Macroergonomic and Analysis Design (MEAD) for Permanent Shelter of Public Transportation

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Abstract

The availability of public facilities is permanent BST (Batik Solo Trans) shelter as public transportation in Surakarta City. Bamwesigye and Hlavackova (2019) explain the smart cities and analyse a private transportation. Sohail, Maunder and Cavill (2006) had research case study about sustainable public transport in developing countries with the critical importance of communication and coordination between stakeholders. Sipus and Abramovic (2017) concern about the accessibility of public transport and just analyzed the demographic factors. The application of macroergonomic method has chosen because this method involves all elements to interact and produce satisfaction. The population of this research is BST's passenger with a sample requirement of 60 respondents with sample criteria being considered respondents who use the BST's permanent shelter at least once, the Transportation Agency, and disabled. The objective of this study is to increase the interest of people to use public transportation for reducing the private vehicles use and improving air quality in the city. The conclusion is four alternatives proposed improvement using (Macroergonomic Analysis and Design) MEAD, that are: design improvement by human centered and universal design, improvement refers to the Ministry of Transportation's standard, redesign of the BST shelter, improvement and utilization of BST shelter facilities.

Keywords
Smart Cities, Public Transportation, Macroergonomic Analysis and Design (MEAD).

1. Introduction
Cities are central of settlement and resident activities that have administrative boundaries regulated in statutory law and settlement that have shown the character and characteristics of urban life (Minister of Home Affairs Regulation Number 2 Year 1987). A city that can be called smart cities is cities that has a new penetration in problem solving and succeeded to increase performance of its city (Widyaningsih and Djunaedi 2013). Smart cities can be defined as a smart city that can provide a better quality of life and comfortable for their people. One of the advantage of smart cities concept based on President Global Innovation Policy Information and Innovation Foundation is that it can create and develop of liveable cities in the future, can make a transportation system to be more efficient and integrated until create people mobility and improve people's welfare and the health services.

Smart transportation is the part of smart cities. Smart city requires smart transportation services. Focus of smart transportation is people mobility by utilizing various modes of public transportation that are integrated, safe, sustainable and comfortable. Transportation creates place utility and time utility because the value of goods becomes higher at destination place than at the origin place (Adisasmita 2010). In another research investigation, Bamwesigye and Hlavackova (2019) explain the smart cities and analyse a private transportation which is bicycle cycling transport. They conclude that smart solutions for smart cities is safe infrastuctures and integration of technology.

The central government currently is ready to realize buy the service scenario, which means that the transfer of private vehicles to public transport is used to reduce congestion and the bad air quality. The people of Surakarta has been facilitated with BST (Batik Solo Trans) public transportation. That is completed with shelter to increase passenger mobility more quickly and efficiently, but BST (Batik Solo Trans) has not been able to attract people of Surakarta for using public transportation. Sohail et al. (2006) had research case study about sustainable public transport in developing countries, this paper highlights the critical importance of communication and coordination between stakeholders. On the other hand, Sipus and Abramovic (2017) concern about the accessibility of public transport. They just analyzed the demographic factors to evaluate the mobility of commuters without analysing the macro scope and asking their customer needs.

The macroergonomic approach has a wide scope that focus on the optimization of sociotechnical system including structure, organization, policies and processes. Macroergonomic is a perspective, methodology and sub-discipline of ergonomics or human factors (Hendrick and Kleiner 2002). It is a sociotechnical approach that is applied in work system design from bottom to top with microergonomics interactions by adjusting the object and problem. The application of macroergonomic method has chosen because this method involves all elements to interact and produce satisfaction in the elements of safety, productivity, efficiency and quality. The objective of this study is to increase the interest of people to use public transportation for reducing the private vehicles use and improving air quality in the city.

1.1 Objectives

The objective of this study is to increase the interest of people to use public transportation for reducing the private vehicles use and improving air quality in the city.

2. Literature Review

Smart cities concept in Indonesia was initiated by an expert from Institut Teknologi Bandung (ITB), Suhono Harso Supangkat. Smart cities maximize services to their citizen and support sustainable development by connecting, monitoring and controlling the various available resources in the city for more effective and efficient. Hariani et al. (2017) had research case about smart cities, this paper highlight that the concept of intelligent transportation system which is based on information and tools (applications on android) as a supporter of smooth traffic on the highway in the Medan as a strategy for Medan to become a smart city. Nilma (2018) showed research that analyze some aspects to make Bandung smart city become one of the smart model that implements communication and information technology in the country. Whereas an IT based system and adequate internet access are not an aspect that must be fulfilled to become a smart city. Lom and Pribyl (2020) had research with the approach of interconnection of different systems within a city and suitable for modelling of dynamic behaviour only.

