Intelligent Surgical Instrument Stock Inventory Management

IE3100M System Design Project | Group 13

Department of Industrial and System Engineering and Management

(AY 2021/2022)

Background

About SingHealth: Formed in 2000, SingHealth is the largest group of healthcare institutions in Singapore consisting of public hospitals, private hospitals, national specialty centers and polyclinics.

It aims to deliver appropriate and accessible high quality care, nurture healthcare professionals and pursue innovations to

Motivation

When conducting surgeries, apart from instruments prepared one day ahead, ad-hoc requests for loose surgical instruments can be raised by Operation Theatres during operations. Normally, nurses would need to deliver the item manually, which is a waste of manpower, especially for these specialized nurses. Our project aims to **save manpower and cost by utilizing AGV**.

Project Objective

NHIC launched the Intelligent Surgical Instruments Management (iSIM) project to tackle the issue at hand by automating these repetitive manual tasks so that healthcare workers' manpower can be used more efficiently. The iSIM includes two parts: iSIM-Gonzales and iSIM-Goldfinger. This project focuses on assisting iSIM-Gonzales which proposes to **use Automated Guided Vehicles (AGVs) in responding to ad-hoc surgical instrument requests**.

Similar to iSIM's goal, the objective of this project is to find a **balance between the man hour of nurses used to handle ad-hoc**

Methodology

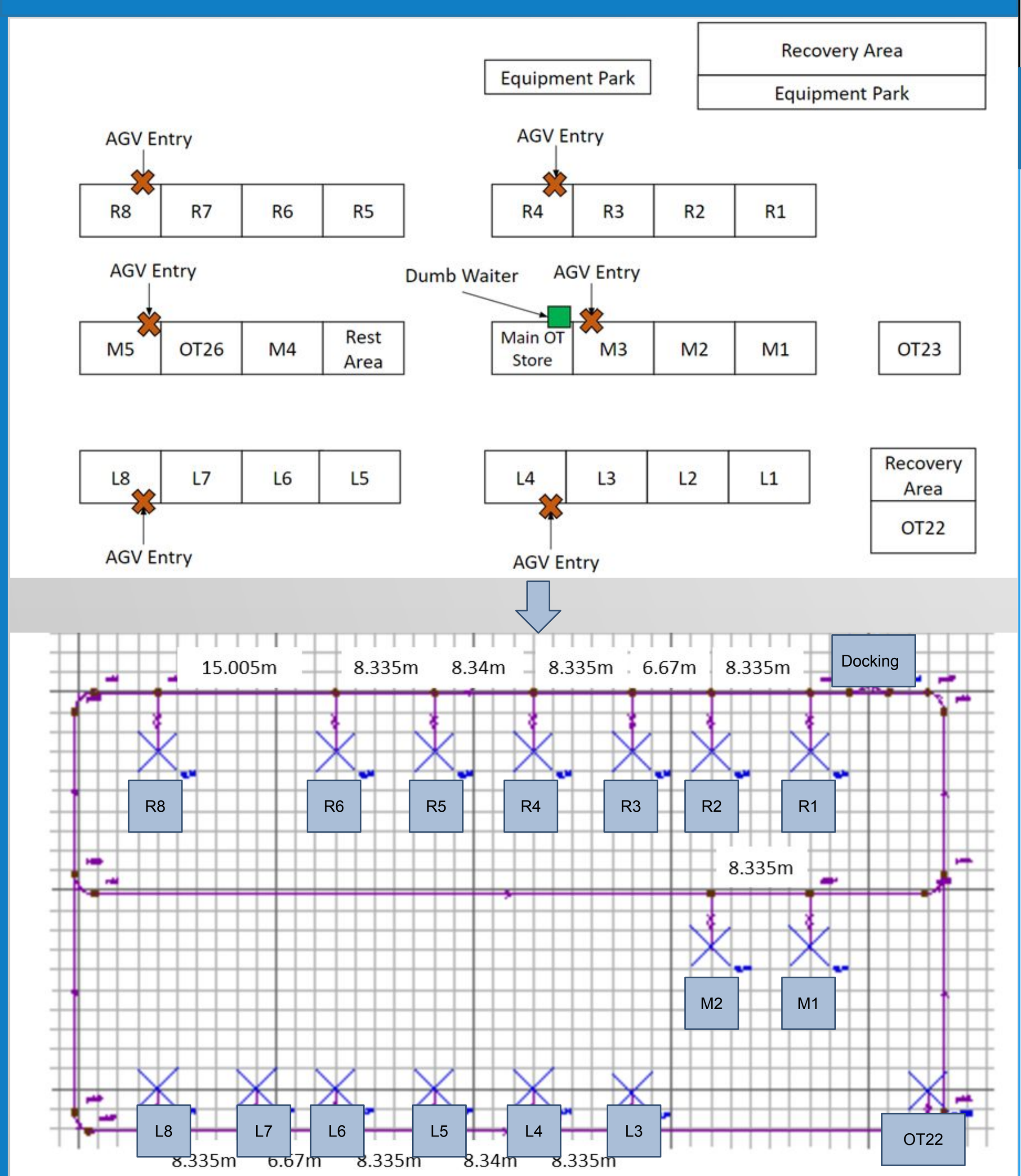
We will be simulating the use of AGVs in serving surgical instrument ad-hoc requests. Each AGV, capable of holding and dispensing (ie. peeling of the packages) **six individual surgical instruments**, will be designed to travel to the designated OTs locations to fulfil these ad-hoc requests.

