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Enhancing Automotive After-Sales Service Shop Layout: Shop & Drive Systematic Layout Planning for Facility Design and Workflow Optimization

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Abstract

Shop & Drive is a vehicle service chain operating in the after-sales service sector, focusing on swift service and quick turnover of parts for car and motorcycle maintenance. However, one of their workshops located in Margonda faces significant challenges in optimizing its service area, affecting customer service efficiency. This study utilizes Systematic Layout Planning (SLP) methods to revamp the facility layout at Shop & Drive Margonda by processing field data using various techniques such as Activity Relationship Chart, Activity Relationship Diagram, Area Allocation Diagram, and material flow analysis to propose alternative layouts. The resulting layout adjustments significantly reduced non-operational areas in the workshop by 47.8%, reduced material flow movement for the car oil change service process and the car shock absorber replacement service process by 47.42% and 42.84% respectively and reduced the number of operators from 7 to 6 workers.

Keywords
After-sales Service, Car Workshop, Facility Layout, Optimization, Systematic Layout Planning.

1. Introduction
Facilities planning holds a pivotal role in augmenting efficiency across various industry sectors. Its primary aim is to bolster all company operations, fostering overall advancement. Thus, every organization necessitates a well-designed

plant layout to minimize process duration and material handling, eliminating unnecessary tasks while optimizing operations for maximum efficiency (Kumar and Naga Malleswari, 2022). A streamlined plant layout can significantly elevate productivity and enhance customer satisfaction, ultimately impacting a company's profitability.

Research from NIOSH highlighted that a thoughtfully structured layout reduces employee fatigue and musculoskeletal issues, fostering enhanced morale and productivity (Waters, 2006), ultimately boosting customer satisfaction. Another study demonstrated that an efficient layout cut service duration, translating to reduced customer wait times and increased satisfaction (Azmi, 2021). These previous research shows that in many companies, particularly in after-sales, customer satisfaction remains crucial, making a well-organized car and motorcycle workshop layout important for enhancing customer satisfaction.

Shop & Drive operates in the after-sales service sector, specializing in prompt service, rapid turnover of general parts, and associated services for both car and motorcycle maintenance. With a nationwide presence, Shop & Drive boasts a total of 370 outlets across Indonesia. This study is specifically centered on the Margonda branch, which extends services to customers daily from 9 AM to 9 PM, encompassing in-store service and deliveries. The branch offers a variety of service options, including oil, shock absorber, and battery services.

Considering Shop & Drive constant rush to serve customers and limited workforce, optimizing the layout becomes crucial to ensure service efficiency. By achieving service efficiency, a company can achieve not only effective service for its customer satisfaction, but also maintain the lowest possible costs in the process of creating a product and/or service for consumer consumption. To gain more accurate and beneficial results, researchers are employing the Systematic Layout Planning (SLP) method to redesign Shop & Drive Margonda's facility layout.

1.1 Objectives
The objectives of this research are: 1) determine the area of each room of the current Shop & Drive workshop; 2) assess the current expenses for materials, necessary tools, required materials, and the workforce size along with their shifts; 3) create an enhanced layout using Systematic Layout Planning methodologies; and 4) compare the space utilized, material costs, required tools and materials, and the workforce before and after the improvements.

2. Literature Review
2.1 Facility Planning
Facility planning is the process of designing spatial layouts, involving analysis, planning, design, and arrangement of spaces, equipment, and workforce aimed at enhancing production efficiency and service systems (Hari Purnomo, 2004). On the other hand, James M. Apple (1990) describes facility layout as the concept, design, and implementation of production systems for goods and services. Well-organized facility layouts typically foster efficiency and sustain the smooth functioning or success of a company (Eko Sri Wahyudi, 2010). Hence, facility layout, that is, facility design, analysis, conceptual and manufacture of systems for a good or service, is an important decision that determines the efficiency of an operation in the long term. (Wibowo et al., 2016)

