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# Rearranging Production Facilities on Electric Vehicles with the CORELAP Algorithm

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**Abstract**

Electric vehicles as an alternative means of sustainable transportation need to be supported because they can reduce carbon emissions by up to 54% and oil demand by 6.4 MMbpd by 2040 compared to conventional vehicles. GATe (Gadjahmada Airport Transporter Electric) is an electric vehicle based on NEV (Neighborhood Electric Vehicle). GATe car production is carried out at the GATe production facility which is still in the prototype stage. This research reorganizes the production facilities for electric vehicles in GATe (Gadjahmada Airport Transporter Electric) cars for the LRIP (Low Rate Initial Production) stage. The facility layout is designed using a fixed position layout approach, that is, the main product does not move. This research uses the CORELAP method with quantitative evaluation in terms of displacement. It was found that the total displacement using the CORELAP algorithm was 1791.15 m.

**Keywords** CORELAP Algorithm, Electric Vehicles, Production Facility, Rearrangement



## INTRODUCTION

Electric vehicles are a type of passenger vehicle that has an electric motor drive either partially (Hybrid Electric Vehicle (HEV)) or as a whole (Battery Electric Vehicle (BEV)).[1] Nowadays, electric vehicles are increasingly in demand and are being developed as a sustainable means of transportation, replacing conventional oil-fueled vehicles. Electric vehicles can be used in various sectors such as private and public transportation. Private transportation that uses electric power is cars, bicycles and Neighborhood Electric Vehicles (NEV) or also called Low Speed Vehicles (LSV). Electrically powered public transportation, namely buses and passenger transport vehicles in certain environments.

In Indonesia itself, electric vehicles as transport vehicles are in the form of buggy cars, one of which is Soekarno-Hatta Airport in Jakarta. In the future, electric cars will be implemented at

[1] Nyoman S Kumara, 'Tinjauan Perkembangan Kendaraan Listrik Dunia Hingga Sekarang', *Transmisi: Jurnal Ilmiah Teknik Elektro*, 10.2 (2008), 89–96.

other airports. The electric car that is being developed is a project from Gadjah Mada University called GATe (Gadjahmada Airport Transporter Electric). GATe is an electric car with a battery swap concept where the battery will be removed when it runs out for the charging process. Currently, GATe cars are produced in a production facility where there are manufacturing, assembly and storage activities. Until now, the GATe production facility is in the stage of creating a GATe prototype with a job shop strategy and implementing a fixed position layout. GATe is produced with a limited number of workers, machines and facility space so it takes 2 months to produce 3 GATe cars. After the due diligence, the GATe production facility will enter into LRIP custody with a target of 8 units/month. With the current condition of production facilities and resources, this target is difficult to achieve. Therefore it is necessary to design a GATe car production facility to achieve the company's objectives at the LRIP stage.

Good facility layout design can minimize transportation costs, material transport costs to production costs by minimizing waste. Based on previous research, there has been no research that discusses the layout design of facilities for the electric vehicle industry. In the automotive industry itself, a layout design study was conducted by Qamar et al., (2020) on military vehicle manufacturing.[2] Then there is research from Nazif et al., (2015) who designed the layout of the car component industry.[3] However, the two studies have different production conditions from the GATE production facility. In addition, there is no production schedule and objective to switch to LRIP. Thus, this study aims to design a GATE car production facility so that the facility can achieve optimal production with existing limitations.

Layout design is one that is considered in the design of production systems. In research conducted by Huang et al. (2007) said that in assembling products that are large, heavy, and difficult to move, a fixed position layout can be used.[4] The advantage of this layout is that it can reduce the movement of work pieces and the risk of product damage due to movement as well as more continuous work that does not require a lot of movement. However, the weakness of the fixed position layout is that the location of the facility area is limited and requires highly skilled workers. In addition, in a large production facility, the fixed position layout on the assembly line

[2] Ahmad M Qamar and others, 'Optimization of Plant Layout in Jordan Light Vehicle Manufacturing Company', *Journal of The Institution of Engineers (India): Series C*, 101 (2020), 721–28.