Transportation includes the movement of people, goods and services that will accelerate the growth and development of a region. Surakarta city is one of the cities that continues to grow rapidly in Indonesia. The people of Surakarta have been facilitated by public transportation which is BST (Batik Solo Trans) that available with the shelter. BST are safe, comfortable and the bus provides AC (Air Conditioner). The existence of BST to increase of using public transportation and air quality. Suwandono (2016) had research for private passenger cars transportation only. Hanafie et al. (2015) had research analyze about public transportation that are incompatible with the utility vehicle.

Macroergonomic approach to create harmony or balance in the work system in a whole (Davis and Moro 2004). Macroergonomic Analysis and Design (MEAD) is a sociotechnical approach that is applied in work system design from bottom to top with microergonomics interactions by adjusting the object and problem. Cahyaditha et al. (2013) had research aims to provide convenience to passengers at station X in the up and down trains. Surya et al. (2013) had research to evaluate the ergonomics of passenger seats only and data collection by interviewing the boat passengers. Dobson (2015) had observed the evolution of Human Factors (HF) and ergonomics in railroadfrom a practitioner's point of view. Indriyani and Sahroni (2018) had research about Transjakarta to evaluate and propose improvements to the handgrip facilities with solution to increase the level of comfort and safety of passengers. Wibowo et al. (2018) had research to design of bus seat ergonomically using Ergonomic Function Deployment (EFD). Toghas (2015) had research aims to assess the problems found in the public facilities and the Trans Jogja shelter using athropometry data. Arminas and Nurwaidah (2019) had research in driver's work area using ergonomic risk which is Nordic Body Map and RULA Method. Hwangboo et al. (2012) had research aims to investigate the relationship between ergonomic

comfort and the provision of accessibility features in the use of public transportation system in Korea. Megiso (2017) had research analysis from the ergonomic point of view in the entry and exit of bus and seat. Raghuvanshi and Vinay (2013) had research investigation the influence of the conditions at work on functional stability of bus drivers. These earlier research never asked to all stakeholders.

This research is concern about smart cities. Surakarta city is one of the cities that continues to grow rapidly in Indonesia. The people of Surakarta have been facilitated by public transportation which is BST (Batik Solo Trans) that available with the shelter, but they don't move from using private transportation to the public transportation. This research applies Macroergonomic Analysis and Design (MEAD) approach in macro scope to analyze what's people complaint, needed and give the suggestion to solve it. The respondent of this research is all stakeholders, which means BST's permanent shelter passengers, the Transportation Agency, and disabled.

3. Methods

Macroergonomic Analysis and Design (MEAD) is a method with a role in solving problem in the macroergonomic approach. MEAD is a related method in designing, analyzing and evaluating work system in organization become effective and efficient. Macroergonomic Analysis and Design (MEAD) is appropriate because this approach is integration between sociotechnical and microergonomics (Hendrick and Kleiner 2002). The Macroergonomic Analysis and Design (MEAD) procedure refers to Hendrick and Kleiner (2002) and Sumarni (2019). There are 9 steps in this particular methodology:

3.1 Scanning the Environmental and Organizational Design Subsystem
This step is identify the vision and mission of a company or organization.

3.2 Making a Problem Factor Tree
The objective of this step is define the problem. Each aspect is analyzed for weakness and the direction of improvement.

3.3 Identifying Variances
This step identifies each subproblem that causes the core problem in the research.

3.4 Creating the Variance Matrix
This step's objective to identify the relationship for each variances. Each variance has a significant final impact, has many relationship with other variables and has a significant impact as a single variance.

3.5 Creating the Key Variance Control Table and Role Network
This step has any variance that analyzed based in supervising side, the directly involved side and the existing supporting activities. The involved side have a role in the responsibility to control the variance.

3.6 Performing Function Allocation and Joint Design
The arrangement of function allocation and joint design aims to systematically allocate functions and tasks to humans, machines or computers. This step aims to create an appropriate allocation function and an alternative design from the variance control table and the existing problem tree diagrams.