2.2 Systematic Layout Planning
Systematic Layout Planning (SLP) is a method employed to organize workplace layouts within a plant, emphasizing the strategic placement of workstations based on their frequent interactions. According to Tomkins (2003), the SLP method involves utilizing diagrams, worksheets, and activity relationship diagrams within production facility layouts to design an efficient flow of goods through layout planning. SLP approach incorporates various visual tools and activity interrelationship diagrams to strategically plan the flow of materials within the layout, aiming for enhanced efficiency and streamlined operations. Essential input data for SLP include five key elements: product (P), production (Q), production line (R), auxiliary service department (S), and production plan (T). Among these, P and Q form the foundation for all other conditions (Li et al., 2021). SLP method involves four phases (Heragu, 2022):

a. Phase I : Identifying the area to be laid out.
b. Phase II : Determining the general arrangement of the designated area.
c. Phase III: Allocating machinery and equipment to specific locations.
d. Phase IV: Planning the installation, obtaining approval, and executing necessary physical changes.

2.3 Activity Worksheet
Activity Worksheet is a tool used to analyze the relationship between activities conducted in a facility layout, showcasing the relationships among activities and the strengths of each relationship. Its purpose lies in identifying the types of activities conducted in a work process and used as a basis to identify optimal process layouts among workstations when improving a facility layout. The rating system used in Activity Worksheets is typically a six-point scale as shown in Table 1 (Muther and Hales, 1913).

Table 1. Activity Worksheet Rating System

Code	Definition
A	Absolutely important closeness relationship between activities
E	Extremely important closeness relationship between activities
Code	**Definition**
I	Important closeness relationship between activities
O	Ordinary closeness relationship between activities
U	No relation necessary between activities
X	Undesirable relations between activities

2.4 Activity Relationship Chart
An Activity Relationship Chart (ARC) is a simple tool used to analyze the relationships between activities or departments in a facility layout. It is a graphical representation of the relationships between activities, with the strength of the relationships indicated by a rating system. ARCs are used in a variety of industries, including manufacturing, warehousing, and retail. They can be used to identify potential bottlenecks or inefficiencies in the layout, determine the appropriate amount of space for each activity, and communicate the proposed layout to stakeholders. The rating system used in ARCs is typically a six-point scale as shown in Table 1 (Muther and Hales, 1913).

2.5 Activity Relationship Diagram
The Activity Relationship Diagram (ARD) serves as a block diagram outlining the general activity connections, representing each task as a distinct element (Apple, 1990). Its purpose lies in structuring the correlation between material flow patterns and the positioning of service-related activities to facilitate the planning and assessment of connections among tasks. This diagram shows the information presented in an Activity Relationship Chart in a unified diagram format, and thus uses the same six-point rating system by Muther and Hales as seen in Table 1.

2.6 Area Allocation Diagram
Area Allocation Diagram is a tool used to provide a visual representation of workstation areas relative to one another as parts of an accurate scaled depiction of the workplace layout. An Area Allocation Diagram depicts the locations of each workstation area based on the analysis conducted through Activity Relationship Charts and Activity Relationship Diagrams in scale to accurately depict the positioning of each workstation within the available area of the facility layout. The Area Allocation Diagram is used to simplify the facility layout design process to position related workstations close to each other while considering the available area within the facility layout, allowing for efficiency in systematic area allocation.

3. Methods
The study was conducted at the Margonda branch of Shop & Drive, with a projected completion time of two months, spanning from October to December 2023. The process for restructuring the production floor involves three key phases: 1) analyzing the current layout; 2) designing the plant layout using SLP principles; and 3) evaluating various layout alternatives as seen on Figure 1. The research objectives were defined based on existing issues, followed by setting research scope. Data collection comprised measurements of the service floor area, service area size, machinery and equipment used, production volume, and cycle times for each production process. Subsequently, data processing factored in production process distances and times to generate new layout designs or alternatives, aiming to minimize waste. The study ends by drawing conclusions and offering recommendations based on the research findings.

