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Designing Government Owned Facilities for Heavy Vehicles and Equipments using BLOCPLAN Algorithm, HIRARC Analysis, and Arena Simulation

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ABSTRACT

While most of scientific management principles are commonly implemented in industrial context with efficiency and financial goals, this research explores the implementation of scientific management principles and methods in a government owned facility context where financial aspect is not the main priority but fast response and safety. A site at Tambaksari Surabaya, owned by Surabaya City Department of Water Resources, Road, and Drainage (SCDWRRD), was used to park, maintain, and repair many heavy vehicles and equipments that support various tasks of SCDWRRD. Not only that, the site also store and stack all spare parts, maintenance and repair equipments in a total of 15,457 m² area. For so long, the site has been divided to several areas that managed separately by the different Divisions under the SCDWRRD and other Departments without considering integration and the implementation of scientific management principles. The condition causes high inefficiency, disorganized work order, difficulty in controlling the flow of spare parts, and potential hazards such as oil spills and unsafe welding practices. This research aims to change the facility layout by analyzing vehicles and people movement, operational efficiency, and occupational health and safety (OHS). Started from the implementation of the BLOCPLAN algorithm, followed by the Hazard Identification, Risk Assessment, and Risk Control (HIRARC) method, the improvement has been successfully made. Stakeholders' feedback on the proposed improvements has been collected through a Focus Group Discussion (FGD) to refine some alternative designs. Lastly, arena software simulation has been used to assess the workstation utility and adjustments for optimization. The findings indicate that the proposed layout reduces total travels by 47.32%, backtracking movement by 43.31%, and cross-movement by 47.37%, thereby promoting safer and more efficient operations. Therefore, this research has demonstrared the use of scientific management in improving city government facilities where rigid bureaucratic structures often hinder integrated solutions.

***Keywords**: BLOCPLAN, HIRARC, Arena Simulation, Facility Layout, Government Facilities*

A. INTRODUCTION

Surabaya City Government envisions transforming Surabaya to an advanced and sustainable global city. The city has established integrated urban spatial planning supported by world-class and sustainable city infrastructure and utilities [1]. This ambitious vision aligns with broader reforms in Indonesian governance, emphasizing increased effectiveness and efficiency in public sector operations. Adopting scientific management principles has emerged as a strategic approach to achieving these goals [2]. Scientific management emphasizes improving efficiency, effectiveness, and productivity through dynamic condition analysis, workflow optimization, worker productivity enhancement, quantitative measure development, and system standardization [3]. In alignment with its vision and mission, Surabaya City

Government seeks to apply scientific management principles to effectively manage city facilities and infrastructure. One prominent application of these principles was initiated in the Division of Facilities and Infrastructure Management in the Surabaya City Department of Water Resources, Road, and Drainage (SCDWRRD). A critical operational site within this Division is the Tambaksari site, which serves six primary functions: vehicle unit welding, material storage, vehicle unit repair, fueling, drainage equipment welding and repair, and security.

As the number of operational vehicles including heavy equipment increases and the number of activities using those vehicles also tremendeously increases to meet the demands of public works in Surabaya, the need of proper management is fundamental. Expansion of the Tambaksari site had been undertaken without adequate planning and had resulted in a poorly mix of facilities. Observations revealed conflicting movements and operational inefficiencies between activities and facilities, with some facilities suffer from inadequate space and resources. This disorganized layout accelerates equipment wearout and tear, thus reduces operational productivity. In addition, the direct field observations highlight significant safety hazards at the Tambaksari site. The unsafe handling of hazardous materials, such as improper gasoline storage and frequent spills in refueling areas, poses risks to worker safety and compliance with Government regulation.

Currently, divisions within SCDWRRD operate independently within their respective scopes, often missing opportunities for integration and collaboration. The potential benefits of integrated operations, including enhanced efficiency and effectiveness, remain unrealized. Therefore, this paper presents a pilot research in integrating operational Divisions through quantitative evaluations, with the goal of promoting scientific management as a replicable model for other city governments in Indonesia.

The current layout shown in Figure 1, which is lacks of proper analysis, yields in inefficient movements, workflow disruptions, inefficient space usage, and safety risks. Therefore, an effective facility planning is essential to achieve optimal interactions among labor, materials, machinery, and equipment. The key principles of an ideal layout, such as minimizing travel distances, ensuring smooth workflows, maximizing space utilization, and prioritizing safety and satisfaction [4], are critical for addressing the inefficiencies at the Tambaksari site.

This study focuses on implementing scientific management principles, incorporating facility layout planning, occupational health and safety measures, and simulation methods, to redesign and improve the Tambaksari site. By addressing these challenges, this study aims to enhance the operational efficiency, effectiveness, and safety of heavy vehicles workshop and maintenance facilities within a city government institution. This research is a pilot project for the application of scientific management in the government sector, especially facility layout planning, that could be used as a benchmark for other city government.

B. LITERATURE REVIEW

B1. Facility Layout Design and Planning

Facility layout design and planning are critical components for optimizing operational efficiency and productivity in manufacturing and service environments. Literature indicates that effective layout planning reduces material handling costs, improves workflow, and enhances safety [5]. The facility layout encompasses the arrangement of physical spaces, equipment, and resources to ensure seamless operation. Various layout types, including product, process, cellular, and fixed-position layouts, are used depending on the nature of the operation. Furthermore, advancements in Industry 4.0 have emphasized the need for flexible and adaptive layouts that can accommodate dynamic production demands and rapid technological changes [6]. Integrating sustainable practices into layout planning has also gained attention, with the aim of reducing environmental impact while maintaining operational efficiency.

