# Paratransit Ergonomics

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**ABSTRACT**

In order to improve effectiveness, ergonomics is needed in every part of our activities including in designing the paratransit. Through library research, mini lab-testing, and field study, we could find out how ergonomics our paratransit is, in this case paratransit route Pusat Grosir Cililitan (PGC) Mekar Sari. Based on the study, it is revealed that the ergonomics value which should be applied cannot be achieved due to overloaded passengers of the transportation that caused inconvenience.

**Keywords**: paratransit, ergonomics, convenience

## Introduction

Ergonomics is needed in every activities of life in order to provide convenience, get easiness, support low cost efficacy, avoid accidents, create good performance, boost efficiency and effectiveness. Otherwise, life will be much more complicated.

Convenience, welfare, and performance are easily affected by the facilities designed compatibly human bodies; their dimensions, normal body movement, muscle power, speed, temperature, sound, etc. One of the facilities is the transportationation used by the people.

To design a compatible facilities including paratransit, we need a discipline called Ergonomics / Human Engineering. If people apply it when they design the paratransit, they will consider some factors which are the size and shape of human body, muscle power, fast response, light, eye-sight, ideal working temperature, noise, factors caused tiredness, and pollution effect. After considering these factors and applying the Ergonomics to the facilities they design, they will feel convenient, pleasure, satisfied, healthy, have high productivity, work effectively, efficiently and at minimum risk.

To test whether the paratransit route PGC – Mekar Sari is ergonomics or not, researchers tried to collect the data through library research, take samples from mini ergonomics' lab, analyze statistically, give the data of body measurement, take field sample, and study the case.

Library research is needed to have a better understanding of what ergonomics is and how to apply it by salient reading through books, magazines, newspapers, and sites about Ergonomics, Human Engineering, and Designs.

## Results and Discussion

The findings have been identified in the mini ergonomics' lab, where there are some steps to be applied. First, conducting the primary study to find out the dimensions of interior from the paratransit which will be studied. In this case, it means the

paratransit route PGC – Mekar Sari. Second, deciding the dimensions of human body to be measured. Then, designing and measuring the compatibility of the human body and the facilities; for example the seats in the vehicles.

The samples used in this study are taken randomly from passengers of 'angkot' (e.g Mikrolet, KWK) route PGC-Mekar Sari, respondents are based on various gender, ethnicity, age, and social status. After collecting the data and filling in the table, the researchers analyze the data statistically. First, we made the histogram and the normal distribution calculation. Then, we made the table based on percentile calculation (5 %, 50 %, and 95 %).

In designing the ergonomics' seats, we have to decide the measurement of the seats and the interior of the transportation like the height and width of the door, the height of the bus, the width and height of the seat, the standard size of single and double seats, and also the space between seats.

The case can be studied then, after collecting the data field and studying the field physically. We analyze the data whether it has applied the ergonomics' discipline or not related to the interior and facilities dimensions. We analyze the dimensions, shapes, and the ergonomics' passengers' capacity. As stated before, researchers pick out to study the paratransit route PGC – Mekar Sari for this case.

## A. Ergonomics

The International Ergonomics Association defines ergonomics or human factors as follows; "Ergonomics (or human factors) is the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data, and methods to design in order to optimize human well-being and overall system performance."

Ergonomics is rooted from Greek. The word is a combination of "Ergon" means work and "Nomos" means law or rules. The term is used in Europe and other countries with the same or different names. For example, in Scandinavia they use the word Biotechnology that resembles the same meaning. In USA and other countries, they popularize the word Human Factors that related to Ergonomics. While in the military services in USA, the term Human Engineering is more popular and the psychologists call it Psychology Engineering.

According to William S. Marras from Ohio State University, Human Factors focused on people and their interaction with products, utilities, facilities, procedures, and environment that are used at work and daily activities.