3.7 Understanding Roles and Responsibilities Perceptions
This step is important to identify how workers perceive their roles. The analyst can compare expected roles with perceived roles and can identify whether there are any gaps.

3.8 Designing or Redesigning Support Subsystem and Interfaces
Each aspect is analyzed for variance and proposed improvement. This step aims to determine the support subsystem and influence the existing system.

3.9 Implementing, Iterating, and Improving
At this point, it is desirable to execute or implement the work process changes prescibed, design interfaces and allocate functions.

4. Data Collection

The data that was used in this study consist of primary and secondary data. The researcher obtained primary data by conducting observation and interview. The secondary data was obtained from Badan Pusat Statistik (BPS) of Surakarta for the number of vehicles that have been registered in the city and PT. BST (Bengawan Solo Trans) for the number of BST's passengers. We are using judgment sampling for the sampling method. The population of this research is BST's passenger with a sample requirement of 60 respondents with the sample criteria being considered respondents who use the BST's permanent shelter at least once, the Transportation Agency, and the disabled. The questionnaire used refers to Suminar (2010) and Koto and Asnawi (2016). The questionnaire was given to 60 reguler users, a head of the transportation division in transportation agency and a disabled.

5. Results and Discussion

5.1 Macroergonomic Analysis and Design (MEAD) Approach

5.1.1 Scanning the Environmental and Organizational Design Subsystem

This Bengawan Solo Trans has company profile:

Vision: "Increasing and prioritizing services to the community and changing people's behaviour to move of using public transportation."

Mission: "Providing of mass transportation with excellent quality service, fast, precise, safe, comfortable, efficient, reliable and affordable rates."

5.1.2 Making a Problem Factor Tree

The four main problems are: sociotechnical, standard, placement zone and functional as shown in figure 1. Each aspect is analyzed for weaknesses and the improvement. This stage aim to define the problem on target correctly.