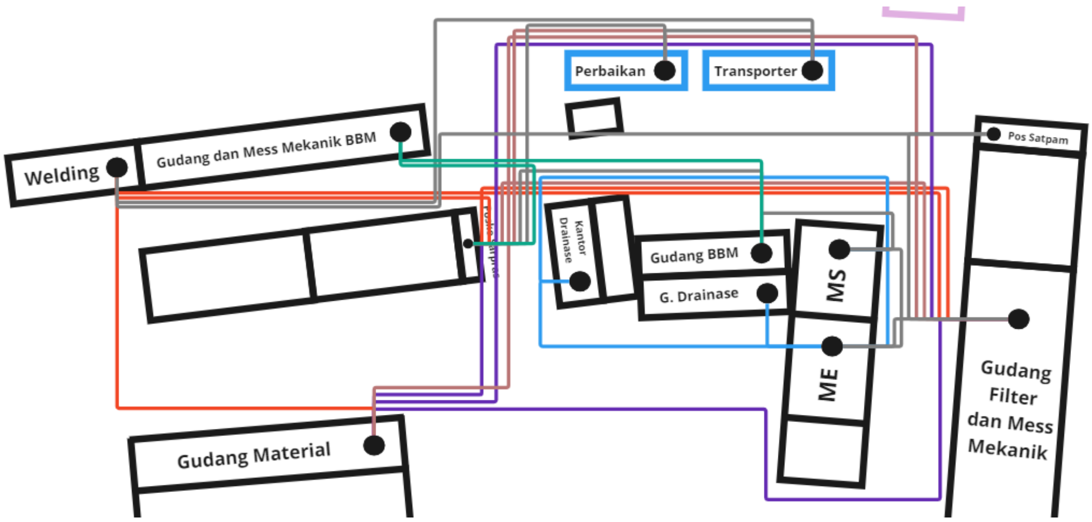

Figure 1. Existing Layout and Movement Patterns of the Tambaksari Facility

B2. BLOCPLAN Algorithm

BLOCPLAN algorithm is a prominent heuristic method for designing block layouts in facility planning. The proposed model leverages adjacency-based criteria to optimize the spatial arrangement of departments and workstations. The algorithm evaluates various layout configurations based on closeness relationships, ensuring that interdependent departments are positioned adjacently to minimize transportation costs and improve communication. Studies have demonstrated that BLOCPLAN provides robust solutions for facility layouts with complex inter-departmental relationships [7]. The proposed algorithm is particularly effective in scenarios with multiple constraints, such as space limitations and workflow requirements. Recent enhancements to BLOCPLAN have incorporated multi-objective optimization approaches, integrating factors such as energy efficiency and ergonomic considerations into the layout design [8].

B3. HIRARC Analysis

Hazard Identification, Risk Assessment, and Risk Control (HIRARC) is an analytical framework widely used to identify and mitigate potential risks in facility layout design. HIRARC systematically recognizes hazards, assesses associated risks, and implements control measures to ensure workplace safety [9]. Incorporating HIRARC into layout planning helps in designing safer workspaces by addressing ergonomic risks, accident-prone areas, and environmental hazards [10]. The integration of HIRARC with advanced simulation tools enhances the predictive capabilities for risk assessment, allowing organizations to visualize potential hazards before implementing layout changes [11]. Moreover, the frameworks adaptability makes it suitable for diverse industries, including manufacturing, healthcare, and warehousing.

B4. Simulation Software for Layout Design

Simulation software has emerged as a powerful tool for facility layout design, enabling detailed modeling and analysis of proposed layouts. Tools like FlexSim, Arena, and Simio allow practitioners to visualize workflows, assess resource utilization, and identify bottlenecks in real-time [12]. The use of simulations provides a dynamic approach for evaluating alternative layouts that incorporate stochastic variables, such as demand fluctuations and machine downtimes. Studies have highlighted the efficiency of simulation software in enhancing decision-making by providing data-driven insights. Additionally, the integration of simulation with optimization algorithms, such as genetic algorithms and particle swarm optimization, further refines layout designs by balancing multiple objectives like cost, efficiency, and flexibility [14]. The increasing accessibility of simulation tools has also facilitated their adoption in small and medium enterprises (SMEs), promoting data-informed layout planning across varied scales of operations.

C. METHODOLOGY

C1. Data Collection Phase

In this stage, ongoing issues in Tambaksari were identified through primary (observation, interviews, and FGDs with SCDWRRD's stakeholders) and secondary data collection. Primary data covered user requirements, existing layout maps, agency details, movement patterns, potential hazards, HR field officers, workload priorities, forecast data for vehicle units, cross-movement, and parked units. Secondary data from SCDWRRD included agency profiles, workload, Standard Operating Procedures (SOP), process flow, heavy equipment details, transport equipment, operational vehicles, repair and welding history, and fuel consumption records.

C2. Data Processing Phase

This stage involved analyzing existing conditions in Tambaksari through the creation of a current layout map. A FGD provided detailed information about the area, followed by calculating backtracking and cross-movement, identifying potential hazards using Preliminary Hazard Analysis (PHA). Alternative facility layouts were developed by computing needs, sizes, and creating an Activity Relationship Chart (ARC). BLOCPLAN Algorithm used these inputs to generate layouts. Health and Safety Analysis, utilizing Failure Mode and Effect Analysis (FMEA) and Hierarchy of Control, was conducted. Expert discussions with stakeholders led to adjustments between layout alternatives and safety analysis, resulting in multiple design options. Furthermore, a final FGD helped choosing the preferred layout alternative.