The purposes of Human Factors are:

1. To enhance the effectiveness and efficiency of daily activities and at work. It also includes enhancing the users' satisfaction and productivity and of course minimizing the errors.
2. To enhance the expected human value such as enhancing the safety and convenience, the work satisfaction and quality of life and also minimizing the tiredness and stress.

Human factors and ergonomics are concerned with the 'fit' between the user, equipment, and their environments. It takes account of the user's capabilities and limitations in seeking to ensure that tasks, functions, information, and the environment suit each user.

Chapanis (1985) defines Human Factors as a method to find and apply information collected about human behavior, ability, limitation, and other

characteristic to design tools, systems, tasks, activities, productive field, safety, convenience, and effectiveness.

Ergonomics, physically, is concerned with human body dimensions, temperature, noise, pollution, lights, colours effect, environment, human interaction with machines or tool, etc (see Table 1).

One of the sub-discipline of Ergonomics is Anthropometry. In Greek, it means measurement of the individual human. Today, it plays an important role in industrial design, clothing design, ergonomics, and architecture where statistical data about the distribution of body dimensions in the population are used to optimize products.

In this study, the measurement of human body dimensions covers sufficient samples to fulfill the statistical data. This statistic data contains sufficiently normal data that represents a population. The data needed must cover these categories; male, female, age, origin, social status or level, and others.

There are two different size of human body; big (maximum) and small (minimum). In the field of Ergonomics, only 95 % of human body dimensions that can be used to design and implement the tools while the rest 5 % will have its own problem.

The usual measurement of human body dimensions are:

1. 5 % percentile is called minimum
2. 50 % percentile is considered average
3. 95 % percentile is defined maximum

Each percentile is used and designed compatibly with the tools and environment (see Figure 1 & 2).

## B. Statistical Analysis

This study is using SPSS 17 in processing the data collected. The result shown in the form of histogram, normal data analysis, 5 %, 50 %, 95 % percentile. Using the histogram has given a chance to eliminate useless data such as outliers, maximum and minimum. To decide which percentile is used, the tools dimensions must be considered. As an example, the chair leg, the width of chair per person, must be considered before taking the 95 % percentile from men (see Table 2). For 5 % percentile, the researcher took the data from female length of arms in reaching the holder in Trans Jakarta (see Table 3). For 5 % to 95 % percentile, the researcher took an example from the adjusting seats in the car or from the adjusting head rest in a car.

## C. Sample Collection in the Field

By measuring the interior dimensions of the paratransit and measuring the seats, the researcher took the primary data from 4 paratransits route PGC – Mekar Sari as the case study.

After doing the research of some paratransits route PGC – Mekar Sari, there are some results can be concluded. The first one is paratransit type Toyota Kijang, produced 1993 (Panca Tunggal). The width of the seats is 220 cm while male length of shoulder (95 % percentile) is 49.16 cm. In this case, the ergonomics seats availability is 4.5 persons. This data is calculated; 220 / 49.16 = 4.48 (see Figure 3 & 4).

If the driver forces 5 persons to sit in that long seat, it will be uncomfortable. But, in reality, 6 persons can sit in that seat. Using the dimensions of hip width, only 5 persons can sit in the long seat in an uncomfortable way of sitting due to shoulder break one another. The data is calculated this way; 220 / 40.3 = 5.46 (see Figure 5).

Talking about the smaller seat with only 151.5 cm height and the male shoulder width (95 % percentile) is 49.16, it shows

that ergonomically only available for 4 persons (151.5 / 49.16 = 3.08) beyond the reality (see Table 4).

The seat next to the driver is available for only 2 passengers. This is due to the calculation 140.5 cm (the width of the seat) divided by 49.16 (male shoulder width). Unfortunately, the drivers often force 3 persons to sit next to him (see Figure 6).