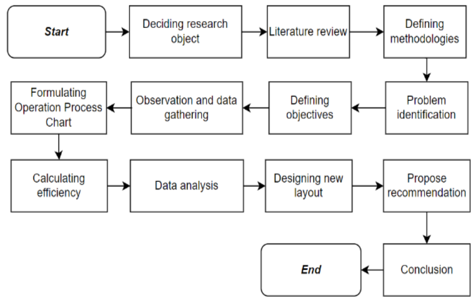


Figure 1. Research Methodology

4. Data Collection

4.1 Existing Layout

In conducting facility layout optimization on Shop & Drive Margonda, field observation is conducted at the site to collect quantitative data on the facility and to evaluate room for improvement within the facility. Data collection is done by primary research, mainly through on-site measurements and observations, combined with expert interviews conducted with the operators working in Shop & Drive Margonda. Based on data collected on the service floor of Shop & Drive Margonda, the overall area of the production floor is recorded at 201.72 m^2. The existing service area layout of Shop & Drive Margonda can be seen in Figure 2. Table 2 shows the floor area and dimensions of each workstation based on the existing layout of Shop & Drive Margonda.

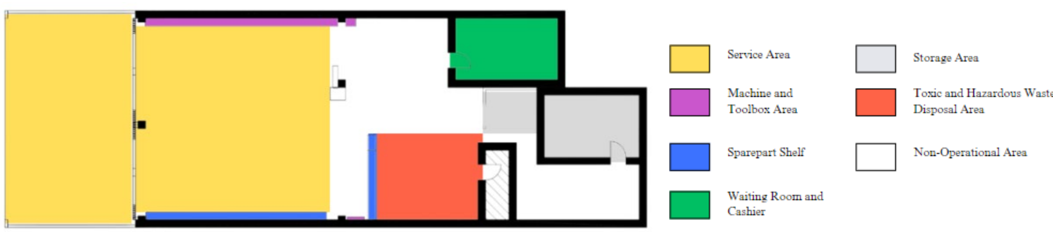


Figure 2. Existing Layout of Shop & Drive Margonda

Table 2. Dimensions of Shop & Drive Margonda Existing Workshop Layout

Function	Work Area	Total	Dimensions		Area (m^2)	Area Allocation Percentage (%)
			Length (m)	Width (m)		
Service Area	Outdoor	1	5.00	8.20	41.00	20.33%
	Indoor	1	7.50	7.26	54.45	26.99%
Inventory and Materials	Machine and Toolbox Area	1	7.52	0.30	2.26	1.12%
	Spare Part Shelf	1	10.70	0.30	3.21	1.59%
	Storage Area	1	5.50	2.36	12.99	6.44%
Unloading	Toxic and Hazardous Waste Disposal Area	1	4.00	3.20	12.80	6.35%
Transaction	Waiting Room Area	1	4.00	2.20	8.80	4.36%
Idle	Non-Operational Area	1	-	-	66.21	32.82%
Total Area					201.72	100.00%

Based on the findings reflected in Shop & Drive Margonda's existing layout, Shop & Drive Margonda has a significant proportion of non-operational space that could be optimized to enhance efficiency in the area; with 66.21 m^2 of non-operational space making up 32.82% of Shop & Drive Margonda's floor area. This indicates an opportunity of optimization by minimizing these non-operational areas to increase service capacities for operational activities and minimize inefficient movement in the facility in fostering a more effective and efficient operational environment.

4.2 Operation Process Chart

Shop & Drive Margonda offers various types of after-sales service processes for cars; with two of its main services including oil change and shock absorber replacement in cars. In analyzing Shop & Drive Margonda's process efficiency, both services are translated into operation process charts (OPC). The process charts between car oil change service and car shock absorber replacement service are shown separately to identify the sequence of activities in each process and identify improvement opportunities within each part of the sequential process. Figure 3 shows the Operation Process Chart for the car oil change service and Figure 4 shows the Operation Process Chart of car shock absorber replacement service.