C3. Facility Design Finalization Phase

In this stage, the finalization of the facility layout design was processed through the simulation. Simulation was used to evaluate the design of the preferred Tambaksari site layout. The simulation began with creating an Activity Cycle Diagram (ACD) and building a simulation model using Arena software. Verification and validation of the model are then carried out. Subsequently, an analysis of the simulation results was conducted, and adjustments were made. A comparison was then made between the existing layout and the improved layout.

C4. Facility Visualization Phase

In this stage, 2D and 3D visualization of the layouts were created using SketchUp Pro 2022 software.

D. RESULTS

D1. Analysis of the Existing Condition

Currently, there are three Departments and one Labour Intensive Program (or *Program Padat Karya* in Bahasa) operate in Tambaksari site. Those three Departments are SCDWRRD, Surabaya City Department of Transportation (SCDT), and Surabaya City Department of Communication and Information (SCDCI). In constructing their facilities, each Department builds on the available vacant land without a clear cohesive plan. This caused the Department's facilities in the Tambaksari site to be scattered and unstructured. Several facilities that belong to the same Department are not close to each other. This situation causes several problems, such as inefficiency and lack of monitoring. The current layout of the Tambaksari site can be seen in Figure 2.

Figure 2. Existing Facility Layout

The black lines represent the Tambaksari site border. Blue boxes show facilities that belong to the Infrastructure Divison, while light pink boxes correspond to facilities belong to the Drainage Division. Moreover, red boxes represent facilities owned by the Roads and Bridges Division. Orange boxes show facilities owned by the SCDT. Last but not least, brown box denotes the area belong to Labour Intensive Program.

In facility planning, movement distance is tried to be minimized by chosing the shortest achievable travel distance between one facility to another. Optimizing movement distance is a common objective in solving facility layout issues, so it is necessary to calculate the movement distance to assess each facility. The total distance between each facility in the existing layout is 1,604 m, as recapped in Table 3.

Backtracking certainly increases total movement distance and inefficiency. Therefore, proper layout should minimize backtracking [5]. The backtracking calculation in this study is conducted by observing the movements and their frequency. This study calculates backtracking by observing movement frequencies in Tambaksari over seven days, representing all possible common movements. Human-machine movements' frequency is depicted in a From-To-Chart (FTC), a quantitative tool used in a facility planning analysis[15]. Table 4 presents forward and backward movements resulted for all observed activities in Tambaksari.

From processing the human-machine movement frequency data for each activity in Table 4, a forward percentage of 35.88% and a backward percentage of 64.12% has been calculated. These percentages suggested that the level of inefficient movement in the currentt layout is high, thus facilities must be rearranged to avoid backtracking.

TABLE 3
Distance of Each Facility

Origin	Destination	Distance (meters)
Welding		
Infrastructure Post	Filter Warehouse + Mechanic Staff Room	70
Filter Warehouse + Mechanic Staff Room	Welding Zone	133
Welding Zone	Warehouse	30
Warehouse	Welding Zone	30
Welding Zone	Infrastructure Post	53
Sub Total		**316**
Storage		
Infrastructure Post	Material Warehouse	35
Material Warehouse	Filter Warehouse + Mechanic Staff Room	112
Filter Warehouse + Mechanic Staff Room	Parking	82
Parking	Material Warehouse	52
Sub Total		**281**
Repair		
Infrastructure Post	Filter Warehouse + Mechanic Staff Room	70
Filter Warehouse + Mechanic Staff Room	Unit Repair Zone	87
Unit Repair Zone	Warehouse	55
Warehouse	Unit Repair Zone	55
Unit Repair Zone	Infrastructure Post	32
Sub Total		**299**
Drainage Welding and Repair		
Infrastructure Post	ME	62
ME	MS	6
MS	Warehouse	101
Warehouse	MS	101
Sub Total		**270**
Security		
Security Post	Filter Warehouse + Mechanic Staff Room	33
Filter Warehouse + Mechanic Staff Room	ME	21
ME	MS	6
MS	Refueling Station	21
Refueling Station	Infrastructure Post	22
Infrastructure Post	Unit Repair Zone	32
Unit Repair Zone	Parking	32
Parking	Welding Zone	64
Welding Zone	Employee Parking	19
Employee Parking	Security Post	4
Sub Total		**254**
Refueling		
Infrastructure Post	Filter Warehouse + Mechanic Staff Room	70
Filter Warehouse + Mechanic Staff Room	Parking	82

Origin	Destination	Distance (meters)
Parking	Fueling Station	32
	Sub Total	**184**
	Total	**1,604**

TABLE 4
Forward dan Backward Movement in the Existing Layout

Forward		***Distance Coefficient***	***Backward***	
Distance from Diagonal	***Moment***		***Moment***	***Distance from Diagonal***
2	2	1	170	170
61	61	1	40	40
11	11	1	54	54
58	58	1	12	12
58	58	1	69	69
12	12	1	114	114
0	0	1	0	0
0	0	1	2	2
56	56	1	0	0
0	0	1	0	0
	258	**719**	**461**	
	35,88%		**64,12%**	

Moreover, cross-movement can also increase movement distances and create potential conflict points as well as risks. The calculation of cross-movement was done by depicting the movement of activities according to the existing process flow. Then, the potential conflict points were identified and tabulated. The current facility cross-movements were illustrated in Figure 3, in which each activity was distinguished by color, and potential conflict points were marked by red circles. Based on the results, 19 instances of cross-movement were found.