The second analysis is applied to Suzuki Carry 1000 cc, 2001 (Panca Tunggal). The first analysis is for the long seat. It has width 214 while male shoulder width is 49.16. It means after dividing the researcher get the availability 4 persons to sit there. As usual, if the driver forces 5 to 6 people to sit there, it will be much more uncomfortable. The second analysis is the door height. Male height (after bowing with 95 % percentile) is 124.14. It means the door height (only 99 cm) is really not sufficient for passengers. The door height should be 124.14 cm. This number comes from 124.14 – 99 = 25.14. The third one is taken from the width of seat next to the driver. The width is 130 cm while the male shoulder is 49.16 cm. If we devide this number, we'll get only 2 persons available to sit there. In some cases, drivers force 3 persons to sit next to him.

The last type of paratransit is Toyota Kijang 2003 (RS). From the ergonomics analysis, the researchers get some results. Measuring the range of the long seat to the smaller seat is 142 cm, this calculation is needed to know the suitable space for passengers sitting face to face. The calculation is (64.04 + 30.40) x 2 = 188.88. It means there will be high inconveniences due to the crossing feet of the passengers one another. They need space 64.04 x 2 = 128.08 cm. There is of course space for knees but still it is difficult for them to get in and get out (see Figure 7).

## Conclusion

Based on the case study that has been explained above, it can be concluded that our paratransit esp. route PGC – Mekar Sari still needs to be improved to create ergonomics paratransit that support passengers conveniences. It can be done when the government regulation also work hand in hand with the ergonomics discipline in designing paratransit. Otherwise, the discipline cannot be applied due to the naughty drivers who love to force unreasonable number of passengers into their car.

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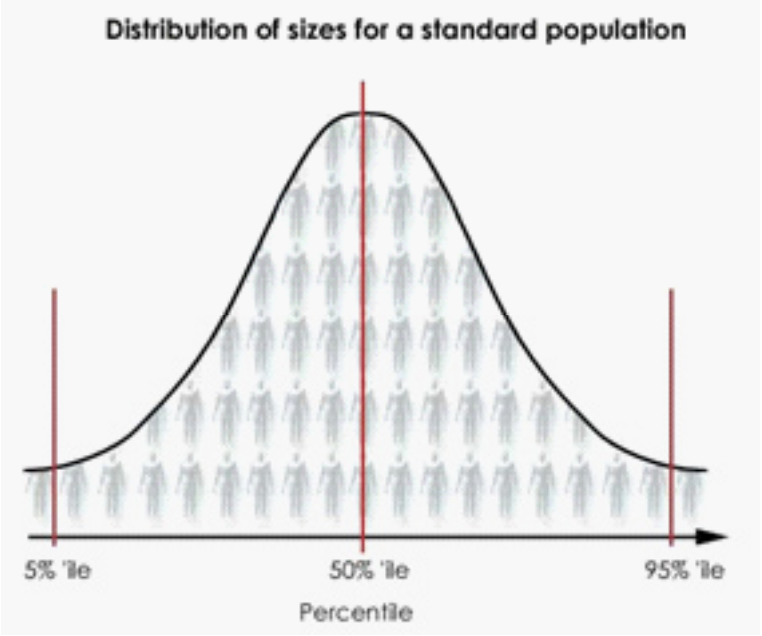
# Appendices