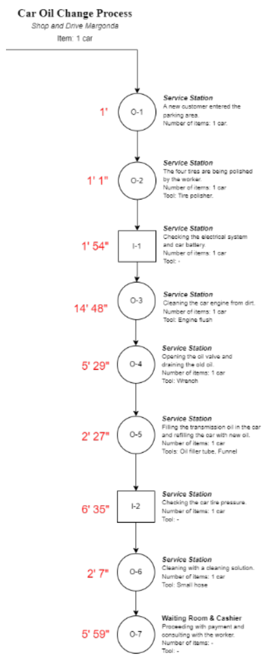


Figure 3. Car Oil Change Operation Process Chart

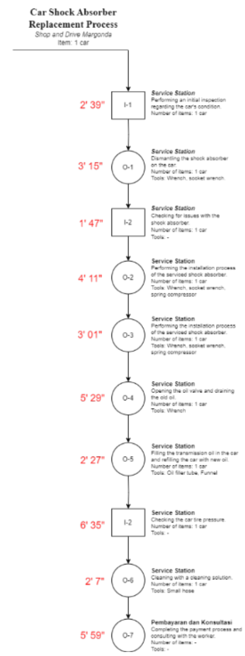


Figure 4. Car Shock Absorber Change Operation Process Chart

Based on the Operation Process Chart depicted in Figure 3 and Figure 4, we found the observed cycle time for the Car Oil Change process took 41 minutes and 20 seconds, accommodating a maximum of 4 cars per cycle, totaling to 44 minutes and 19 seconds in standard time. Similarly, the Car Shock Breaker Change required 36 minutes and 16 seconds per cycle for a maximum of 2 cars, totaling 46 minutes and 53 seconds in standard time. Calculating the efficiency as a ratio of the total standard capacity to the total cycle capacity, the efficiency derived for Car Oil Change stands at 92%, while for the Car Shock Breaker Change stands at 78.5%.

4.3 Material Flow

Shop & Drive Margonda's material flow, as depicted in Figure 5, represented the process of receiving material from its suppliers to the storage area and its restocking process for the spare part shelf every week. The materials received include oil, battery, shock absorber, tire, and car spare parts such as wiper or filter which are sent from the head of Astra Otoparts by car. The material flow starts with the material shipment arriving at Shop & Drive Margonda based on the existing layout (Figure 2). Upon arrival, the car will be parked in the outdoor service area. The products then will be handled by the workers and then stored in the storage area. When the shelf near the service area no longer has enough materials to display, materials from the storage area are taken and put on the spare part shelf. It is also to be noted that the maximum capacity in Shop & Drive is assumed to only happen for 2 days in 1 week and the rest only reached 20% of its maximum capacity.

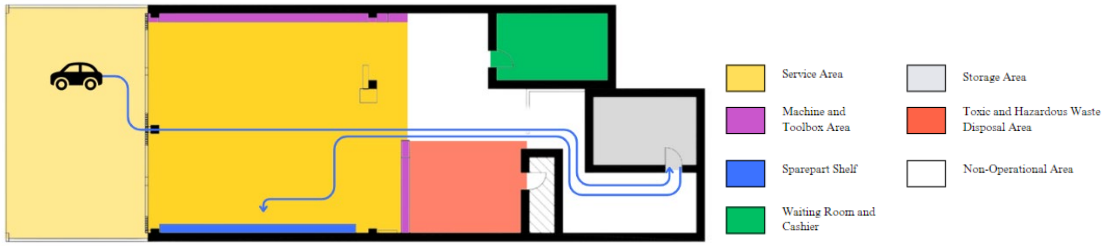


Figure 5. Material Shipment Flow of Shop & Drive Margonda

Table 3 shows detailed information of the ideal weekly requirement of the materials needed for Shop & Drive service processes. The car oil change process requires two types of supplies: the engine flush and oil, with each requiring a weekly supply of 292 units and 584 units respectively to fulfill the weekly service demand in Shop & Drive Margonda. On the other hand, the shock absorber replacement process requires one type of material supply, the shock absorber, with a weekly supply requirement of 138 units to fulfill the weekly service demand in Shop & Drive Margonda.

