



## Safety and Health Suitability of Locally Built Isuzu NPR (Kitkit) Buses with Ergonomic Consideration

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### Abstract

Among the many public transportation modes found in Ethiopia, buses are the most popular means of transport both in rural and urban areas of the country. The locally built buses are becoming common where they can be fabricated in local garages of big cities of Ethiopia. These busses are built locally where usually imported trucks cabin and loading decks are dismantled and the trucks are converted to passengers' buses adding passenger's seats and canopies with related accessories. Nevertheless, so much complaints are heard on the design of the air conditioning and seats framework material and dimension of these Isuzu NPR buses locally named 'Kitkit' where passengers are facing discomfort, fatigue, stress and health related issues. A descriptive survey research method was employed in order to assess the current status of passenger comfort in minibus around Addis Ababa city. This study attempted to show the results and findings based on the secondary and primary data obtained from different sources. Subjective method had been carried out in the form of questionnaire. In this study the seat and anthropometric dimension measurements were considered as objective methods requiring the output in the form of data interpretation from the measuring device.

**Keywords:** Transportation; Ergonomics; Anthropometry; Safety; Comfortability

### Introduction

Transport is the relocation of people, creatures and properties from one position to another. Types of transport embrace air, land (rail and road), water, cable, pipeline and space. Transport signifies one of the most significant people's actions worldwide. The transport plays immeasurable elements of economy. The showground can be alienated into infrastructure, vehicles and operations. Transportation is important since it permits trade between persons that implies for the growth of societies. Transport arrangement entails of the fixed connections such as railways, airways, roads, waterways, canals and pipelines. In other hands, the terminals such as airports, railway stations, bus stations, warehouses, trucking terminals, refueling depots (including fueling docks and fuel stations) and seaports. To inculcate the studies with previous research study, it has considered the previous works conducted in Indian Automotive Research Association (2008) with the objective of lad transportation classification in units of Micro Bus, Mini Bus, Midi Bus and Standard Bus. The study conducted in this research was focussed with the interest that will be concentrated in the units of intercity transport midi bus, specifically with seat capacity 24 which is modified locally by bus body builders [1]. This study also focuses on the same fassion on the transports of built ISUZU NPR to allviate the ergonomically health and safety issues existance.

Studies attempted to show that ideas of transportation limits that were unthinkable just a few decades ago [2]. However, it is now more considered around the ecosphere with the help and provision of major organization of government. A passenger bus in any country is a kind of businesses which is connected directly to the wealth and maintains the permanency of the government. Ethiopian transport was started in 1942, when fascist Italy was driven out of Ethiopia, by accumulating vehicles and spare parts used by the invader [3]. Tokyo Ishikawajima ship building and engineering co., Ltd. and Tokyo gas and Electric Company commenced Isuzu Motors from Isuzu River in 1934 and it was named Isuzu Motors in Japan. Most of researchers studied on passenger load, crawling effect, seat design, and air conditioning of public bus. However, as long as researchers finding, there are gaps on air conditioning system of Isuzu NPR BUS.?

Different Researchers studied about Isuzu NPR bus performance analysis in Addis ababa city Eshetie, Birhanu and Daniel [3]. Teshome Dengiso [4] also showed in his finding that Passenger's ergonomics assessment of locally adapted intercity buses by considering anthropometric standards in line with consideration of thermal comfortability. The air conditioning system is dismantled from Isuzu truck and not reinstalled during body work. Addis

Ababa city administration vehicle and driver licensing and controlling authority is a public transport authority based in Addis Ababa, Ethiopia.

Studies did not consider the transport comfort in Ethiopia as the consideration of government and ministry office is less (Wikipedia, 2019). The road transport must be given attention to create comfort for the employee and customers in their ergonomical design no matter how the economy of the country. The focus on the ergonomical design supports the health and safety of the employee/driver and the customers which resulting in musculoskeletal disorder.

According to the study conducted by Shen., *et al.* [5] passenger comfort is an important criteria to be used in measuring the quality of public transport services and a crucial influence in occupants' choice of traffic mode. According to this study comfort on board of a bus service plays an essential role in customer satisfaction levels beyond or to the expectation of the customer. Hence, comfort improvement can be a convenient strategy for attracting more customers. When the comfort is not considered the dynamic motion, especially accelerations, significantly disturb passenger comfort. Transportation has indispensable function for the passengers. However, the carrying capacity has to be limited by the vehicle designer at their ergonomically consideration starting from design to production process.

Therefore, this study aims at identifying the ISUZU NPR impact on passengers and drivers in line with the ergonomic design point of view.