[3] Ahmad Nazif Noor Kamar and others, 'Improving Productivity by Simulate Facility Layout: A Case Study in a Car Component Manufacturer', *International Journal of Industrial Management*, *Malaysia*, 2016.

[4] George Q Huang, Y F Zhang, and P Y Jiang, 'RFID-Based Wireless Manufacturing for Walking-Worker Assembly Islands with Fixed-Position Layouts', *Robotics and Computer-Integrated Manufacturing*, 23.4 (2007), 469–77.

will limit communication between workers. Then, to improve the implementation of fixed position layout on assembly lines, RFID-based wireless manufacturing was implemented by Huang et al. (2007) to collect and synchronize production data. It is hoped that production flows can be more regular and work-in-process inventory can be reduced. Many previous studies support the fixed position layout as the appropriate layout to be applied on assembly lines for products that are large, heavy, and difficult to move. These characteristics are in accordance with the characteristics of the research object, namely the GATe production facility which produces large electric cars.

There are 2 classification methods in layout design, namely deterministic methods and heuristic methods. The deterministic method is defined as an optimization method that will produce optimal objective function results, gives more certain results but has a weakness, which requires complicated mathematical calculations.[5] The deterministic method is more suitable for small-scale projects. While the heuristic method will produce a near optimal solution. The disadvantages of the deterministic method are that it has calculations that are less complicated, does not take a long time, and can be applied to large-scale problems.[6]

By Rossin et al., (1999) it was explained that in the heuristic algorithm in designing facility layouts, there are 2 different approaches.[7] First, the development algorithm where there is already an existing facility layout and the designer wants to develop or increase the efficiency of that layout. Meanwhile, the second approach is to use a construction algorithm where there is no layout of the related facilities and the algorithm will place departments into the available areas. The CRAFT method has been used in various studies, such as to design layouts, including by Deshpande, et al. (2016) to design an alloy steel factory layout with mass production and compare it with the use of the ALDEP method. The result obtained is that the ALDEP method produces a better layout in terms of moving costs.[8] For traditional construction methods, there is CORELAP, which was previously carried out by Siregar et al. (2013) compared the BLOCPLAN algorithm to improve layout in transformer manufacturing companies. The objective used in this research is about the moment of displacement. It was found that the CORELAP algorithm can reduce the

[5] Alaa Al Hawarneh, Salaheddine Bendak, and Firas Ghanim, ‘Construction Site Layout Planning Problem: Past, Present and Future’, *Expert Systems with Applications*, 168 (2021), 114247.

[6] Al Hawarneh, Bendak, and Ghanim.

[7] Donald F Rossin, Mark C Springer, and Barbara D Klein, ‘New Complexity Measures for the Facility Layout Problem: An Empirical Study Using Traditional and Neural Network Analysis’, *Computers & Industrial Engineering*, 36.3 (1999), 585–602.

[8] Vivek Deshpande and others, ‘Plant Layout Optimization Using CRAFT and ALDEP Methodology’, *Productivity Journal by National Productivity Council*, 57.1 (2016), 32–42.

moment of displacement greater than the BLOCPLAN algorithm. Meanwhile, in research conducted by Triagus Setiyawan et al., (2017), the BLOCPLAN method produced a smaller displacement moment than the CORELAP method in a soybean-based food production factory. Differences occur because of differences in products that are made and may be a contribution to each type of industry. In addition, CORELAP has also been implemented with an objective total closeness rating by Azis Dwianto et al. (2016).[9] The ALDEP method was implemented by Suhardini & Rahmawati (2019) to develop the initial layout of a furniture company. Research by Saifurrahman (2020), uses the CORELAP algorithm and an intuitive approach for designing the layout of CNC machine fabrication facilities. In this study, in general, the researcher took a layout type in the form of a fixed position layout and a process layout. The research resulted in a layout that was evaluated in terms of displacement load.[10]