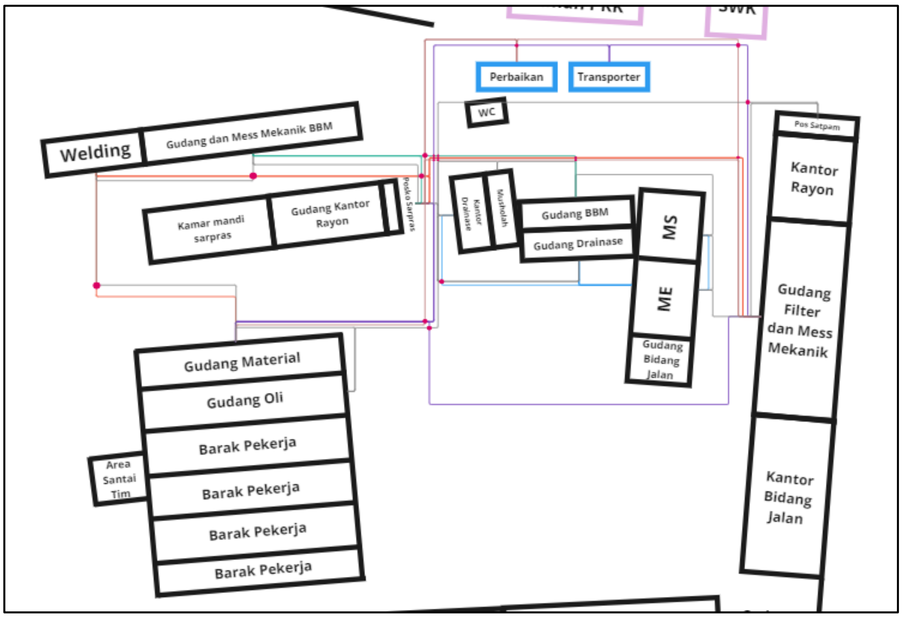

Figure 3. Existing Cross-Movement Points

D2. Development of Alternative Layouts

Required facilities were determined by breaking down the required process of each activity. For that purpose, series of interview had been conducted with several key persons in the SCDWRRD and other Departments. Table 5 shows the required facilities for each Division and Department using the Tambaksari site.

TABLE 5
Required Facilities

SCDWRRD					SCDCI	SCDT	Supporting Needs
Drainage	Secretariat	Security Division	Road Division	Land Acquisition			
Gubeng District Office	Secretariat Warehouse	Security Office	Road Division Office	Storage Warehouse	Warehouse	SCDT Warehouse	Praying Room
Genteng District Office		Safety Post	Road Division Warehouse			Transit Room	Parking
Gubeng District Warehouse		Employee Transit Zone					Toilet
Genteng District Warehouse		Material Warehouse					
		Welding Zone					
		Unit Repair Zone					
		Vehicle Washing Zone					
		Drainage Repair and Welding Zone					
		Fueling Station					
		Parking					

From the interviews, it was revealed that warehouse and office facilities could utilize a shared space, thus there is only one warehouse and office building that accommodates all warehouses and offices in the Tambaksari area. The required width of each facility was calculated based on the need of each activity and the available space. Table 6 shows the area calculation that has considered the need of each Division and Department for the next 10 years.

Based on the 10 years estimation on the activity growth, the total area required in Tambaksari is 22,428 m2. This estimate was adjusted based on FGDs with SCDWRRD's stakeholders. In addtion, aisle allocation, that is crucial for communication and transportation, is also calculated [16].

Furthermore, an Activity Relationship Chart (ARC) that depicts relationships between areas and serves as a qualitative assessment of facility relationships has been developed [17]. Proximity codes (1-5) in Table 7 were determined based on shared record usage, shared workforce, intensity of personnel contact, workflow sequence, and potential unpleasant conditions [18]. The resulted ARC is shown in Figure 4.

TABLE 6
Area Calculation

	Vehicles/Instrument		Area (m^2)	Ruang Operator (m^2)	Area per Object (m^2)	Sub Total (m^2)	Amount (each)	Estimated Increase (each)	Total Object (each)	Total Area (m^2)	Aisle (%)	Total Required Area (m^2)
	Length (m)	Width (m)										
Main Office					324						17%	380
Warehouse						3898						3898
Welding Workshop (A)	9,81	3,19	32	32	64	96	3	1	4	384	8%	415
Vehicular Repair Workshop (B)	9,81	3,19	32	32	64	96	10	1	11	1056	8%	1141
Drainage Equipment Repair and Welding Workshop (C)	3,00	1,50	5	5	10	15	2	1	3	45	5%	48
Vehicular Washing Workshop (D)	9,81	3,19	32	32	64	96	8	1	9	864	7%	925
Fueling Station (E)										2793	7%	2989
Permanent Tank Are 5,000L	3,05	1,4	5	5	10	15	4	0	4	60		60
Tank Truck 16,000L	8,40	2,50	21	21	42	63	3	0	3	189		189
Fueling Area	5,83	1,86	11	11	22	33	1	0	1	33		33
Security Post			12			12	1	0	1	12	0%	12
Employee Transit Zone	1,9		1,9	0	1,9	3	833	0	833	2499	6%	2649
Operational Vehicle Parking										8441	8%	9117
Two-Wheel Parking	2,07	0,83	2	0	2	3	72	3	75	225		225
Three-Wheeler Parking	3,57	1,33	5	0	5	8	14	2	16	128		128
Vehicular Parking	5,36	2,16	12	0	12	18	8	2	10	180		180
Six-Wheeler Parking	9,70	2,49	25	0	25	38	103	2	105	3990		3990
14-wheeler Parking	5,72	2,43	14	0	14	21	1	1	2	42		42
Excavator Parking	9,81	3,19	32	0	32	48	71	3	74	3552		3552
Heavy Vehicle Parking	7,34	2,44	18	0	18	27	10	2	12	324		324
Employee Parking										2985	6%	3165
Motorcycle Parking	0,75	2,00	2	0	2	3	923	0	923	2769		2769