Table 3. Calculation of Shop & Drive Material Supply

Process	**Material Supply**	**Capacity per Cycle**	**Total Capacity**		**Total Supply (units/week)**
			Maximum (2 Days)	**20% (5 Days)**	
Car Oil Change	Engine Flush	2	48	10	292
	Oil	4	48	10	584
Shock Absorber Replacement	Shock Absorber	2	22	5	138

4.4 Material Handling

Material handling is the moving, packaging, and storing of materials by using special tools or manual handling throughout the process. Managing the tools and machines required for this process involves maintaining enough of each item based on their demand, especially during peak periods, without overstocking. Proper organization and storage of these tools play a key role in ensuring they are easily accessible when needed, optimizing the workflow efficiency. Table 4 shows the minimum amount of equipment and tools necessary to fulfill the service order demand in Shop & Drive Margonda; with a minimum of 5 for every equipment and tools used in the car oil change process, and a minimum of 3 for every equipment and tools used in the car shock absorber replacement process.

Table 4. Calculation of Shop & Drive's Minimum Requirement of Equipment and Tools

Process	**Machine & Tool**	**Total Required**	**Arrival Rate (# of cars)**			**Required Number of Machine & Tools**		
			Normal (6 hrs)	**Peak (3 hrs)**	**Average**	**Normal (6 hrs)**	**Peak (3 hrs)**	**Average**
Car Oil Change	Brush	1	2	4	3	2	5	4
	Wrench	1						
	Funnel	1						
	Minimum Required Number of Machine and Tools					**5**		
Shock Absorber Replacement	Socket Wrench	1	2	2	2	3	3	3
	Spring Compressor	1						
	Wrench	1						
	Pliers	1						
	Spanner	1						
	Minimum Required Number of Machine and Tools					**3**		

4.5 Workers
4.5.1 Job Distribution
There are a total of 7 workers hired in Shop & Drive Margonda. There is no specific job distribution for the workers as each operator can handle every part of the operation, both for the oil changing process and the shock absorber changing process in Shop & Drive Margonda, without specific job allocations per operator. However, when Shop & Drive Margonda is operating at maximum capacity, each cycle of each process will usually be handled by one to two workers. As the research focused on optimizing both processes, the total number of workers were taken into consideration to reduce the operational costs.

4.5.2 Working Shift Schedule
Shop & Drive Margonda has a total operational hour of 9 hours, starting from 9 AM and ending at 6 PM from Monday to Sunday. There is no specific period allocated for breaks within the operational hours for the workers. Therefore, it is assumed that the workers work continuously according to the flow of the customer arriving at Shop & Drive Margonda for a total of 9 hours, with an allowance of 15% to account for breaks and downtime.

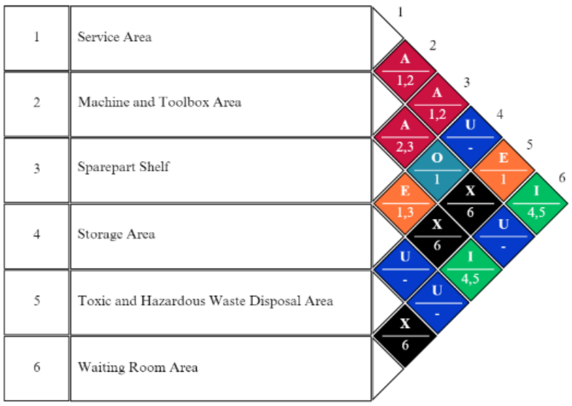
5. Results and Discussion
5.1 Activity Worksheet
To analyze the relationships among the service processes conducted in each workstation within the facility, an Activity Worksheet is designed to reflect the desired closeness ratings among each activity conducted in the service process. Table 5 shows the desired Activity Worksheet detailing the relationships among activities conducted within the service process in Shop & Drive Margonda. Activities with important relationships with each other need to be conducted within proximity of each other to maximize efficiency of movement between activities and minimize material flow costs.