### Problem statement

According to the study conducted by Teshome Dengiso [4] the major challenges of the Midi bus locally manufactured was the less consideration given by the bus body builders for the passengers' comfort in line with ergonomics, safety and health consideration. So much complaints are heard on the design of the air conditioning and seats framework material and dimension of these Isuzu NPR buses locally named 'Kitkit' where passengers are facing discomfort, fatigue, stress and health related issues especially for those who are long distance travelers. In addition to this, there is the absence strong control and standards to control the transporters has been designed ergonomically safe to the health of the passengers. The only settlement of the transportation shortages and challenges ignoring the comfort of the passenger has latent effect on the health of the customers.

### Objectives

#### General objective

To indicate the way of improving ergonomic suitability of ISUZU NPR bus by identify the main factor of discomfort and the way out.

#### Specific objective

- Assessing and analyse thermal appropriateness of the passenger compartment.
- To check whether the existing seat of the bus will give enough comfort to the passengers or not with respect to dimension and safety.
- To propose mitigation and ways forward to the ergonomically challenges of the bus design.

#### Methodology

The research methodology followed was a descriptive and it was used to address the passengers of Mid-bus of Addis Ababa city. The primary and secondary data was used to analyses and arrive on the proper recommendation after data analysis. The main data was obtained from particular and unbiased assessment of the transportation epicenter and drivers. For the objective evaluation personal observation, dimensional measurements of existing locally manufactured mid buses which is come to the inspection to the case company from August to September and measurements of relevant anthropometric dimensions (Molenbroek., *et al.* 2009).

The survey was carried out over a period of one months. Published and unpublished documents were collected from different institutions such as Addis Ababa city vehicle and driver licensing and controlling authority bureau, Local garage, different research papers studied by the former researchers for the development of passenger comfort. Data once collected, it was subject to the analysis. The analysis attempted to use descriptive statistics which are means, standard deviations, and fifth, fiftieth and ninety-fifth percentiles using simple Excel package. Thermal comfort is an important aspect to be considered in the ergonomics evaluation of the compartment, which are important interfaces between man and machine in autos. Determining thermal comfort in vehicles is a complex job, because thermal comfort involves the interaction of numerous variables and automobiles are susceptible to temporal variations in their thermal surroundings. In this study, the thermal suitability was searched with the target topic encompassing thermal comfort in vehicles. As the same time, some other sources related to the topic were used from internet, basic information, articles and books through making a personal evaluation. Individual assessment is also undertaken grounded on statistical analysis by gathering passengers' opinion towards comfort of the passenger compartment. The customers were enquired to appraise comfort of the seats from prospective view of their usage. This assessment of the customer was to assess customers' evaluation on comfort of existing locally manufactured thermal appropriateness of passenger seats. The study considered place where many ISUZU buses stays for a while waiting for passengers and easily available from the required information to gather from. That means, it was carried out at the bus station where most of Isuzu buses would stop to wait passengers and riding in mid-buses. The research was based

more of its analysis by considering a survey questioner and distributed to the sample population. The research was collected data by presenting this research questions to the customers to respond the questionnaire until they have the buses. This approached was used to clarify the questions to the passengers while they are filling and responding in case there may be inconsistency and misunderstanding of the requests. The target population ranges in the age of 18 to 63 as they are balancing and able to provide reliable feedback. The questionnaire prepared using a Likert scale type from which the participant fill by selecting the appropriate once they assume. These question majorly focused on closed ended questions so that the opinion of the respondent’s easily grasped and simplicity increase for respondents.

The research focused on user perspective of view that the really respond and solution was expected to the end. After the questioners the best solution of the problem is proposed, selected, or designed by the researcher. To obtain the value of passenger safety along with in-vehicle, a two-day passenger safety survey on the framework of the seat was conducted at the Bus. By observation of the inside of the buses the pros and cons of the seat material cross-sectional shape is listed out and also the best type which guarantee for good safety cross-sectional shape of the framework metal will be recommended or designed if the pre-existing is not applicable to assure the safety of the passengers.