	Vehicles/Instrument		Area (m²)	Ruang Operator (m²)	Area per Object (m²)	Sub Total (m²)	Amount (each)	Estimated Increase (each)	Total Object (each)	Total Area (m²)	Aisle (%)	Total Required Area (m²)
	Length (m)	Width (m)										
Car Parking	2,30	5,00	12	0	12	18	12	0	12	216		216
Mosque			300			300	1	0	1	300	0%	300
Toilet	0,76	1,52	2	0	2	3	24	0	24	72	5%	76

TABLE 7
Proximity Codes

Proximity Codes	Definition	Condition
A	*Proximity Imperative*	Meets all qualitative factors, except Code 5
E	*Especially important*	Does not meet one qualitative factor, except Code 5
I	*Important*	Does not meet two qualitative factors, except Code 5
O	*Ordinary importance*	Does not meet three qualitative factors, except Code 5
U	*Unimportant*	Does not meet four qualitative factors, except Code 5
X	*Undesirable proximity*	Fulfils Code 5

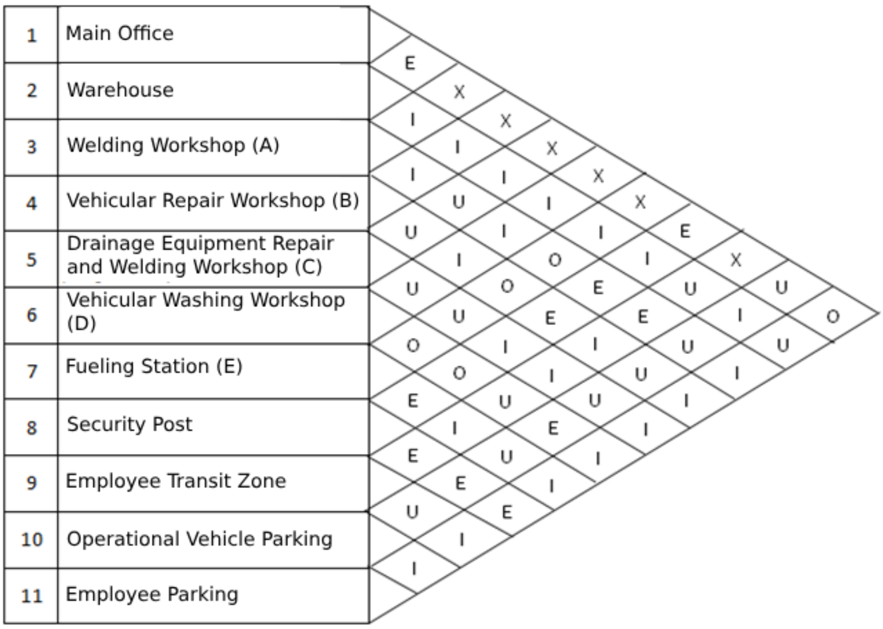

Figure 4. Activity Relationship Chart (ARC)

D3. Hazard Identification and Risk Assessment

This study employs the Preliminary Hazard Analysis (PHA) method to identify potential hazards, thus utilizing various sources such as past reports, injury data, field inspections, and government regulations. Risk assessment adopts the Failure Mode and Effect Analysis (FMEA) concept, which evaluates frequency, capacity, and severity qualitatively. From the data collection and processing, falling and explosion, was identified as the highest-risk hazards, with Risk Priority Numbers (RPN) of 15 and 10, respectively. To control and mitigate risks, risk controls were integrated into layout alternatives, following the Hierarchy of Control. Table 8 outlines the evaluated hazards and the corresponding risk assessment and control results for activities in Tambaksari.

D4. Design of Layout Alternatives

Based on all data collection and data processing stages, multiple layout alternatives were developed and categorized into scenarios such as:

1. Scenario 1
   a. All facilities are on the ground floor with a single entrance system.
   b. All facilities are on the ground floor with a dual entrance system.

TABLE 8
Risk Assessment and Control for Activities in the Tambaksari Site

Hazard	Frequency	Severity	Ability	RPN	Hierarchy of control	Description
Inhaling toxic gas and particles	2	2	1	4	PPE (Personal Protective Equipment)	Use welding mask
Contamination by corrosive materials	2	1	1	2	PPE	Use protective gloves
Noise pollution	3	1	1	3	Engineering controls	Construct buildings with soundproof walls.
High Temperatures	2	1	1	2	Engineering controls	Construct buildings with sufficient ventilation and adequate climate control.
Ergonomic Injuries	2	1	1	2	Administrative control	Implement Standard Operating Procedures (SOP) regarding work limitations to ensure employees can work optimally.
Electrocution	3	2	1	6	Eliminasi	Remove exposed cables or equipment that may cause electric shocks.
Fire	2	4	1	8	Engineering controls	- Separate fire-related activites and flammable items from high density facilities. - Design fire retardant buildings.
Scratches/Cuts	2	1	1	2	PPE	Use protective gloves
Exposure to sparks	2	1	1	2	Administrative control	- Implement SOPs for the use of machinery/equipment. - Hold in-depth trainings on machine/equipment operations
Falling Objects	3	3	1	9	PPE	Use a protective headgear (helmet).
Falling	5	3	1	15	Engineering controls	- Build adequate storage to place scattered objects. - Organize objects that have high risk of causing falls.
Slipping Hazards	5	1	1	5	Engineering controls	- Secure building floors by increasing friction and drainage - Create a special zone for activities that may require water
Tripping Hazards	5	1	1	5	Engineering controls	- Build adequate storage to place scattered objects. - Organize objects that have high risk of causing trips.
Low Visibility	2	1	1	2	Engineering controls	Design buildings with sufficient natural light and adequate illumination.
Interference from workers in other departments	2	2	1	4	Administrative control	Implement SOPs regarding work rules and interaction with other service personnel.
Machine/Equipment Vibration	2	1	1	2	Administrative control	Implement SOPs regarding work limitations to prevent workers from prolonged exposure to vibrations
Explosion	2	5	1	10	Engineering controls	- Design special separated storage for explosive materials

