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Strategy for Implementing Park-and-Ride as a Supporting Facility for Commuter Movement

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Abstract: The Sidoarjo Regency Transportation Agency has identified Sidoarjo Station as one of the sites for the construction of park-and-ride (P&R) facilities. With an average daily traffic of 1,200 passengers, it is the biggest origin station in the Sidoarjo Regency. This study's primary goal was to create a plan for integrating P&R at Sidoarjo Station as a facility that supports passengers traveling between Sidoarjo and Surabaya. SWOT analysis was employed in this study to create an implementation plan for P&R. The findings led to the development of several P&R implementation strategies at Sidoarjo Station, such as offering parking spots large enough to meet the demands of commuters and station guests, P&R amenities compliant with parking regulations, and the provision of P&R supporting amenities that can boost community satisfaction and trust.

Keywords: station, park-and-ride, strategy, commuter, movement

1. Introduction

There are two types of transportation approaches that can be used to solve transportation problems: supply-side management and demand-side management. Supply-side management is often referred to as a conventional approach because it seeks to accommodate the growth of motorized vehicles from year to year through increasing transportation capacity without considering the long-term impacts[1),2)]. Along with the development of sustainable transportation planning trends, especially in the environmental aspect, there has been a shift from supply-side management to demand-side management because it is considered more environmentally friendly[1)]. Therefore, over the course of the next decades, shifts in the ways in which humans travel, work, and live, coupled with sustainable innovation and technology, are going to dramatically and exponentially transform certain types of transport businesses across the globe, especially in developing countries[3),4)].

Based on[5)], major Indonesian cities continue to organize their transportation according to the antiquated or traditional paradigm, which entails enlarging roadways without making room for innovative, sustainable modes of transportation that specifically address the demands of human mobility. The public transportation network is still limited, and the quality of public transportation services is not optimal, which only serves the needs of movement in the city center. Therefore, for many living in suburban areas, using a private automobile is still the only practical way to get to and from the city core[6),7),8)]. This circumstance is the reason why commuters in Indonesia use public transit at a low rate. As many as 78% of urban people are private vehicle users[9)]. The application of demand-side management can be a solution to solve urban transportation problems in Indonesia. In general, demand-side management or TDM is divided into four categories based on their characteristics, which are increasing the number of alternative modes of transportation, imposition of taxes, parking and spatial management, and policy implementation. P&R is a type of TDM that falls under the "improve transport option" category. It takes the shape of parking lots that are connected to the public transportation system in an effort to promote public transportation use and ease traffic[10)]. P&R is closely associated with commuter activities since these facilities can serve as a link between the city center and the suburban area as well as a transfer node that can spread travel demands[5)].

When visitors arrive at the location of activities in the city center, they can transfer from using private vehicles, such as cars, motorcycles, or bicycles, to public transportation by using P&R, or parking facilities[11)]. P&R can also be defined as facilities supporting the use of public transportation. This is because P&R is located far from the center of activity or economy in an area, where most of the area has not been optimally served by public transportation networks. As a result, commuters can

access transportation easily by switching transportation modes[12]. P&R is an attempt to accommodate the growing demand for public transportation while simultaneously reducing the number of trips in a given area[10],[11]. The provision of P&R facilities in an urban area can offer various positive impacts on the sustainability of the city. Examples include reducing congestion levels, cutting off the duration of long trips during peak hours, increasing accessibility, lowering the use of private vehicles, and improving environmental quality[10],[13],[12].