Table 5. Shop & Drive Margonda's Activity Worksheet

No.	Process	Involved Locations	Process Relationship Rating					
			A	E	I	O	U	X
1.	Car placement	Service Area	2, 3, 4, 6	-	5, 7	-	-	-
2.	Component inspection	Service Area, Machine and Toolbox Area	1, 3, 4, 5	-	6	-	7	-
3.	Disassembly of machine components	Service Area, Machine and Toolbox Area	1, 2, 4, 5	-	6	-	7	-
4.	Assembly of machine components	Service Area, Machine and Toolbox Area, Spare Part Shelf, Storage Area*	1, 2, 3, 5	-	6	-	7	-
5.	Cleaning of machine components	Service Area, Machine and Toolbox Area	2, 3, 4	-	1, 6	-	7	-
6.	Workspace cleaning	Service Area, Toxic and Hazardous Waste Disposal Area	-	1	2, 3, 4, 5	-	-	7
7.	Service consultation & payment	Waiting Room Area	-	-	1	-	2, 3, 4, 5	6

(*): Only utilized when the required spare part is not displayed on the shelf

5.2 Activity Relationship Chart
Based on the relationships among the processes conducted in each workstation shown in the Activity Worksheet (Table 5), an Activity Relationship Chart is designed to reflect the desired closeness ratings among each workstation. Figure 6 shows the desired Activity Relationship Chart among the work areas in Shop & Drive Margonda and the reasoning behind the closeness rating among each workstation. Workstations with high closeness ratings need to be located within close proximities with each other to maximize efficiency of movement between activities and minimize material flow costs.



Code	Reason
1	Material flow between work areas
2	Sharing the same operators between work areas
3	Similarity of function between work areas
4	Ease of communication with clients
5	Increasing sales
6	Exposure to toxic and hazardous materials

Figure 6. Shop & Drive Margonda's Activity Relationship Chart

5.3 Activity Relationship Diagram

Based on the relationships among the processes conducted in each workstation, an Activity Relationship Diagram (ARD) is designed to present the desired closeness ratings among each workstation. Figure 7 shows the desired Activity Relationship Diagram among the work areas in Shop & Drive Margonda. Workstations with high closeness ratings need to be located within close proximities with each other to maximize efficiency of movement between activities and minimize material flow costs.

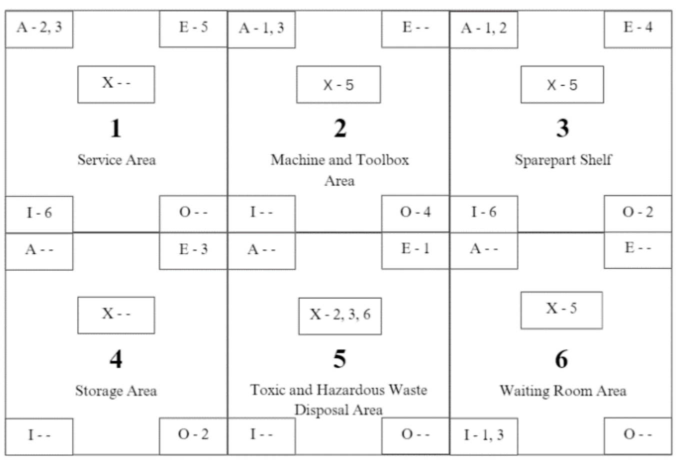


Figure 7. Shop & Drive Margonda's Activity Relationship Diagram

5.4 Improved Layout

Based on the findings shown in the Activity Relationship Chart (Figure 6) and Activity Relationship Diagram (Figure 7), improvements on Shop & Drive Margonda's facility layout need to be conducted in order to increase process efficiency among workstations to expedite flow among related activities in the service process and maximize space efficiency and utilization within the facility. An Area Allocation Diagram (AAD) is used to visualize the area distribution and general positioning of the workstations within the available building space of the facility as shown in Figure 8.