Automod simulation software will be used to assist us in finding the optimal implementation solution for the AGVs.

These 2 areas will be our focus:

1. To find out the **optimal docking area** for AGVs
2. To find out the **optimal combination of AGV restocking frequency & number of AGVs required** as well as the **cost saved** given a desired AGV utilisation rate.

PMS Model (Simulates Actual Layout)



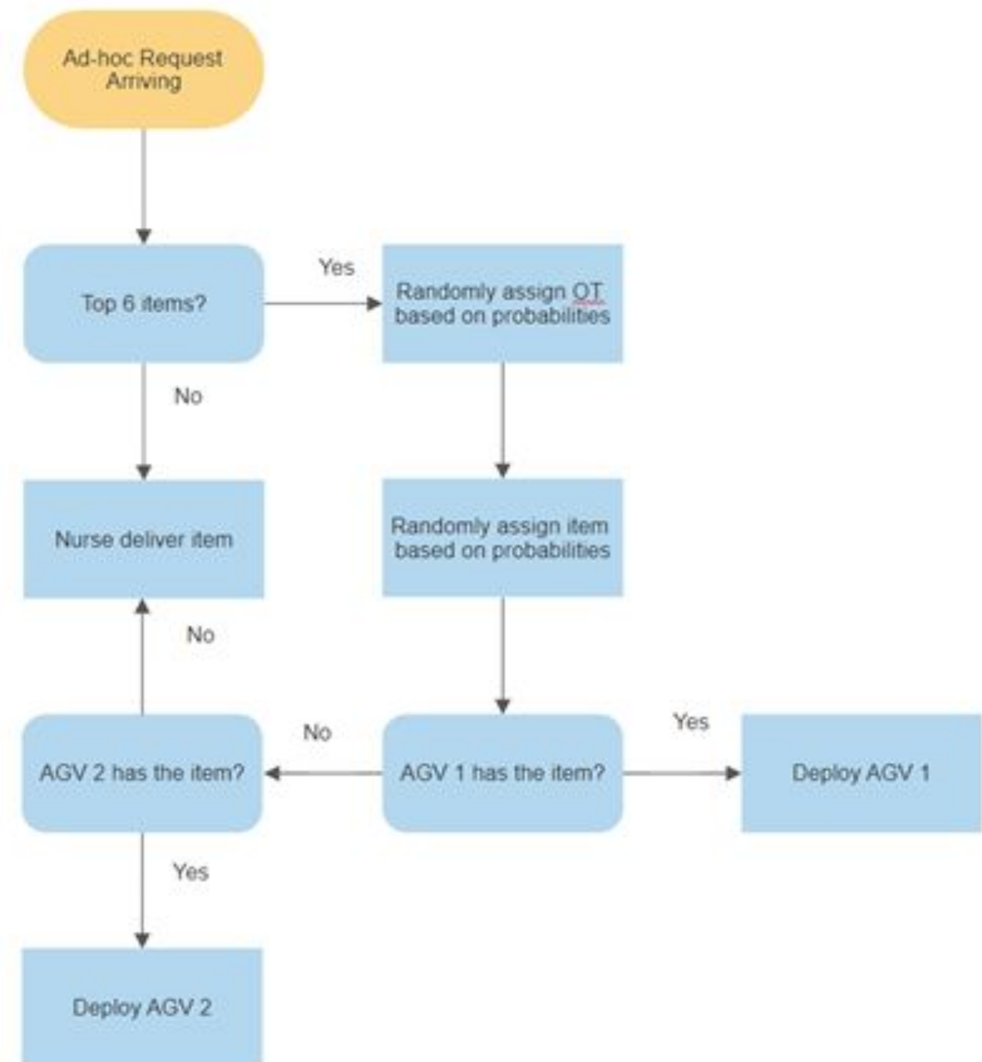
Ad-hoc Frequency

Historical Data of ad-hoc requests are provided. The **top six most frequently requested** loose instruments are loaded in the AGV and thus can be delivered by AGV when requested.

When an ad-hoc request arrives in the system, **three judgments** will be randomly assigned by the model based on calculated probabilities:

- Whether this request belongs to the top 6 instruments?
- Which OT requests the instrument?
- Which type of instrument has been requested?

Main Logic of System



Data Inputs

Name	Data	Remarks
Interarrival time between each ad-hoc request	Normally distributed with mean 36 min, standard deviation 5 min.	Estimated from data