Hazard	Frequency	Severity	Ability	RPN	Hierarchy of control	Description
Pinching	2	2	1	4	Administrative control	- Implement SOPs for the use of machinery/equipment. - Hold in-depth trainings on machine/equipment operations
Vehicular Unit Runover	2	4	1	8	Engineering controls	Design adequate separation between vehicle and worker pathways.
Vehicular Crashes	2	4	1	8	Engineering controls	Design adequate separation between vehicle and worker pathways.

2. Scenario 2
   a. Facilities are divided into two floors with a single entrance system.
   b. Facilities are divided into two floors with a dual entrance system.
3. Scenario 3
   a. Facilities are divided into three floors with a single entrance system.
   b. Facilities are divided into three floors with a dual entrance system.

The BLOCPLAN algorithm utilizes facility name, area, and ARC data to generate several recommended layout alternatives. Table 9 recaps layout scores resulted from running the BLOCPLAN algorithm software.

TABLE 9
BLOCPLAN Algorithm Layout Scores

Scenario	***Layout***	***Score***
1	1	0,72
	2	0,70
2	1	0,58
	2	0,36
3	1	0,63
	2	0,44

Based on the total areas needed and the maximum area of Tambaksari, Scenario 1 is inapplicable because the required facility area is larger than the available land area. Therefore, only Scenario 2 and Scenario 3 are further evaluated.

D5. Selection of a Preferred Layout Alternative

Remaining alternatives resulted from the previous stage were then presented in two FGDs with SCDWRRD’s stakeholders. The FGD determined that Scenario 2 – Layout 1, named as Alternative 1, and Scenario 3 – Layout 1, named as Alternative 3, must be removed. This decision indicated that the use of single entrance system was not selected. This left Scenario 2 – Layout 2, named as Alternative 2, and Scenario 3 – Layout 4, named as Alternative 4, could be proceeded into further consideration.

Based on the further discussion, it was determined that the alternative that was suitable for the on-site conditions and landscape is Alternative 4. Several further refinements to the preferred layout alternative were made based on the results of further discussion with the SCDWRRD’s stakeholders.

D6. Finalization of the Preferred Alternative

In this stage, simulation and design adjustments were executed. Started with a conceptual model in the form of an Activity Cycle Diagram as a reference, illustrating system interactions with a queue structure, a simulation model was built [19]. The simulation design involved three entities, which were vehicle units, equipment, and material requests—arriving randomly based on Poisson distribution. Arrival metrics, collected through observation and stakeholders' input, included average times for vehicle units (9 minutes, max 1,680 units), equipment entities (15 days, max 2 entities), and material requests (4 hours, max 60 requests monthly).

Simulated activities covered vehicles for welding, repair, drainage equipment work, material storage, washing, and fueling. Simulation was conducted over 8 hours with 30 iterations, in which each iteration represented a day for 8 working hours. Model verification in Arena software ensures alignment with the conceptual model, confirming error-free construction [20]. Model validation involves comparing simulated and observed processed vehicle units using the t-test statistical method to assess significant differences between the two sample groups system [20]. In the t-test statistical test, the hypotheses are as follows:

H0 : $\mu_0 = \mu_1$

H1 : $\mu_0 \neq \mu_1$

The t-test statistical test uses a 95% confidence interval, the decision made is as follows:

p-value $\leq$ 0,05; reject H0

p-value > 0,05; accept H0

The result of the statistical test is attached in Figure 5.

