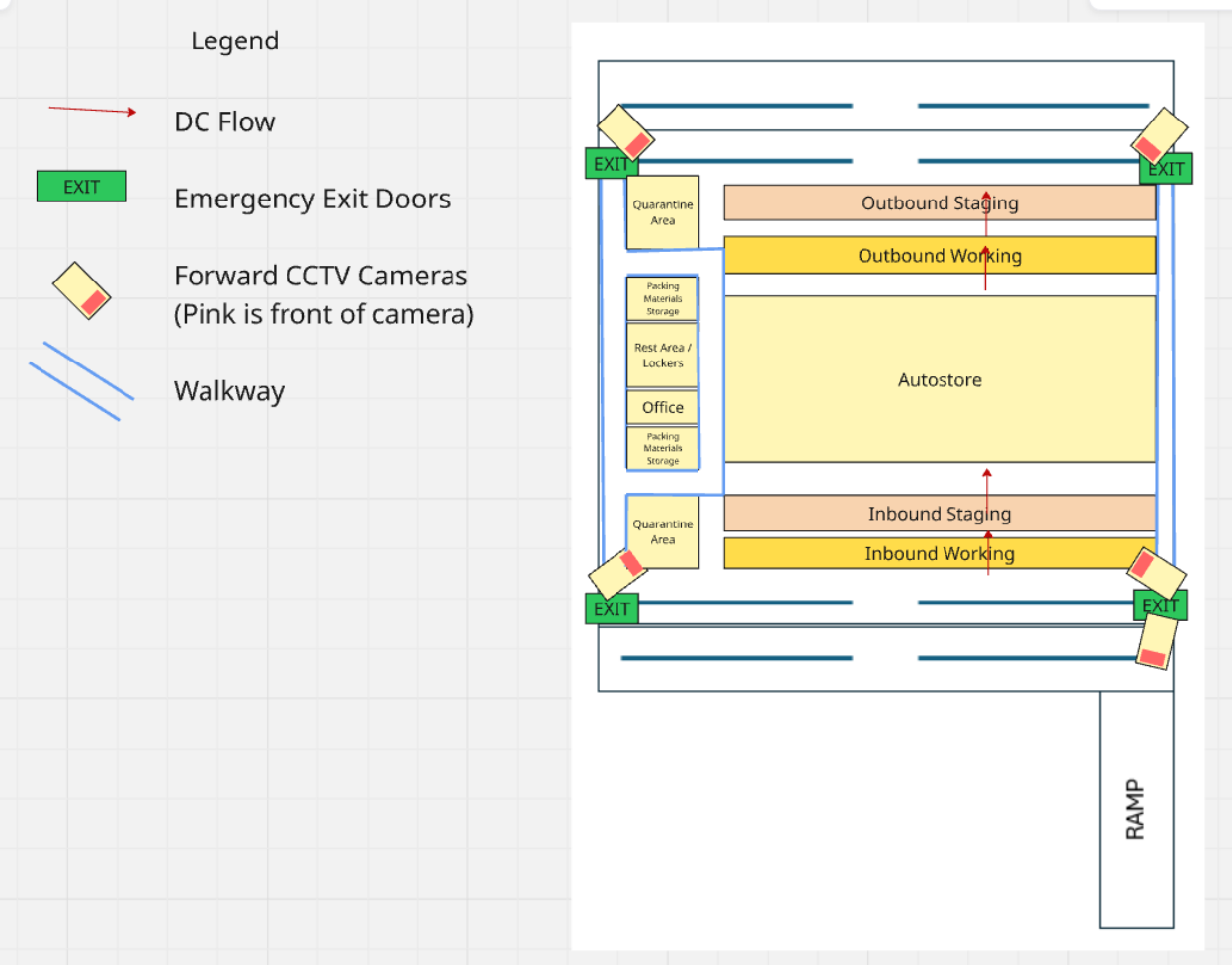
  = Area of One Pallet ×
  Target No. of Pallets Received or Shipped at a point in time ×
  1 + Factor for Working Space)

In conclusion,

Inbound Working Area Space: 1.32 * 97 * (1+0.8) = 231 m^2 (rounded up)

Outbound Working Area Space: 1.32 * 29 * (1+0.8) = 69 m^2 (rounded up)

Estimated total DC space area



The Distribution Center contains:

1. Auto Store Area
2. Inbound/Outbound Staging Area
3. Inbound/Outbound Working Area

Working and Staging Space area

((231 + 62) + (205 + 69)) * (1+0.25) = 709 m^2 (Rounded Up)

Hence, total Area

709 + 10000 = <u>10709 m^2</u>

F. Pallet-In-Pallet-Out operation

Recommended: Drive-Thru Racking
FIFO is a requirement and there's low SKUs (30 SKUs), which are well suited and high volume per SKU. Maximizes storage density by removing aisles between racks. Suitable for storing large quantities of the same SKU in lanes. Also, it costs less than VNA.