*Source : Ergonomic, Image, Google.com*

**Figure 1 Normal Distribution with 5 %, 50 %, and 95 % Percentile**

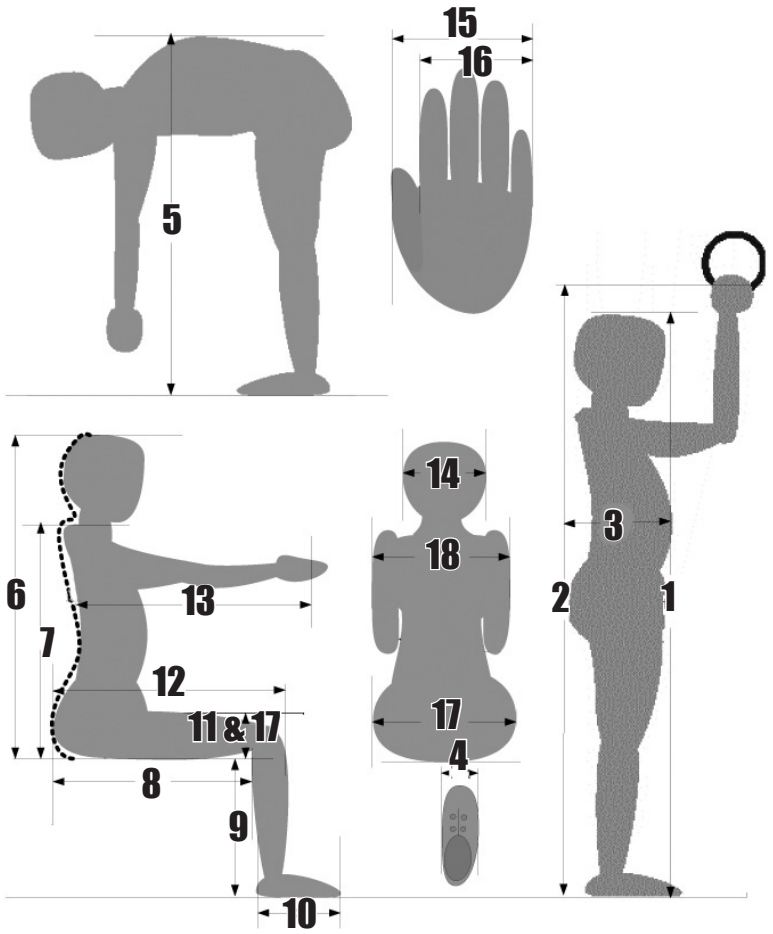



**Figure 2 Parts of Human Body Measured to Design Ergonomics Paratransit**

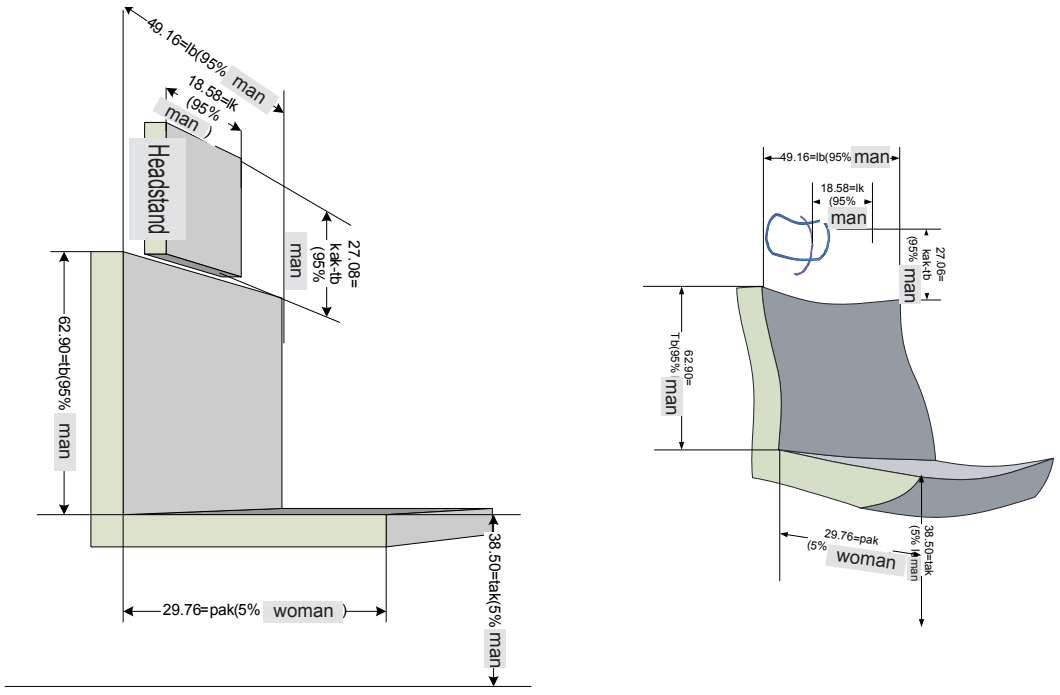



**Figure 3 A Seat Standard Size in Paratransit for One Person**

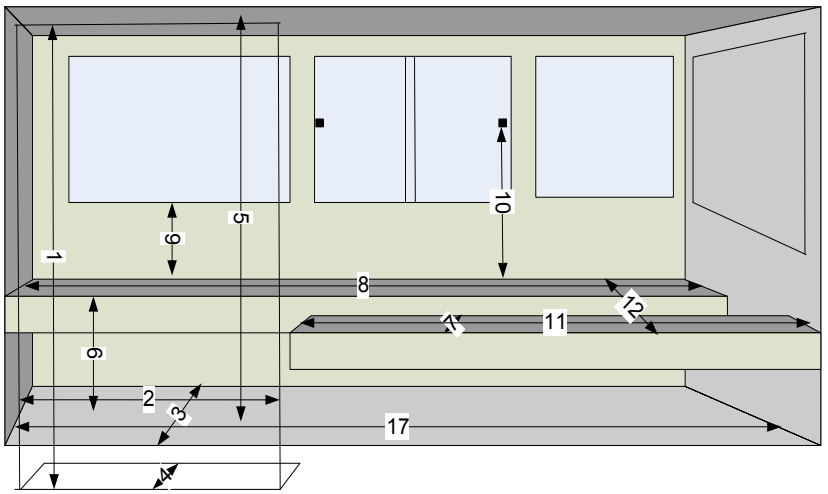



**Figure 4 Paratransit Interior Dimensions**

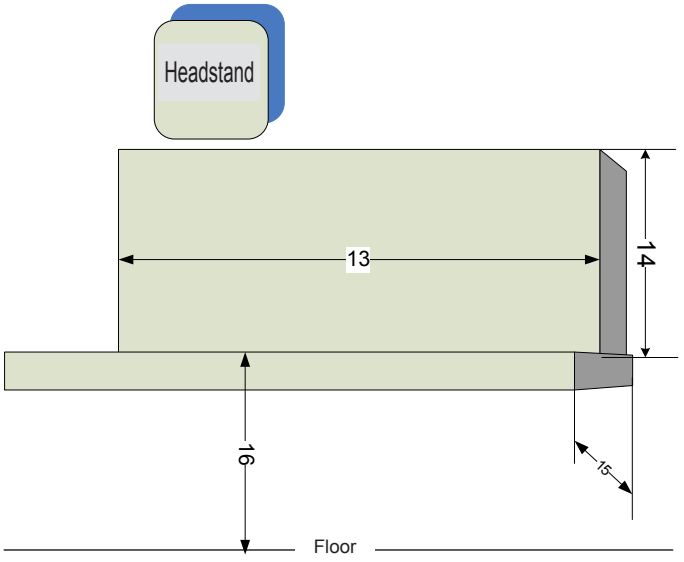



**Figure 5 Seats for Drivers and Passangers**

**Figure 6 Paratransit Interior Dimensions of Toyota Kijang**

**Figure 7 The Door and The Interior of Toyota Kijang**

## Table 1 Human Body Measurement Studied by McCormick in USA

**Selected Anthropometric Dimensions**

| | | MALE | | | | | FEMALE | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ID | DESCRIPTION | MED | SD | MIN | MAX | GF | MED | SD | MIN | MAX | GF |
| A | Height | 69.1 | 2.44 | 59.5 | 77.6 | a | 63.2 | 2.48 | 55 | 73 | d |
| B | Shoulder Breadth | 17.9 | 0.91 | 14.6 | 22.8 | a | 13.4 | 1.22 | 8.7 | 19.3 | d |
| C | Hip Breadth(Seat) | 15.3 | 1.11 | 12 | 21.3 | b | 14.6 | 1.04 | 12.1 | 20.6 | c |
| C | Hip Breadth(Stand) | 13.2 | 0.73 | 8.3 | 15.8 | a | 15 | 1.03 | 11.8 | 18.9 | e |