For the object used in this research, the automotive industry, several layout studies have been carried out. In a study of layout design in military vehicle manufacturing by Qamar et al (2020), a multi-objective Systematic Layout Planning (SLP) framework was used, namely in terms of total transportation distance, closeness of departmental relationships, and total space required.[11] The alternative used is brainstorming so there is no special method used.[12] The selection of alternative layouts is carried out using the AHP (Analytical Hierarchy Process) method by considering the predetermined objectives. This research is quite complex where the method used is intuitive by considering quantitative and qualitative objectives. Another study was conducted by Kamar et al (2016) which compared production line efficiency between traditional layouts and cellular manufacturing (CM) layouts. Then the CM machines are grouped and arranged using an intuitive method, namely adjusting to patterns such as zig-zag, V-shape and U-shape. From the alternative layouts that have been created, a simulation test was carried out with ARENA software and it was found that the U-shape layout of the CM can increase productivity by up to 13.3% and efficiency by 18.8%. Research by Kamar et al (2016) is quite complex where machines are grouped into cells which is an appropriate method for industries with batch production, but in designing the layout they still use intuitive methods.

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[9] Qodri Azis Dwianto, Susy Susanty, and Lisye Fitria, 'Usulan Rancangan Tata Letak Fasilitas Dengan Menggunakan Metode Computerized Relationship Layout Planning (CORELAP) Di Perusahaan Konveksi', *Reka Integra*, 4.1 (2016).

[10] ANAS SAIFURRAHMAN, 'Perancangan Tata Letak Fasilitas Untuk Fabrikasi Mesin CNC Batik Tulis Menggunakan Pendekatan Systematic Layout Planning' (Universitas Gadjah Mada, 2020).

[11] Qamar and others.

[12] Qamar and others.

## METHOD

The design and development in this research focuses on GATe Car production facilities in the form of only one type of product. Several factors need to be considered, such as the close relationship between departments. This factor will then carry out an evaluation of the displacement. This research uses GATe car production data, rolling meters, stopwatches, Microsoft Excel software, and draw.io software.

The stages carried out during the research include the following. The first is to observe the existing conditions of the GATe Car production facility to get an overview of the layout sequence. Second is identifying problems to find clearer research directions. The third is to conduct a literature study to gain deeper insight regarding facility design so that you can find out the contributions and problems that can then be raised in research. Fourth is production data collection which is carried out to design facilities in the form of REL charts and from-to charts. Fifth is data processing. Then validation is carried out on GATe workers. Sixth is to analyze the condition of the existing layout in the form of capacity, limitations and department functionality. Seventh is designing departmental needs in the form of space requirements for machinery, materials and workers as well as designing the department visually. Eighth is to prepare alternative layouts using the CORELAP algorithm which takes into account the closeness rating value. The CORELAP (Computerized Relationship Layout Planning) algorithm allows the layout to have a shape other than a square or rectangle so that it is more realistic. The CORELAP mechanism begins by placing the department with the largest total proximity rating in the middle of the empty block area, followed by the placement of other departments. Ninth is evaluating the layout by looking at the utility of the facility to select an alternative from several recommendations that have been designed. The tenth is to compare the existing layout with the selected layout.

## RESULTS AND DISCUSSION

GATE car production activities are carried out in buildings without partitions measuring 16.4 m x 12.4 m. The main GATE Car assembly area is located in the center of the facility. Meanwhile, component-making machines such as hand grinding machines, welding machines, and others are located around the main assembly area. However, there are several rooms that are also used for the continuity of production activities such as during the acrylic assembly process, electrical system assembly, and painting in the oven area.