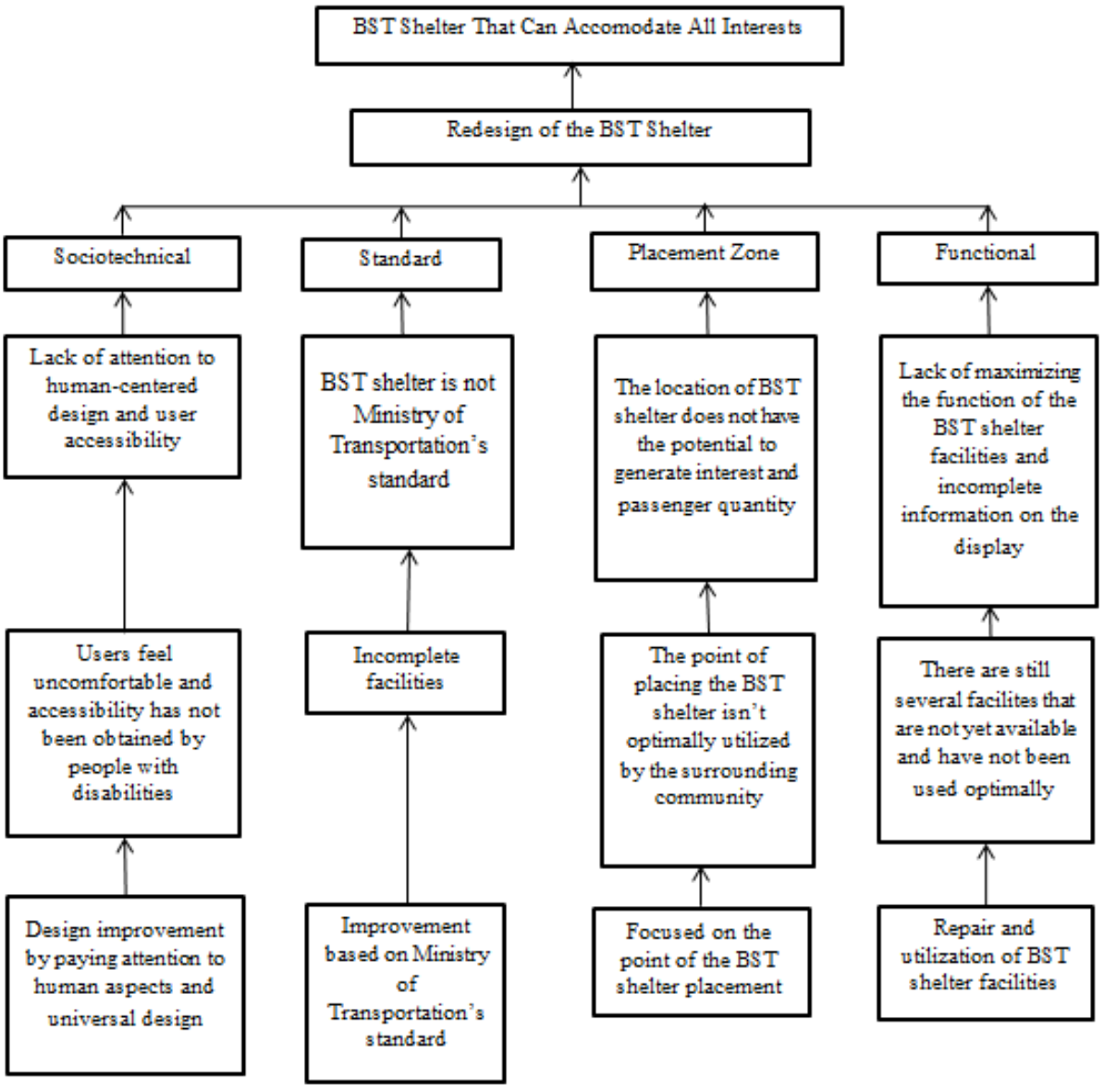

Figure 1. The problem factor tree

5.1.3 Identifying Variances

This research variances data are:

a. The facilities design are not human centered.
b. BST shelter is not Ministry of Transportation's standard.
c. The location of the BST shelter is difficult to reach by users.
d. Lack of maximizing the function of the BST shelter facilities.
e. Incomplete information on the display.

5.1.4 Creating the Variance Matrix

There are six key variances with the identification of relationship between them which are shown in table 1.

Table 1. The variance matrix

No	Variance	Type of Variance Data		
		Has a Significant Final Impact	Has Many Relationship Between Variables	Has a Significant Impact As a Single Variance
1	The facilities design are not human centered	√	√	√
2	The difficulty of disabled for accessing independently	√	√	√
3	BST shelter is not Ministry of Transportation's standard	√	√	x
4	The location of the BST shelter is difficult to reach by users	x	x	√
5	Lack of maximizing the function of the BST shelter facilities	√	√	√
6	Incomplete information on the display	x	x	√
Information: √ = It has relationship between variables x = There is no relationship between variables				

5.1.5 Creating the Key Variance Control Table and Role Network

The side have a role and responsibility to control the variance. Table 2 shows the variance that occured and responsible side for controlling the variance in current condition.

Table 2. The key variance control and role analysis

No	Variance	The Supervising Side	The Directly Involved Side	The Existing Supporting Activities
1	The facilities design are not human centered	The Transportation Agency, Facilities Construction Supervisor	User	-
2	The difficulty of disabled for accessing independently	Non-Governmental Organization, Development Center for Children with Disabilities of Surakarta	User	-
3	BST shelter is not Ministry of Transportation's standard	The Transportation Agency, Facilities Construction Supervisor	User	-
4	The location of the BST shelter is difficult to reach by users	The Transportation Agency, Facilities Construction Supervisor	User	-
5	Lack of maximizing the function of the BST shelter facilities	The Transportation Agency, Facilities Construction Supervisor	User	-
6	Incomplete information on the display	The Transportation Agency, Facilities Construction Supervisor	User	-

5.1.6 Performing Function Allocation and Joint Design

Requirements analysis focuses on the tasks that determine the needs or conditions, taking possibly conflicting requirements of the various stakeholders, analyzing, documenting, validating and managing software or system requirements. The process of function allocation and joint design as shown in figure 2.