| C | Hip Breadth(Seat) | 13.9 | 0.87 | 11.4 | 18.1 | a | | | | | |
| D | Foot Breadth | 3.8 | 0.19 | 3.2 | 4.7 | a | | | | | |
| E | Arm Span | 70.8 | 2.94 | 58.3 | 82.3 | a | | | | | |
| F | Arm Reach | 34.6 | 1.65 | 27.6 | 39.8 | d | 31.8 | 1.29 | 28.3 | 35.4 | e |
| G | Chest Depth | 9 | 0.75 | 6.7 | 13 | a | | | | | |
| H | Hand Breadth | 3.5 | 0.16 | 3 | 4.1 | a | | | | | |
| I | Forearm-Hand | 18.9 | 0.81 | 15.4 | 22.1 | | | | | | |
| J | Buttock-Knee | 23.6 | 1.06 | 18.5 | 27.6 | a | 22.6 | 0.96 | 19.7 | 26.7 | e |
| K | Seat Length | 18.9 | 0.96 | 15.4 | 23.1 | b | 18.2 | 1.04 | 15.2 | 22.2 | c |
| L | Sitting Knee Hgt | 21.7 | 0.99 | 17.3 | 24.8 | a | 17.2 | 1.07 | | | d |
| M | Foot Length | 10.5 | 0.45 | 8.9 | 12.2 | a | 9.6 | 0.4 | 8.9 | 10.9 | e |
| N | Erect Sit Height* | 36 | 1.29 | 29.9 | 40.2 | a | 34.1 | 1.02 | 30.7 | 34.4 | e |
| P | Shoulder Hgt(Seat) | 23.3 | 1.14 | 18.9 | 27.2 | a | 24.6 | 3.02 | | | d |
| Q | Seat Height | 19 | 0.89 | 15.6 | 22 | b | 18.1 | 0.89 | 15.4 | 20.6 | c |

Notes:

Source: McCormick, 1964

* Normal Sitting Height is about 2" Less Than Erect Height

Group "c" Data Are Medians, Groups "d" & "e" Data Are Means

Groups:

a- 4000 Air Force Flying Personnel, Herzberg, Daniels and Churchill

b- 1959 Civilian Males, Hooten and Staff

c- 1908 Civilian Females, Hooten and Staff

d- 10,042 Civilian Females, O'Brien and Shelton

e- 447 Female Pilots, Randall, Damon, Benton and Pratt

**Table 2 Male Body Dimensions, n = 70**

| No | Parts of The Body | Percentile 5% (Minimum) | Percentile 50% (Average) | Percentile 95% (Maximum) |
|---|---|---|---|---|
| 1 | height | 153.12 | 166.4 | 179.44 |
| 2 | arm span height | 161.74 | 176.2 | 188.46 |
| 3 | weight | 20.00 | 26.00 | 35.08 |
| 4 | foot weight | 8.72 | 10.50 | 13.02 |
| 5 | height when bowing | 104.18 | 115.90 | 137.94 |
| 6 | head to toe | 76.46 | 82.40 | 89.98 |
| 7 | shoulder height | 50.52 | 57.00 | 62.90 |
| 8 | seat length | 36.40 | 42.93 | 49.06 |
| 9 | seat height | 38.50 | 42.40 | 47.22 |
| 10 | leg length | 23.44 | 28.50 | 30.40 |
| 11 | width | 10.46 | 13.30 | 17.20 |
| 12 | hip to knee | 47.52 | 56.00 | 64.04 |
| 13 | arm span | 54.76 | 63.40 | 69.54 |
| 14 | head width | 15.16 | 17.00 | 18.58 |
| 15 | 5 fingers width | 9.32 | 10.80 | 13.000 |
| 16 | 4 fingers width | 6.6 | 8.20 | 10.00 |
| 17 | hip width | 29.64 | 33.20 | 40.30 |
| 18 | shoulder width | 39.94 | 44.20 | 49.16 |