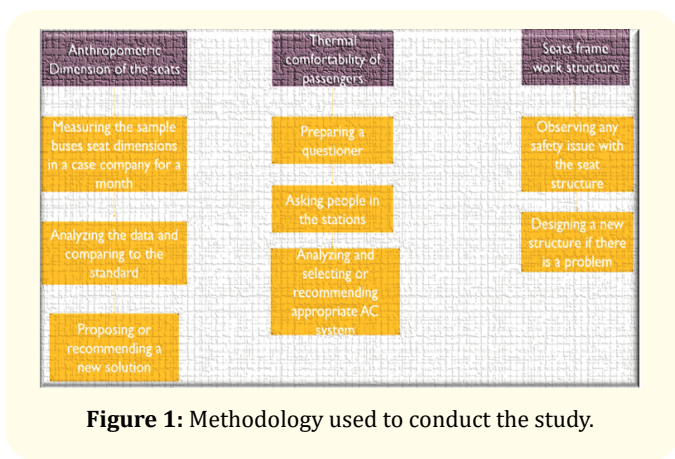


Figure 1: Methodology used to conduct the study.

## Result and Discussion

### Thermal suitability and questionnaire analysis

Isuzu NPR buses are built locally where usually imported trucks cabin and loading decks are dismantled and the trucks are converted to passengers’ buses adding passenger’s seats and canopies with related accessories. Nevertheless, so much complaints are heard on the design of the air conditioning. Isuzu NPR passengers are facing discomfort, fatigue, stress and health related issues especially for those who are long distance travelers. The newly imported cargo type trucks have an air conditioning system. However, when those trucks are converted to passenger busses the air conditioning systems (blower, heat exchanger, hoses and refrigerant

tubes) are dismantled and sold out to local spare part markets. And as long as these paper researchers observed there is no way to re install appropriate air conditioning system to the passenger compartment. The respondents from which data was collected is 23 regarding minibus thermal comfortability. All of them had responded that they used this bus before the questioners given to them. 73.9% of the population use Isuzu NPR buses for more than 1 year. 87% are not happy with the transport service and complained about the dimension of the seats, the discomfort of internal temperature and excessive passenger number. 80% were explained the poor thermal comfort of the passenger’s compartment. 60% are travel a long-range distance. Most of the Passengers used Isuzu NPR for long distance rather than short range. The last question faced to the respondent is their suggestion or comment to make with regard to thermal comfortability and most of them raised good ideas which is mounting possible and appropriate temperature cooling system to the compartment of the passengers, redesigning of the orientation, type and position of a glass windows and controlling the number of passengers during a single trip according to the limit of the seats [6-22].

### Seat anthropometry and framework structure

Thirty-two Isuzu NPR mid-buses which came to inspection to the case company are selected for this study. The minibus has normally accommodation capacity of 25 peoples as the neutral design allowed it including driver and all the seats are facing toward the front view. The range of Smallest and extreme values were taken through direct dimensioning from the buses and each one of the dimensional variables compared with the standard (minimum, maximum or recommended values).

### Entrance and exit doors

The customers who are in exist and entrance doors are not feeling comfortable. The doors width are not designed ergonomically and are not considered the international standards for vehicle design. The door is not designed for the 95<sup>th</sup> percentile population or users. The obtained data result when compared to the dimension given with the established value in standard table shown in the Table 1 is not comparable.

### Stairs and handrails

The steps at the bus entrance and exit are usually complained that disability people are not able to walk and climb over it easily. This is the design problems of the minibuses built locally. The consideration of differently abled people is not a common in developing countries like Ethiopia. The common problems that we are practicing is that descending steps is more difficult than climbing steps as muscles stretch during descending. We know that buses with better handlers and handrails are easier to exist and enter. However, in Ethiopian case more than 95% minibuses are not using the handrails to assist aged and differently abled passengers.

### Gangways dimension

The found values showed that the undertaking of the users within the unit is painful, forcing in most cases to lateral displacements. The passengers move in the base holding all the corridor spaces and congested fully. Therefore, to move within the corridor it is difficult and it enforces the passenger to push each other in the long run they create high uncomfortable environment with high thermal condition.

### Seats dimensions

To assess the seats; it is vital to consider the segments of population like taller and bigger size people, for example when evaluating the leg room available for passenger in the seated position and for others, the sector of smaller population, for example for the height of the seats. As shown in Table 1, data corresponding to the height of the seats and their comparison with the values internationally recommended according to ergonomic standards criteria [4].