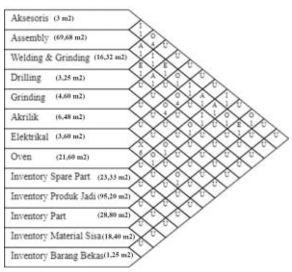
The current GATe production facility is a fixed-position layout type. During the assembly process, the product does not move from one department to another, but workers and machines come to the car assembly site. To improve the design of the GATe production facility, the layout type in the form of a fixed position layout will still be implemented so that improvements are focused on the distance and number of displacements that occur.

The main movement at the GATe production facility occurred in the production area. While in the non-production area there is no significant displacement. The number of flows on the from-to chart is the sum of the forward and backward movements between departments. One of the most movements occurs between assembly and welding & grinding areas. The following table from-to chart which states the frequency of transfers between departments

Table 1 From-to Chart of Movement Frequency of GATe Production Facilities

| ***From-to Chart*** | Aksesoris | *Assembly* | *Welding & Grinding* | *Drilling* | *Grinding* | Akrilik | Elektrikal | Oven | *Inventory Spare Part* | *Inventory Produk Jadi* | *Inventory Part* | *Inventory Material Sisa* | *Inventory Barang Bekas* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Aksesoris | | 7 | 2 | 0 | 0 | 0 | 0 | 0 | 6 | 0 | 2 | 0 | 0 |
| *Assembly* | 7 | | 53 | 5 | 10 | 2 | 6 | 20 | 24 | 1 | 12 | 0 | 0 |
| *Welding & Grinding* | 2 | 53 | | 13 | 34 | 0 | 1 | 0 | 7 | 0 | 0 | 0 | 0 |
| *Drilling* | 0 | 5 | 13 | | 0 | 0 | 2 | 0 | 2 | 0 | 0 | 0 | 0 |
| *Grinding* | 0 | 10 | 34 | 0 | | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| Akrilik | 0 | 2 | 0 | 0 | 0 | | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| Elektrikal | 0 | 6 | 1 | 2 | 0 | 0 | | 0 | 3 | 0 | 1 | 0 | 0 |
| Oven | 0 | 20 | 0 | 0 | 1 | 0 | 0 | | 0 | 0 | 0 | 0 | 0 |
| *Inventory Spare Part* | 6 | 24 | 7 | 2 | 0 | 1 | 3 | 0 | | 0 | 0 | 0 | 0 |
| *Inventory Produk Jadi* | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | 0 | 0 | 0 |
| *Inventory Part* | 2 | 12 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | | 0 | 0 |
| *Inventory Material Sisa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | 0 |
| *Inventory Barang Bekas* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |

Determination of the relationship on the REL chart between production departments is carried out based on the from-to chart produced and the considerations of employees and supervisors of the GATe production facility. The close relationship between production departments is as follows.

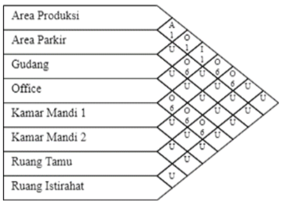



| *Kedekatan* | *Keterangan* |
|---|---|
| A | Mutlak berdekatan |
| E | Sangat penting untuk berdekatan |
| I | Penting untuk berdekatan |
| O | Kedekatan biasa |
| U | Tidak penting berdekatan |
| X | Tidak boleh berdekatan |

| Kode | Alasan |
|---|---|
| 1 | Kemudahan aliran material |
| 2 | Kemudahan pengawasan |
| 3 | Peralatan yang sama |
| 4 | Pekerja yang sama |
| 5 | Komunikasi |
| 6 | Kenyamanan |

Figure 1 REL Chart Production Department

To see the relationship in all departments, by generalizing the relationship between the production department and each department in the non-production area. This is done because there is no significant transfer of expenses between each production department to each non-production department. REL chart of all departments as follows.