Paired T-Test and CI: C1, C2

```
Paired T for C1 - C2

            N   Mean  StDev  SE Mean
C1          8  48.25   7.94     2.81
C2          8  53.75   1.75     0.62
Difference  8  -5.50   6.78     2.40


95% CI for mean difference: (-11.17, 0.17)
T-Test of mean difference = 0 (vs ≠ 0): T-Value = -2.29  P-Value = 0.056
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Figure 5. Model Validation Results

The t-test analysis indicated a p-value > 0.05, accepting H0 and suggesting no significant difference between simulation and real outputs. Thus, the simulation model was valid and accurately represents the existing system.

Analysis revealed that underutilized workstations were found in the vehicle unit repair and washing workshops. Four workstations in the repair workshop and five in the washing workshop, identified as unused in 30 iterations, then they were removed from the layout. Table 10 displays adjusted facility area calculations for the repair facility layout design.

According to the adjustments presented in Table 10, the required space is reduced to 21,499 m2. Table 11 shows the calculation of the total distance of each facility in the preferred layout alternative.

Based on Table 11, the total distance traveled in the preferred layout alternative is 845 m. This preferred layout can reduce the total distance traveled by up to 47.32%.

TABLE 10
Area Calculation of the Preferred Alternative

	Vehicles/Instrument		Area (m^2)	Ruang Operator (m^2)	Area per Object (m^2)	Sub Total (m^2)	Amount (each)	Estimated Increase (each)	Total Object (each)	Total Area (m^2)	Aisle (%)	Additional Required Area (m^2) Length (m)
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Main Office					324						17%	380
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	Vehicles/Instrument		Area (m^2)	Ruang Operator (m^2)	Area per Object (m^2)	Sub Total (m^2)	Amount (each)	Estimated Increase (each)	Total Object (each)	Total Area (m^2)	Aisle (%)	Additional Required Area (m^2) Length (m)
	Length (m)	Width (m)										
Welding Workshop (A)	9,81	3,19	32	32	64	96		4		384	8%	415
Vehicular Repair Workshop (B)	9,81	3,19	32	32	64	96		7		672	8%	726
Drainage Equipment Repair and Welding Workshop (C)	3	1,5	5	5	10	15	2	1	3	45	5%	48
Vehicular Washing Workshop (D)	9,81	3,19	32	32	64	96		4		384	7%	411
Fueling Station (E)					74					282	7%	302
Permanent Tank Are 5,000L	3,05	1,4	5	5	10	15	4	0	4	60		
Tank Truck 16,000L	8,4	2,5	21	21	42	63	3	0	3	189		
Fueling Area	5,83	1,86	11	11	22	33	1	0	1	33		
Security Post			12			12	1	0	1	12	0%	12
Employee Transit Zone	1,9		1,9	0	1,9	3	833	0	833	2499	6%	2649
Operational Vehicle Parking						163				8441	8%	9117
Two-Wheel Parking	2,07	0,825	2	0	2	3	72	3	75	225		
Three-Wheeler Parking	3,57	1,33	5	0	5	8	14	2	16	128		
Vehicular Parking	5,362	2,163	12	0	12	18	8	2	10	180		
Six-Wheeler Parking	9,7	2,49	25	0	25	38	103	2	105	3990		
14-wheeler Parking	5,72	2,43	14	0	14	21	1	1	2	42		
Excavator Parking	9,81	3,19	32	0	32	48	71	3	74	3552		
Heavy Vehicle Parking	7,34	2,44	18	0	18	27	10	2	12	324		
Employee Parking										2985	6%	3165
Motorcycle Parking	0,75	2	2	0	2	3	923	0	923	2769		
Car Parking	2,3	5	12	0	12	18	12	0	12	216		
Mosque			300			300	1	0	1	300	0%	300
Toilet	0,762	1,524	2	0	2	3	24	0	24	72	5%	76

TABLE 11

Distance of Each Facility for the Preferred Alternative

Origin	Destination	Distance (meter)
Welding		
Office	Employee Transit Zone	1
Employee Transit Zone	Warehouse	92
Warehouse	Welding Zone	1
Welding Zone	Office	89
Sub Total		183
Material Storage		
Office	Warehouse	76
Warehouse	Employee Transit Zone	92
Employee Transit Zone	Unit Parking	1
Unit Parking	Warehouse	6
Sub Total		169
Repair		
Office	Employee Transit Zone	1
Employee Transit Zone	Warehouse	92
Warehouse	Unit Repair Zone	6
Unit Repair Zone	Office	6
Sub Total		105
Drainage Equipment Welding and Repair		
Office	Employee Transit Zone	1
Employee Transit Zone	Warehouse	92
Warehouse	Drainage Equipment Welding and Repair Zone	16
Drainage Equipment Welding and Repair Zone	Office	85
Sub Total		109
Security		
Security Post	Employee Parking	29
Employee Parking	Refueling Station	6
Refueling Station	Unit Repair Zone	1
Unit Repair Zone	Office	6