**Table 3 Female Body Dimensions, n = 30**

| No | Parts of The Body | Percentile 5% (Minimum) | Percentile 50% (Average) | Percentile 95% (Maximum) |
|---|---|---|---|---|
| 1 | height | 148.70 | 158.30 | 167.17 |
| 2 | arm span height | 158.17 | 167.55 | 186.29 |
| 3 | weight | 19.82 | 24.05 | 32.96 |
| 4 | foot weight | 8.08 | 9.55 | 11.67 |
| 5 | height when bowing | 106.27 | 114.25 | 124.14 |
| 6 | head to toe | 74.39 | 80.25 | 85.39 |
| 7 | shoulder height | 43.86 | 54.05 | 61.71 |
| 8 | seat length | 29.76 | 44.3 | 49.75 |
| 9 | seat height | 37.32 | 41.40 | 50.03 |
| 10 | leg length | 24.00 | 25.75 | 29.88 |
| 11 | width | 9.71 | 11.55 | 16.00 |
| 12 | hip to knee | 49.58 | 53.85 | 62.60 |
| 13 | arm span | 53.47 | 58.95 | 69.63 |
| 14 | head width | 12.98 | 16.55 | 19.05 |
| 15 | 5 fingers width | 9.00 | 10.15 | 11.73 |
| 16 | 4 fingers width | 6.39 | 8.00 | 9.73 |
| 17 | hip width | 29.35 | 32.85 | 39.4 |
| 18 | shoulder width | 36.82 | 43 | 41.62 |

**Table 4 The Measurement Result of Interior Paratransit Dimensions**

| No | Description | Paratransit 1 | Paratransit 2 | Paratransit 3 | Paratransit 4 |
|---|---|---|---|---|---|
| 1 | Brand | Toyota Kijang | Toyota Kijang | Suzuki Carry 1500 cc | Suzuki Carry 1000 cc |
| 2 | Year | 1993 | 2003 | 2002 | 2001 |
| 3 | Body of a car | Panca Tunggal | RS | Panca Tunggal | Panca Tunggal |
| 4 | Route | PGC-Mekar Sari | PGC-Mekar Sari | PGC-Mekar Sari | PGC-Mekar Sari |
| 5 | 1=door height | 109.5 | 110.3 | 107.0 | 99.0 |
| 6 | 2=door height | 64.0 | 72.5 | 69.5 | 70.0 |
| 7 | 3=deck length | 129.0 | 132.5 | 128.4 | 124.2 |
| 8 | 4=stair length | 13.0 | 19.7 | 15.4 | 13.7 |
| 9 | 5=cabin height above the head | 127.5 | 130.5 | 122.0 | 116.0 |
| 10 | 6=pedestal seat height | 33.0 | 33.5 | 34.5 | 27.0 |
| 11 | 7=length cushion | 38.0 | 33.5 | 29.5 | 32.0 |
| 12 | 8=the width of seat base | 220.0 | 219.3 | 232.0 | 214.0 |
| 13 | 9=the width of seat base | 34.5 | 32.0 | 32.2 | 31.5 |
| 14 | 10=pedestal seat - window height | 53.5 | 50.5 | 51.1 | 49.5 |
| 15 | 11=cushion width | 151.5 | 136.0 | 142.5 | 134.5 |
| 16 | 12= face to face cushions width | 135.3 | 142.0 | 137.5 | 129.0 |
| 17 | 13=passangers cabin seat width | 140.5 | 141.5 | 132.0 | 130.0 |
| 18 | 14=driver seat height | 49.5 | 53.0 | 58.0 | 53.0 |
| 19 | 15=driver cushion length | 47.5 | 48.4 | 45.4 | 47.3 |
| 20 | 16=driver cushion lenght | 24.5 | 34.5 | 36.1 | 34.0 |
| 21 | 17=deck length | 230.0 | 218.0 | 226.0 | 218.0 |

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