Velocity of AGV	0.5 m/s	Expert Opinion
Time for restocking by nurses	150 s	Expert Opinion
Time for nurse to deliver an item	Normally distributed with mean 20 min, standard deviation 4 min.	Estimated from data

Optimal docking location

Besides the original layout where docking location is at **top right, bottom right, top left and bottom left** are selected as alternative docking location to be tested.

The **average time for an AGV serving an ad-hoc request** is collected from simulating PMS model under different scenarios (restocking frequency ranging from 1 to 5 time per day with 2 AGV deployed). A **smaller** value of time implies better performance.

Optimal docking location: **Top Right**

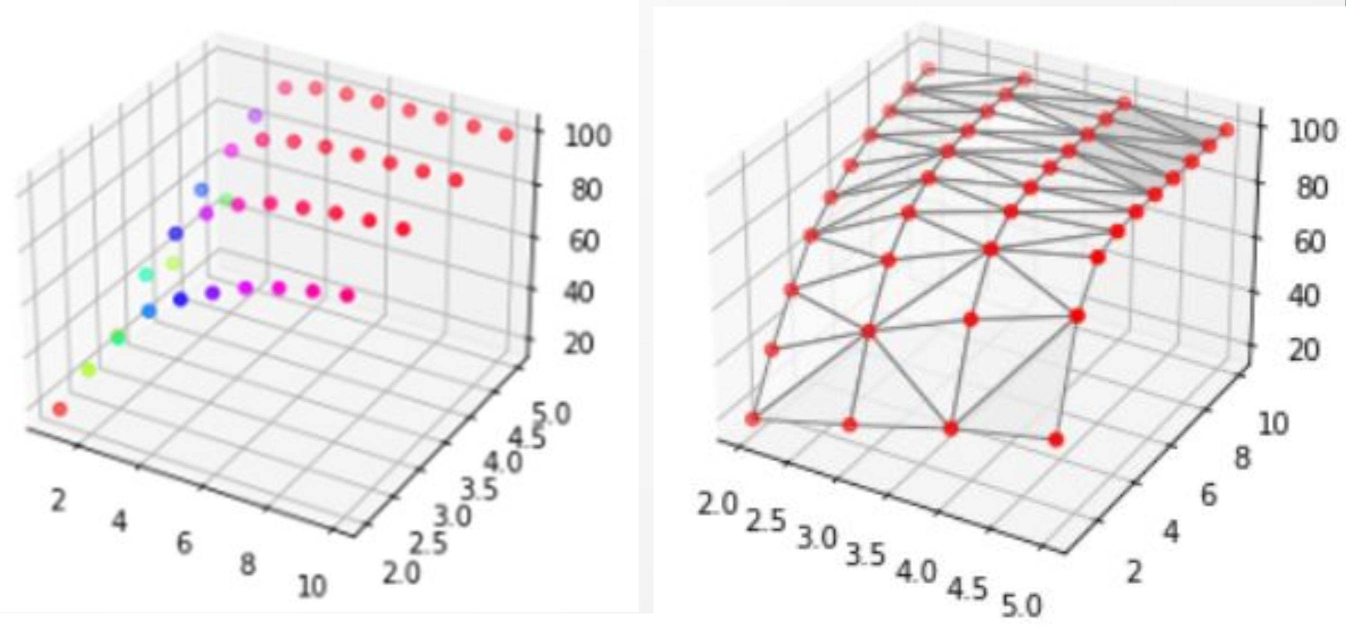
Restocking	Top right (seconds)	Bottom right (Seconds)	Top left (Seconds)	Bottom left (Seconds)
1	236.34	322.25	291.6	333.5
2	228.48	319.08	289.36	331.78
3	213.98	325.3	287.44	328.88
4	217.55	317.65	292.39	321.89
5	213.24	321.66	288.38	324.75