| *Kedekatan* | *Keterangan* |
|---|---|
| A | Mutlak berdekatan |
| E | Sangat penting untuk berdekatan |
| I | Penting untuk berdekatan |
| O | Kedekatan biasa |
| U | Tidak penting berdekatan |
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| Kode | Alasan |
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| 3 | Peralatan yang sama |
| 4 | Pekerja yang sama |
| 5 | Komunikasi |
| 6 | Kenyamanan |

Figure 2 REL Chart for All Departments

The design requirements for each worker are assumed to be the same, namely in the form of a room area for work with a squatting position of 1.12m x 0.56m (Sanders & McCormick, 1993). Then, space requirements and design are carried out for each department in the GATe production facility. This is because there is a squatting position in each process. Examples are when workers pick up work objects, set up machines, or during the car assembly process. Meanwhile, for each department, an additional allowance of 150% is used according to recommendations by Stephens & Meyers (2005). Determination of room requirements, obtained by doing calculations in each department. For example, in Table 2, the assembly department has 6 work activities, so the space requirement is obtained by adding up the area of the work center for each work activity, the area of the worker's room, and the material space. The sum is then multiplied by the total allowance of 150%. The room requirements of each department can be seen in Figure 3.

Table 2 Example of Calculation of Room Requirements for the Assembly Department

| No | Departemen | *Work Center* | Ukuran (cm) | Panjang (m) x Lebar (m) | Jumlah | Luas *Work Center* (m2) | Jumlah Pekerja | Luas Ruang Pekerja (m2) | *Material Space* (m2) | Sub-Total | Total (x *Allowance* Produksi 150%) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | *Assembly* | Mesin Las | 50 x 50 | 0.5 x 0.5 | 2 | 0.50 | 12 | 7.5264 | 18.06 | 41.17 | 61.76 |
| | | Gerinda Tangan | 30 x 30 | 0.3 x 0.3 | 2 | 0.18 | | | | | |
| | | Bor Tangan | 30 x 30 | 0.3 x 0.3 | 2 | 0.18 | | | | | |
| | | *Jig Chassis* | 410 x 160 | 4.1 x 1.6 | 1 | 6.56 | | | | | |
| | | *Jig Top Roof* | 452 x 117 | 4.52 x 1.17 | 1 | 5.29 | | | | | |
| | | Rak | 240 x 120 | 2.4 x 1.2 | 1 | 2.88 | | | | | |

Table 3 Space Requirements for the GATe Production Facilities Department

| No | Department | Sub-Total | Total (x Allowance Production 150%) |
|---|---|---|---|
| 1 | Assembly | 41.17 | 61.76 |
| 2 | Welding & Grinding | 17.19 | 25.78 |
| 3 | Drilling | 2.67 | 4.01 |
| 4 | Grinding | 13.53 | 20.3 |
| 5 | Accessories | 2.62 | 3.93 |
| 6 | Acrylic | 4.23 | 6.35 |
| 7 | Electrical | 6.71 | 10.06 |
| 8 | Oven | 15.9 | 23.85 |

| | | | |
|---|---|---|---|
| 9 | Finished Product Inventory | 110.84 | 110.84 |
| 10 | Part Inventory | 18.2 | 27.3 |
| 11 | Leftover Material Inventory | 20.28 | 30.42 |
| 12 | Used Goods Inventory | 18.39 | 27.59 |

When designing alternative layouts, there are several assumptions used, such as the shape of the room in the GATe production facility cannot be changed, there will be demolition of the room if the room is not utilized, and there are departments that cannot be moved, namely the warehouse, bathroom, oven, used goods inventory. , finished product inventory, and office.

Calculations with the CORELAP algorithm, using a REL chart that has been converted into proximity weights. The closeness weight is added up by EVERY department so that it becomes a TCR (Total Closeness Rating).