Comparison of Palletised Storage System

Factor	Floor	Drive-In	Drive-Thru	Push-Back	PLS	APR	DDR	VNA	Mobile
Utilisation of Building's Horizonal Floor Space	5	5	5	5	5	1	3	4	5
Utilisation of Building's Vertical Height	1	4	4	4	4	4	4	5	4
Cost of Investment	1	3	3	4	5	2	3	4	5
Support of FIFO	1	1	5	1	5	5	4	5	5
Support of fast productivity	4	3	4	3	5	5	4	5	1
Ability to access to Ground Cargo	5	1	1	1	1	5	5	4	5
Ability to use during Power Outage	5	5	5	5	3	5	5	5	1

The highest volume of balance is now 4064. In three years' time it will be 4064 * $(1+0.1)^3$ = 5410 cartons (rounded up). Hence, the number of pallets is derived by cartons divided by inbound cartons per pallet. 5410 / 12 = 451 pallets (rounded up). Pallet locations require 30% of total business pallet volume, which is 451 * 0.3 = 136 pallets (rounded up)
The formula for growth is shown below.

$$X \times (1+A)^Y$$

Where:
Y = Business Length Contract
X = Highest Volume
A = Percentage of Growth per year

Drive Thru Racking is Tier 5 (max tier), as the maximum height is 14m. The highest point of cargo is only 10m lower than the ceiling max height.

Height of Palletised Storage System

Storage Solutions	Highest Beam – Measurement from Floor Level	Highest Point of Cargo –Measurement from Floor Level
Floor Storage	N.A.	5m (depending on cargo)
Drive-In / Drive-Thru	8.0 m	10.0 m
Push-Back Rack	8.0 m	10.0 m
Palletised Live Storage	10.0 m	12.0 m
APR	10.0 m	12.0 m
DDR	10.0 m	12.0 m
Powered Mobile Storage	10.0 m	12.0 m
VNA	15.0 m	17.0 m

Hence, technical space per pallet is 0.37

PROJECT BRIEF

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(2b) Technical Space per Pallet – for Question (f)

Technical Space per Pallet (m^2)

No. of Pallet Tier	Floor Storage	APR	Double-Deep	Drive-In	Drive-Thru	Push-Back	VNA	PLS	Mobile
2	1.10	1.65	1.37	0.92	0.92	0.91	1.17	0.91	0.94
3	0.73	1.10	0.91	0.61	0.61	0.61	0.78	0.61	0.63
4	-	0.82	0.69	0.46	0.46	0.46	0.58	0.46	0.47
5	-	0.66	0.55	0.37	0.37	0.37	0.47	0.37	0.38
6	-	0.55	0.46	-	-	-	0.39	0.30	0.31
7	-	-	-	-	-	-	0.33	-	-
8	-	-	-	-	-	-	0.29	-	-

Assuming Height of DC Facility = 14 metres

Honey combing factor for Drive Thru Racking is 70%

Key : Ranked from 1 (being very low) to 5 (very high)

Factor	Floor	Drive-In	Drive-Thru	Push-Back	PLS	APR	DDR	VNA	Mobile
No. of Pallets per SKU	≥ 10	≥ 8	≥ 8	≥ 8	≥ 10	≥ 1	≥ 2	≥ 1	≥ 1
Honeycombing Factor	70%	70%	70%	70%	70%	95%	85%	95%	95%

Source : Rushton, Oxley & Croucher (modified)

Using the Storage Area formula.
The standing storage space area is (0.37 / 0.7) * 136 = 72m ^{2}

The formula for Storage Area is :

- Storage Area
  = Technical Area per Pallet ÷
  Honeycombing Factor of the specified Storage System ×
  Forecasted No. of Pallets to be stored

Conclusion

The proposed system supports daily operations through efficient manpower planning, thoughtful layout design, and the use of Auto Store. It accounts for variations in inbound and outbound volume, preventing overstaffing, and includes buffers to handle unexpected surges. Additionally, the facility is structured to transition smoothly into a Pallet-In-Pallet-Out model when TRAVEL PAL expands its business. Our detailed approach to staffing, space, equipment, and pricing ensures reliability and long-term adaptability.

Overall, this plan sets up TRAVEL PAL for sustained growth while giving QUICK-QUICK LOGISTICS a solid foundation to deliver results as a reliable third-party logistics partner. With the systems and strategies in place, the distribution center is well positioned to support TRAVEL PAL's success in the coming years.

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