Optimal frequency-number combination

To determine the optimal combination of **restocking frequency** and **number of AGV** given a **predetermined AGV utilisation target**, sensitivity analysis is applied with consideration of the costs.

Optimal combination: **the combination with the lowest cost.**

Combination based on utilisation rate



x-axis: frequency y-axis: agv z-axis: utilisation rate

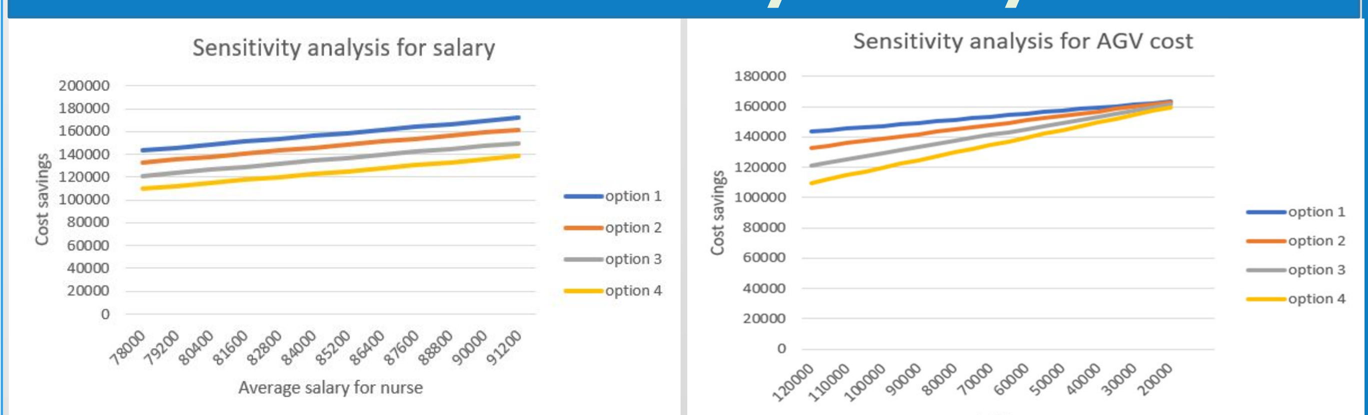
AGV utilisation rate	Restocking frequency	Number of AGV required
50	3	2
	2	3
	2	4
	2	5
60	4	2
	3	3
	2	4
	2	5
70	5	2
	3	3
	2	4
	2	5
80	6	2
	4	3
	3	4
	2	5
90	9	2
	5	3
	4	4
	3	5
100	NA	NA
	NA	NA
	NA	NA
	NA	NA

The combinations achieving **80% utilisation rate** are:

Frequency = 6, AGV = 2 | Frequency = 4, AGV = 3

Frequency = 3, AGV = 4 | Frequency = 2, AGV = 5

Costs sensitivity Analysis



Increasing nurse manpower cost (left) | Decreasing AGV cost (right)

Optimal solution (90% utilisation rate):

Option 1 with $143383 cost saving per year

Conclusion

Using simulation, sensitivity and statistical analysis, we have come to the conclusion that:

1) Top right corner will be the **optimal docking location**
2) Any AGV implementation solution will have its trades off and it depends on the stakeholders' priorities, budget and desired utilisation rate

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