Table 4 Production Department TCR

| ***Total Closeness Rating*** **Departemen Produksi** | Aksesoris | *Assembly* | *Welding & Grinding* | *Drilling* | *Grinding* | Akrilik | Elektrikal | Oven | *Inventory Spare Part* | *Inventory Produk Jadi* | *Inventory Part* | *Inventory Material Sisa* | *Inventory Barang Bekas* | A (64) | E (16) | I (4) | O (1) | U (0) | X (-1024) | TCR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Aksesoris | | I | O | U | U | U | U | U | I | U | O | U | U | 0 | 0 | 2 | 2 | 8 | 0 | 10 |
| Assembly | I | | A | I | E | O | I | A | A | O | E | U | U | 3 | 2 | 3 | 2 | 2 | 0 | 238 |
| Welding & Grinding | O | A | | E | A | U | O | U | I | U | U | U | U | 2 | 1 | 1 | 2 | 6 | 0 | 150 |
| Drilling | U | I | E | | U | U | O | U | O | U | U | U | U | 0 | 1 | 1 | 2 | 8 | 0 | 22 |
| Grinding | U | E | A | U | | U | U | U | U | U | U | U | U | 1 | 1 | 0 | 0 | 10 | 0 | 80 |
| Akrilik | U | O | U | U | U | | U | U | O | U | U | U | U | 0 | 0 | 0 | 2 | 10 | 0 | 2 |
| Elektrikal | U | I | O | O | U | U | | X | O | U | O | U | U | 0 | 0 | 1 | 4 | 6 | 1 | -1016 |
| Oven | U | A | U | U | U | U | X | | U | U | U | U | U | 1 | 0 | 0 | 0 | 10 | 1 | -960 |
| Inventory Spare Part | I | A | I | O | U | O | O | U | | U | U | U | U | 1 | 0 | 2 | 3 | 6 | 0 | 75 |
| Inventory Produk Jadi | U | O | U | U | U | U | U | U | U | | U | U | U | 0 | 0 | 0 | 1 | 11 | 0 | 1 |
| Inventory Part | O | E | U | U | U | U | O | U | U | U | | U | U | 0 | 1 | 0 | 2 | 9 | 0 | 18 |
| Inventory Material Sisa | U | U | U | U | U | U | U | U | U | U | U | | U | 0 | 0 | 0 | 0 | 12 | 0 | 0 |
| Inventory Barang Bekas | U | U | U | U | U | U | U | U | U | U | U | U | | 0 | 0 | 0 | 0 | 12 | 0 | 0 |

Table 5 Overall Departmental TCR

| ***Total Closeness Rating*** **Departemen Keseluruhan** | Area Produksi | *Area Parkir* | *Gudang* | *Office* | *Kamar Mandi 1* | Kamar Mandi 2 | Ruang Tamu | Ruang Istirahat | A (64) | E (16) | I (4) | O (1) | U (0) | X (-1024) | TCR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Area Produksi | | A | O | I | O | O | U | U | 1 | 0 | 1 | 3 | 2 | 0 | 71 |
| Area Parkir | A | | U | O | U | U | U | U | 1 | 0 | 0 | 1 | 5 | 0 | 65 |
| Gudang | O | U | | U | U | U | U | U | 0 | 0 | 0 | 1 | 6 | 0 | 1 |
| Office | I | O | U | | O | O | O | U | 0 | 0 | 1 | 4 | 2 | 0 | 8 |
| Kamar Mandi 1 | O | U | U | O | | U | U | U | 0 | 0 | 0 | 2 | 5 | 0 | 2 |
| Kamar Mandi 2 | O | U | U | O | U | | U | U | 0 | 0 | 0 | 2 | 5 | 0 | 2 |
| Ruang Tamu | U | U | U | O | U | U | | U | 0 | 0 | 0 | 1 | 6 | 0 | 1 |
| Ruang Istirahat | U | U | U | U | U | U | U | | 0 | 0 | 0 | 0 | 7 | 0 | 0 |