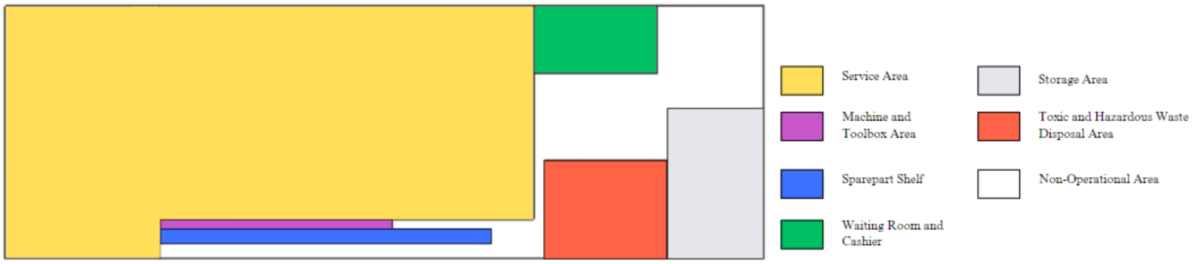


Figure 8. Area Allocation Diagram of Shop & Drive Margonda's Improved Layout

Based on the Area Allocation Diagram shown in Figure 8, an improved layout design for Shop & Drive Margonda is designed in Figure 9. The improved layout maintains the original overall area of the production floor of 201.72 m^2. The dimensions and area distribution of the floor area of each workstation in the improved layout of Shop & Drive Margonda can be found in Table 6.

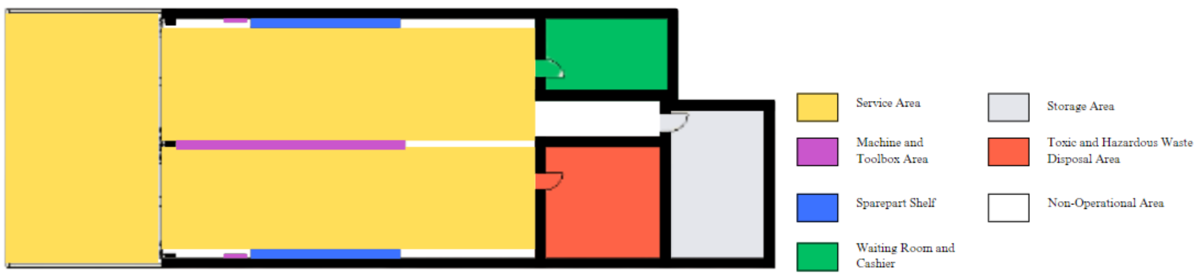


Figure 9. Improved Layout of Shop & Drive Margonda

Table 6. Dimensions of Shop & Drive Margonda's Improved Workshop Layout

Function	**Work Area**	**Total**	**Dimensions**		**Area (m^2)**	**Area Allocation Percentage (%)**
			Length (m)	**Width (m)**		
Service Area	Outdoor	1	5.00	8.20	41.00	20.33%
	Indoor	1	12.12	6.94	84.11	41.69%
Inventory and Materials	Machine and Toolbox Area	1	7.52	0.30	2.26	1.12%
	Spare Part Shelf	1	10.70	0.30	3.21	1.59%
	Storage Area	1	4.85	3.09	14.99	7.43%
Unloading	Toxic and Hazardous Waste Disposal Area	1	4.00	3.20	12.80	6.35%
Transaction	Waiting Room Area	1	4.00	2.20	8.80	4.36%
Idle	Non-Operational Area	1	-	-	34.55	17.13%
Total Area					201.72 m^2	100.00%

Through this improvement in facility layout, Shop & Drive Margonda experiences increased efficiencies in its work processes by increasing the area allocation efficiency in the shop with the reduction of non-operational areas from 32.82% of the shop area to 17.13%, marking a 47.8% increase in area allocation efficiency in the shop. This increase in area allocation efficiencies creates increased available space for operational workstations, which leads to the increase of indoor service area by 54.47% from the initial layout and the increase of available storage area by 15.4%, allowing for increased capacities of service and inventory for Shop & Drive Margonda.

5.4.1 Service

Based on the results of Activity Relationship Chart (Figure 6) and Activity Relationship Diagram (Figure 7) method, the machine and toolbox area should be placed near the spare part shelf, as well as being located within the perimeter of the service area. This is aimed to reduce the movement of the workers as they need to go back and forth toward the machine and toolbox area and the spare part shelf to get the machine, equipment, and inventory they need during the process in the service area. Since the disposal area is only used once at the end of the process, we relocated it further at the back to improve the safety of the service area as well as making it more spacious so Shop & Drive Margonda can increase their maximum capacity to 8 cars per one cycle, making it 2 more cars than the maximum capacity of the existing layout.