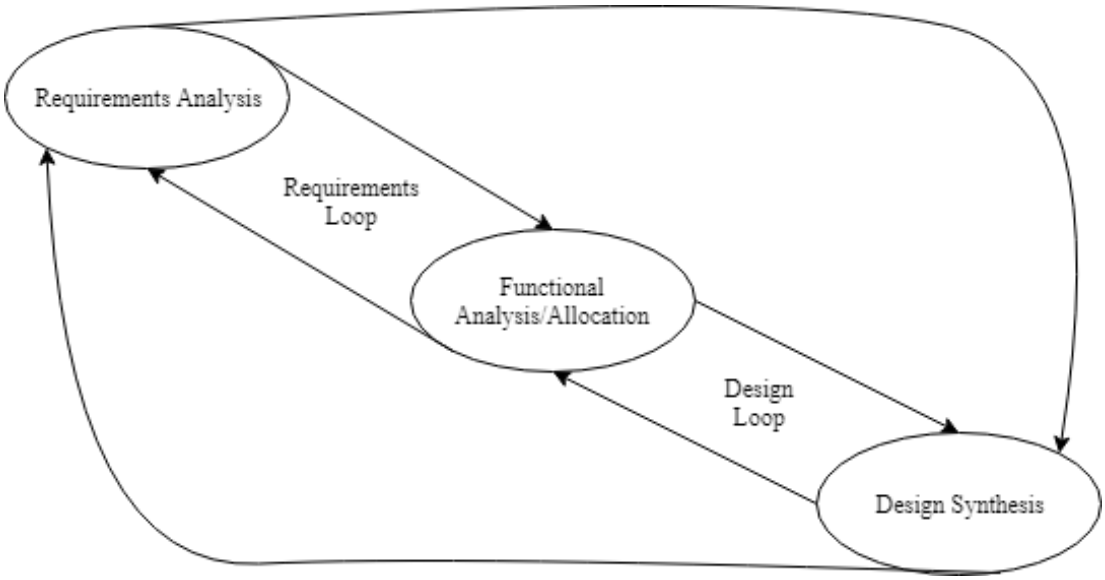

Figure 2. Functional analysis and allocation

5.1.7 Understanding Roles and Responsibilities Perceptions

This stage involves identifying how workers respond to the role that they are doing currently and comparing it with the role that they should be done. Based on table 3, the categories of risks that will occur to success and the effect on cost expenditures are given a negative sign (-).

Table 3. Perceived evaluation of roles and responsibilities

Alternatives	Reach to Organization	Risk of Failure	Effectiveness	Project Cost	Overall Rating
Design improvement by human centered and universal design	1	-2	5	-2	2
Improvement refers to the Ministry of Transportation's standard	2	-1	3	-2	2
Redesign of the BST shelter placement	3	-3	5	-4	1
Repair and Utilization of BST shelter facilities	1	-1	6	-2	4

5.1.8 Designing or Redesigning Support Subsystem and Interfaces

The improvements were made with the internal and external environment in table 4. The four problems are sociotechnical, standard, location, and functional.

Table 4. Designing or redesigning support subsystem and interfaces

Problem	Variance	Improvement
Sociotechnical	- The facilities design are not human centered - The difficulty of disabled for accessing independently	a. Design improvement by human centered b. Design improvement by universal design
Standard	- BST shelter is not Ministry of Transportation's standard	a. Improvement refers to the Ministry of Transportation's standard
Location	- The location of the BST shelter is difficult to reach by users	a. Redesign of the BST shelter placement
Functional	- Lack of maximizing the function of the BST shelter facilities - Incomplete information on the display	a. Repair and improvement of BST shelter facilities b. Utilization of BST shelter facilities

5.1.9 Implementing, Iterating, and Improving

The implementations in this research include:

a. Design improvement by human centered
b. Make improvement to the design of facilities for all passengers (normal and disabled), old people and children
c. Improvement refers to the Ministry of Transportation's standard
d. Maintenance at the BST shelter

The iterations in this research include:

a. Maintain the cleanliness BST shelter and area.
b. Ensure the air circulation.
c. Ensure the light condition of the BST shelter.

d. There are information of tourist attraction and BST routes.

The improvisation to all stakeholders.

6. Conclusion

According to the analysis, it can be concluded four alternatives proposed improvement using MEAD, that are: design improvement by human centered and universal design, improvement refers to the Ministry of Transportation's standard, redesign of the BST shelter, improvement and utilization of BST shelter facilities. These alternatives can be a reference to increase the comfortable, attractiveness of users to move for using public transportation to reduce the private vehicles uses and improving air quality in the city.

This research has the potential contributing for the research on smart cities. Improvement in several way is needed to future research. This research has the theoretical possibilities of Macroergonomic Analysis and Design in smart transportation that related to public facilities. Further research includes development to use Macroergonomic Analysis and Design in collaboration with other methods or multidisciplinary research on a broader and more complex scale. The research sample should use all users from other cities with the same problems in public facilities especially permanent shelter. Future studies may allow investigating the same topic with a broader range of data.

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Biography

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