Arrangements were also made for production facilities with the results as shown in Figure 5. Block layouts were made by determining which department has the highest TCR value to be placed in the middle of the block layout. Then, looking at the relationship between departments that have an A value, they are placed close together. After obtaining the block layout for the production department, proceed with the arrangement of the layout for the entire department with the results shown in Figure 6.

| Departemen | Index |
|---|---|
| Aksesoris | *1* |
| *Assembly* | *2* |
| *Welding & Grinding* | *3* |
| *Drilling* | *4* |
| *Grinding* | *5* |
| Akrilik | *6* |
| Elektrikal | *7* |
| Oven | *8* |
| *Inventory Tool & Spare Part* | *9* |
| *Inventory Produk Jadi* | *10* |
| *Inventory Part* | *11* |
| *Inventory Material Sisa* | *12* |
| *Inventory Barang Bekas* | *13* |

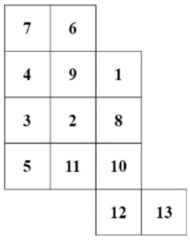


Figure 3 Block Layout of Production Department CORELAP Analysis Results

| Departemen | Index |
|---|---|
| Area Produksi | *1* |
| Area Parkir | *2* |
| Gudang | *3* |
| *Office* | *4* |
| Kamar Mandi 1 | *5* |
| Kamar Mandi 2 | *6* |
| Ruang Tamu | *7* |
| Ruang Istirahat | *8* |

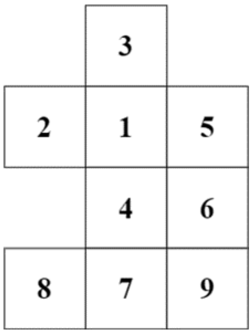


Figure 4 Block Layout Results of CORELAP Analysis for All Departments

With adjustments made based on the shape of the GATe production facility, the layout results use the CORELAP algorithm as follows.

Figure 5 Layout of CORELAP Analysis Results

Departments outlined in black indicate that they have a wall boundary around them.

The displacement distance is calculated using the rectilinear method, which calculates the distance based on the horizontal and vertical displacement between the center of gravity of the departments. Calculation of the distance between departments is done by first creating a rectilinear line as follows.

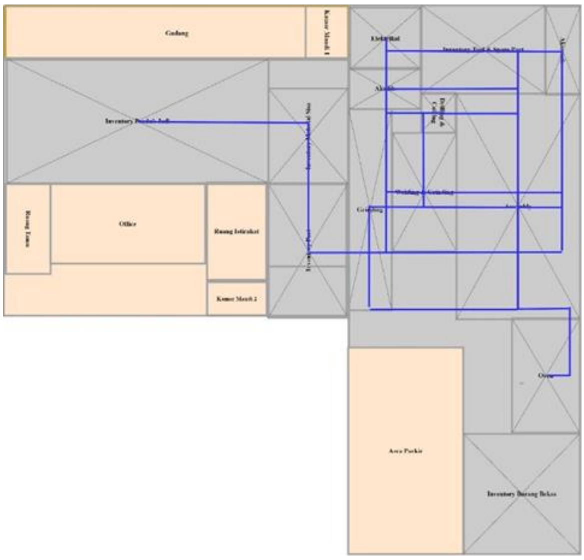


Figure 6 Rectilinear Distance Calculation in the CORELAP Algorithm Results Layout

From the rectilinear path that has been made, then the distance between departments is calculated. Next, the multiplication between the distance traveled and the frequency of movements is performed on the from to chart of the number of movements as follows.