Office	Vehicular Unit Parking	12
Vehicular Unit Parking	Employee Transit Zone	1
Employee Transit Zone	Drainage Equipment Welding and Repair Zone	81
Drainage Equipment Welding and Repair Zone	Welding Zone	1
Welding Zone	Warehouse	1
Warehouse	Security Post	93
Sub Total		231
Refueling		
Office	Employee Transit Zone	1
Employee Transit Zone	Vehicular Unit Parking	1
Vehicular Unit Parking	Refueling Station	46
Sub Total		48
Total		845

Based on the movement estimation for the next 10 years, total backtracking was calculated for the preferred alternative. It is recommended that the material retrieval process could be done before performing activities in the workshop to avoid back-and-forth movements. Table 12 shows the forward and backward calculations in the preferred layout design. It can be seen that the new layout produces 63.65% forward movement and 36.35% backward movement. This layout is proven to successfully reduce backtrack movement by 43.31%.

Furthermore, cross-movement in the preferred alternative is shown in Figure 6. There are still a total of ten points of cross-movement observed in the preferred layout. Compared to the existing condition, the cross movement is reduced by 47.37%. As a summary, comparison between the existing condition and the preferred layout is shown in Table 13. The comparison indicates that the preferred layout alternative significantly improves the site efficiency. Finally, Figure 7 shows the visualization of the preferred layout alternative.

TABLE 12
Forward dan Backward Movement in the Preferred Alternative

Forward		*Distance Coefficient*	*Backward*	
Distance from Diagonal	*Movement*		*Movement*	*Distance from Diagonal*
112	112	1	51	51
61	61	1	9	9
133	133	1	58	58
114	114	1	0	0
6	6	1	0	0
24	24	1	56	56
5	5	1	3	3
2	2	1	28	28
0	0	1	56	56
0	0	1	0	0
	457	718	261	
	63,65%		36,35%	

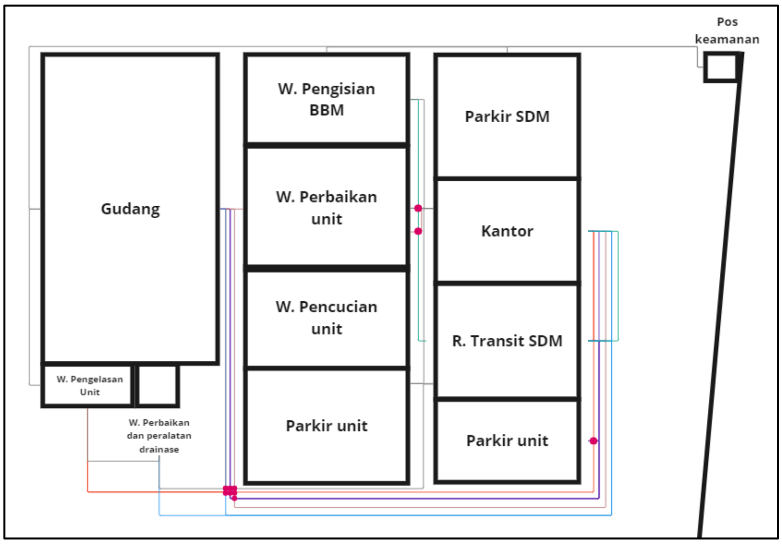

Figure 6. Cross-Movement in the Preferred Alternative

TABLE 13
Comparison between the Existing Layout and the Preferred Alternative

Variable	Existing Layout	Preferred Layout Alternative
Backtracking	63,65%	36,35%
Cross-movement	19	10
Total Movement Distance	1,604 m	845 m

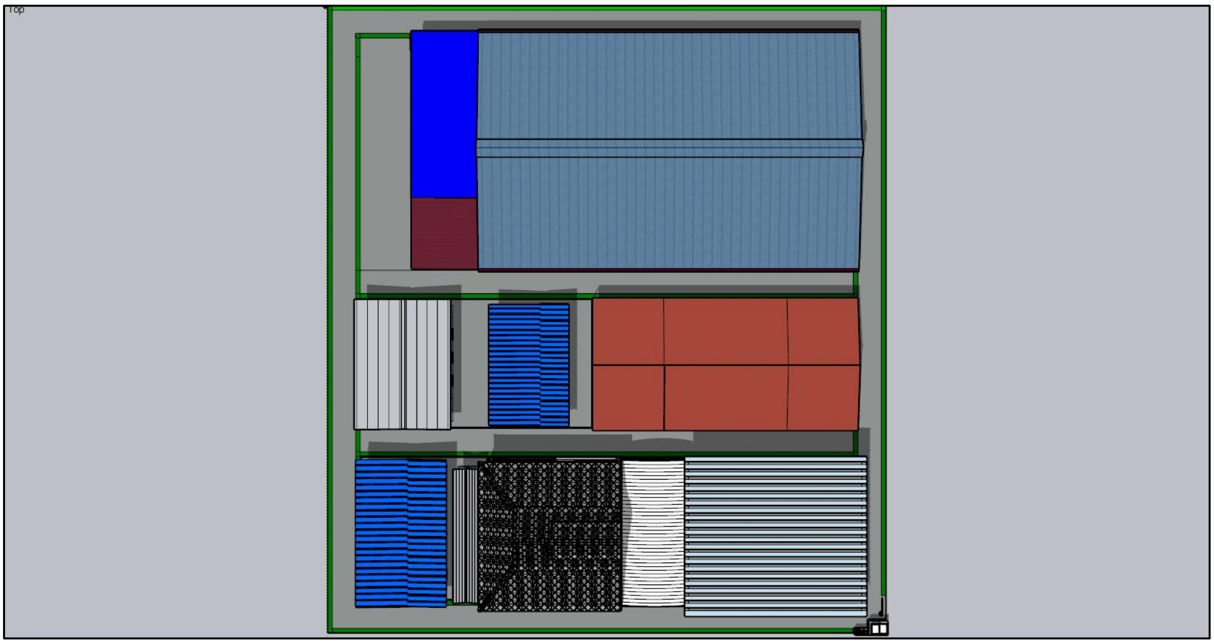

Figure 7. Top-Down View of the Preferred Layout Alternative

E. CONCLUSION

The pilot research presented in this paper has successfully demonstrated the usefulness of scientific management implementation to redesign a better layout with increased efficiency and safety for government owned facilities. The combination of several methods including layout analysis, BLOCPLAN Algorithm , HIRARC, and simulation has significantly enhanced the layout performance by adding more spaces in a form of three storey building with 13 facilities including an office, warehouse, vehicle welding workshop, vehicle repair workshop, drainage equipment welding and repair workshop, vehicle washing workshop, fuel filling workshop, employee transit room, security post, employee parking, vehicle parking, mosque, and toilet, with total area of 21,499 m2.

The preferred layout alternative has reduced the backtracking movement from the current condition by 43.31%, which is very significant in terms of efficiency. Additionally, the new design also reduces the estimated total distance by 47.32%, which is again a tremendous performance in facilitating smoother movement. Furthermore, in terms of safety, the new layout design can reduce risk by reducing 47.37% of the potential cross-movements in the current condition.

Interestingly, based on the simulation results, facilities with potential zero utility can be identified and removed, which is significant to the reduction of unnecessary workstations. This fact is a evidence based validation to the required facilities discussed in the FGD.

Conclusively, the results produced by this pilot research have significantly convinced the upper management of SCDWRRD that the use of scientific management methods is proven to be effective to provide quantitative and accurate justification for better solutions. Accordingly, the approaches used in this study can be used by other cities in Indonesia or elsewhere.

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