Dimension in cm	Max	Min	Average	Standard deviation	Standard
Access and Exit Doors Width,	70	65	67.33	1.7	70 min
Step Height,	40	30	35.6	2.88	15-20 max
Track (Place the feet at the time of descending)	25	20	22.4	1.83	25-30 min
The Road to the Last Step, Cm	54.5	45	50.77	2.57	38
Gangways (Aisle)	30	25	29	6.13	35min
Seat Height	46	40	43	2.16	40-46
Space for The Leg	30	28.55	26.55	1.36	30 min
Seat Width	40	30	34.53	4.43	40 min
Inclination of Seat Cushion in Degree	4°	-4°	-	-	14-24
Inclination of Backrest of Seat in Degree	94	90	-	-	110-130

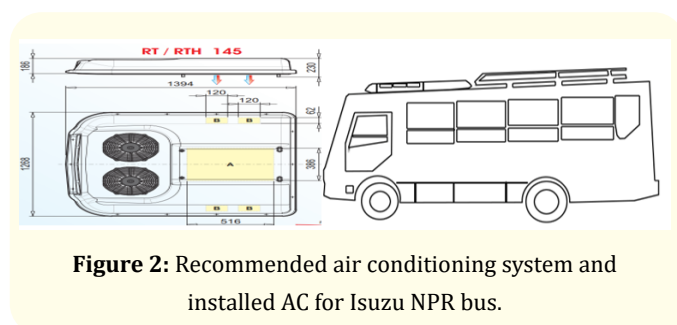
**Table 1:** Inspected Isuzu NPR bus dimension and recommended international standard (Teshome, 2017).

According to the Table 1 indication that this study showed a deviation between the sizes of current locally modified passenger seats of Isuzu NPR and the anthropometric dimensions of passengers. We can learn from this that anthropometric data of the passengers were not engaged in the plan and modification of the chairs. This study is an indication that traveler seats of Isuzu NPR and passengers' anthropometric dimensions are at variance.

Our minibus ISUZU modifiers usually use still framework that is constructed from steel or metal. In theory, the function of structural backbone has been limited to providing shape for the cushioning members and support for its own weight and that of its occupant. Therefore, the designers should redesign and consider the ergonomic philosophy to the minibus comfort creation.

In the case of this midi-bus the seat frame work made from rectangular steel tubulars. These rectangular cross-section tubulars make a sharp edge which make hazardous seat structure due to not well trimmed. Because of aging the seat cushion are tear off from the structure of the seat and the framework become exposed out. These exposed sharp structures will hurt mostly the passengers' body and may tear their dresses during accident (collision and overturning) and sudden stoppage of the vehicle. As long as the researchers of this paper observed this type problem was seen in most of the buses which are used for a commercial purpose for a long time. Ergonomically this type of problem is not desirable in the industry of transport services with regard to safety.

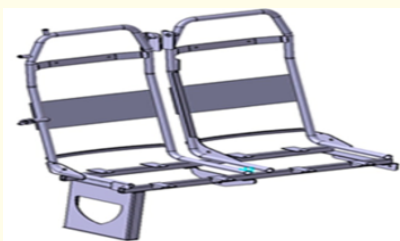
Through subjective assessment, on the thermal comfortability of the passenger's compartment. Although the respondents were dissatisfied with the air temperature of existing passenger compartment of Isuzu NPR midi-buses, they still complained about certain feature of the area, such as position of glass windows and the number of peoples travel at a time. Mounting appropriate type of air conditioning system is the best way to figure out this heat problem. Roof Top unit RT 145 is the most appropriate type of air conditioner of the current technology. Roof top air conditioner with an innovative design developed to condition mid-buses up to 25 seats. Universal, compact and affordable, it uses the lateral airducts for a best distribution of the fresh air.



**Figure 2:** Recommended air conditioning system and installed AC for Isuzu NPR bus.

As studied before the frame work structure cross-sectional shape is not recommended to this kind of vehicle. It may cause a high level of injuries on the passengers and eliminating the angular edge or a sharp edge is the best choice to tackle the problem. Using round cross sectioned tubulars is better than the rectangular one. The newly designed and proposed structural frame work of the seat is shown below in the figure.





**Figure 3:** Proposed Circular cross-section structural frame work of Isuzu NPR bus the seat.

### Conclusion and Recommendation

According to the findings of the paper, the following conclusions are made.

- We can conclude that the study consisted of both objective and subjective methodology while conducting this case study. The questionnaire was prepared based on the subjective method and provided informative results. Based t on the subjective methods, the dimensions of seat measurements were required the output in the form of data interpretation from the measuring apparatus.
- According to Table 1 the study has showed that the deviation from the standards has been recognized in the modified minibus ISUZU design. These tell that the anthropometric data of the passengers were not considered during design of the modification plan the seat chairs. This study is an indication that traveler seats of Isuzu NPR and passengers’ anthropometric dimensions are at variance.
- It has been seen in literature review that seat design heavily based on the anthropometric data measurements and consideration to meet an ergonomic seat design. Therefore, this study can recommended anthropometric data should be used upon designing for modification of minibus transportation.
- Therefore, this paper would may help in an ergonomic passenger seat design of Isuzu NPR mid-buses.

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