Table 7 From to Chart Total Transfer Load in the CORELAP Algorithm

| **CORELAP *From to Chart* (Beban Perpindahan)** | *Aksesoris* | *Assembly* | *Welding & Grinding* | *Drilling* | *Grinding* | *Akrilik* | *Elektrikal* | *Oven* | *Inventory Tool & Spare Part* | *Inventory Produk Jadi* | *Inventory Part* | *Inventory Material Sisa* | *Inventory Barang Bekas* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Aksesoris | | | | | | | | | | | | | |
| Assembly | 74.2 | | | | | | | | | | | | |
| Welding & Grinding | 29.28 | 304.2 | | | | | | | | | | | |
| Drilling | | 46.5 | 65.65 | | | | | | | | | | |
| Grinding | | 78 | 125.8 | | | | | | | | | | |
| Akrilik | | 27 | | | | | | | | | | | |
| Elektrikal | | 97.2 | 10.15 | 13.54 | | | | | | | | | |
| Oven | | 259.8 | | | 20.79 | | | | | | | | |
| Inventory Tool & Spare Part | 25.14 | 242.4 | 81.9 | 5.6 | | 10.9 | 17.67 | | | | | | |
| Inventory Produk Jadi | | 29.41 | | | | | | | | | | | |
| Inventory Part | 48.12 | 162.4 | | | | | 15.52 | | | | | | |
| Inventory Material Sisa | | | | | | | | | | | | | |
| Inventory Barang Bekas | | | | | | | | | | | | | |
| **Total Beban Perpindahan per Departemen** | 176.7 | 1247 | 283.5 | 19.14 | 20.79 | 10.9 | 33.19 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Total Beban Perpindahan** | **1791.15** | | | | | | | | | | | | |

The total displacement generated using the CORELAP algorithm is 1791.15 m. Obtain the final results of the layout design.

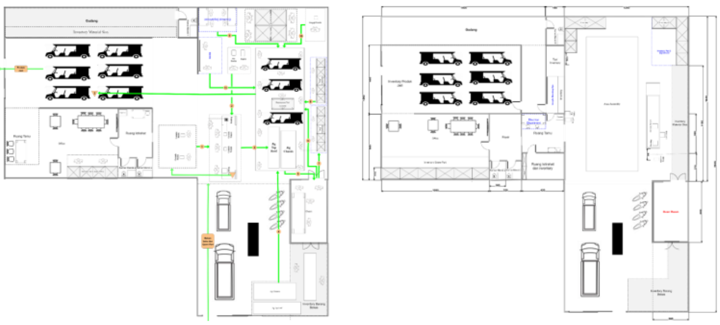

Figure 7 Comparison of the Selected Layout with the Existing Layout

The image on the left is the layout selected via the CORELAP algorithm, while the image on the right is the existing condition layout. There are several adjustments to the layout arrangement of the selected layout. Several departments such as finished product inventory, used goods inventory, warehouse, parking area, and oven cannot be moved. There is demolition of walls in the existing rest room, existing acrylic room, existing tool inventory, and existing warehouse so that cars can have road access to be moved to the finished product inventory. In addition, warehouses which in their existing conditions are not properly utilized, are designed to be utilized as inventory of leftover materials. Residual material inventory does not have a location that matches CORELAP results. But this has no impact because it does not consider the flow of movement from the remaining material inventory to other departments. Meanwhile, the inventory part has been adjusted by being moved to the right side of the assembly. This is because the previous placement of inventory parts, namely near the bathroom, made it impossible to see the condition of the short building structure. Moving parts inventory to the right side of the assembly and close to the oven is an advantage because there is movement between these departments. The visualization of each department is also adjusted to the results of the CORELAP layout design so that there are several differences with the department design visualization.

Apart from that, material handling can also be used such as trolleys to be used to transport materials such as scrap metal, body covers, etc. so that materials can be moved in large quantities at once.

## CONCLUSION

Based on the research that has been done, several conclusions can be drawn that answer the research objectives as follows:

1. The layout is designed based on the fixed position layout.
2. Layout design is carried out with a quantitative objective in the form of load displacement. Meanwhile, the qualitative approach, in the form of closeness of relationship, is considered in the way of alternative layout arrangements. From the calculation results, the alternative layout designed using the CORELAP algorithm has a smaller displacement load so this alternative is recommended for GATe production facilities.

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