5.4.2 Material Flow Optimization

In evaluating the effectiveness of the facility layout optimization conducted in Shop & Drive Margonda, material flow distances are calculated as a measure of process efficiency improvement to identify the impact of facility layout optimization. Table 7 shows the calculation of the movement reduction of material flow from the improved layout of Shop & Drive Margonda. Based on the calculation, it is found that the improved layout of Shop & Drive Margonda generates a total material flow movement reduction of 47.42% the car oil change service process, and 42.84% for the shock absorber replacement service process, totaling up into an optimization of 45.13% both processes.

Table 7. Optimization of Material Flow in Improved Layout of Shop & Drive Margonda

Process	Code	From	To	Distance Before Improvement (m)	Distance After Improvement (m)	Optimization
Car Oil Change	1	Service Area	Toolbox Area	8.4	4	52.38%
	2	Toolbox Area	Service Area	8.4	4	52.38%
	3	Service Area	Spare Part Shelf	8	8	0%
	4	Spare Part Shelf	Service Area	8	8	0%
	5	Service Area	Machine Area	4.1	0.4	90.24%
	6	Machine Area	Service Area	4.1	0.4	90.24%
	7	Service Area	Machine Area	4.1	0.4	90.24%
	8	Machine Area	Service Area	4.1	0.4	90.24%
	9	Service Area	Spare Part Shelf	8	8	0%
	10	Spare Part Shelf	Toolbox Area	0.8	0.4	50%
	11	Toolbox Area	Service Area	8.4	4	52.38%
	12	Service Area	Toxic and Hazardous Waste Disposal Area	12	12	0%
	13	Toxic and Hazardous Waste Disposal Area	Waiting Room Area	6	3.1	48.33%
	Average Improvement for Car Oil Change Process					**47.42%**
Shock Absorber Replacement	1	Service Area	Toolbox Area	8.4	4	52.38%
	2	Toolbox Area	Service Area	8.4	4	52.38%
	3	Service Area	Spare Part Shelf	8	8	0%
Shock Absorber Replacement	4	Spare Part Shelf	Service Area	8	8	0%
	5	Service Area	Machine Area	4.1	0.4	90.24%

Process	Code	From	To	Distance Before Improvement (m)	Distance After Improvement (m)	Optimization
Shock Absorber Replacement	6	Machine Area	Service Area	4.1	0.4	90.24%
	7	Service Area	Spare Part Shelf	8	8	0%
	8	Spare Part Shelf	Service Area	8	8	0%
	9	Service Area	Machine Area	4.1	0.4	90.24%
	10	Machine Area	Service Area	4.1	0.4	90.24%
	11	Service Area	Toxic and Hazardous Waste Disposal Area	12	12	0%
	12	Toxic and Hazardous Waste Disposal Area	Waiting Room Area	6	3.1	48,33%
	Average Improvement for Absorber Replacement Process					**42.84%**

5.4.3 Job Distribution

As stated below in Table 8, it is found that Shop & Drive Margonda can operate efficiently with 6 workers, one less than the status quo. It is also recommended for the workers to have a clear job distribution. For the oil changing process, 4 workers are needed for the operation to meet the total target service rate. Meanwhile, the shock absorber process needed 2 workers to meet the target service rate.

Table 8. Calculation of Operator Allocation in Improved Layout of Shop & Drive Margonda

Process	Maximum Capacity/Cycle	Target Customer	Cycle Time	Total Operation Time (hr)	Length of Working Shift (hr)	Total Operator Needed
Car Oil Change	4	48	44’19”	35.45	9	4
Shock Absorber Replacement	2	22	46’53”	17.18		2

6. Conclusion

The improved facility layout will increase the efficiency of Shop & Drive Margonda in conducting car oil change and car shock absorber replacement service processes. The improvement layout reduces the material flow movement by 47.42% for the car oil change service process, and 42.84% for the shock absorber replacement service process, totaling up into an optimization of 45.13% for both processes. The resulting layout adjustments also increased the area allocation efficiency in the shop by 47.8% and reduced the number of required operators from 7 to 6 workers.

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