The existence of P&R is a solution to reduce individual travel time, improve the quality of travel, as well as to promote the use of public transportation[14],[15]. Based on [16], in general, there are two categories for P&R, namely bus-based and rail-based. In this study, the type of P&R used is rail-based. Furthermore, P&R can also be classified into three categories based on its location and function[17],[18]. Meanwhile, according to [19], P&R is classified according to its location and function. Based on its location, P&R is divided into two types: P&R that is relatively far from the city center with the main target being sub-urban communities; and P&R that is directly adjacent to the CBD with the main objective of reducing traffic spikes. Meanwhile, when viewed based on its function or use, P&R is divided into two types, namely exclusive (serving public transportation, such as trains or buses) and shared facilities (serving the general public, located in shopping centers, education, etc.). Meanwhile, when viewed based on the distance of the P&R location from the city center, P&R is divided into three types[18],[20], namely the sub-urban type, remote long-distance, and local urban. Based on[21], the success of P&R planning is influenced by several factors, such as the characteristics of individual trips, the quality of P&R, the availability and ease of accessing public transportation, and the characteristics of parking at the destination location. The more benefits you get when using P&R facilities, the greater the public's intention of using them. When selecting their preferred form of transportation, commuters prioritize the benefits that offer the most. In the context of traveling using P&R facilities and public transportation, commuters tend to consider the length of the trip and the cost of the trip as the most important attributes for a commuter to determine the mode of transportation to be used[22].

On the individual aspect, the decision to use public transportation is not only influenced by one's economic condition, but it can also take into account one's perception of public transportation itself. For example, knowledge and experiences form perception and contribute to a person's behavior[23]. In addition to personal beliefs, societal contexts and the roles of those closest to them who are deemed significant also play a role in shaping an individual's intention to use P&R facilities and public transportation. This is the state in which an individual recognizes that others closest to them may model their attitudes and actions after them[10]. Furthermore, [24] also explained that underutilized P&R facilities are caused by the physical characteristics of the parking lot, the quality of public transport services provided, and parking capacity. In other words, this corroborates the findings of [25], in which the performance of P&R services also significantly affects the use of P&R.

Transportation policy is an instrument used to limit the use of private vehicles and increase the use of public transportation. In line with this, in their research, [24] explained that restrictions on the use of private vehicles and the application of progressive parking rates encourage people to use public transportation. This is also explained by [26], in which the policy regarding the use of private vehicles is one of the considerations for travelers in choosing a mode of transportation. Through this approach, the implementation of P&R will be more effective and optimal.

Surabaya is the capital as well as the economic center in East Java Province which is one of the destination cities for workers, especially workers who come from outside the city of Surabaya. Based on the Central Bureau of Statistics (2018), the area of origin contributed the largest percentage of commuters to Sidoarjo Regency, accounting for 40% or as many as 109,351 of the total number of commuters in the City of Surabaya, which totaled 169,560 persons. The City of Surabaya offers a number of alternate modes of transportation that can accommodate the movement of Sidoarjo - Surabaya commuters due to the growing number of commuters and their transportation needs from sub-urban areas to the city center. One such mode of transportation is the commuter train, which has a large carrying capacity and a short travel time[27]. However, based on KAI Passenger Data for 2019, the level of commuter train use in Sidoarjo Regency is still relatively low, namely only 3,176 people use commuter trains out of the total number of 109,351 people from Sidoarjo who are active in Surabaya. The low use of trains by commuters has an impact on the level of congestion on the road connecting Sidoarjo - Surabaya which ranges from 0.90 to 1.58 based on Surabaya City Transportation Masterplan. Sidoarjo Station is one of the locations recommended by the Sidoarjo District Department of Transportation for the development of P&R facilities. This is due to the fact that Sidoarjo Station, which has an average daily passenger count of 1,200, is the biggest originating station in Sidoarjo Regency. The construction of P&R at Sidoarjo Station is also supported by the government's plan. Based on the 2018 National Railway Master Plan, there are plans for station development, including P&R facilities at stations located in national, provincial and district/city strategic activity centers, one of which is Sidoarjo Station [27].

While P&R planning in affluent nations has been extensively studied, little is known about P&R planning in emerging nations. Few research have examined the relationship between parking qualities and public transportation circumstances and user behavior toward the intention to utilize P&R facilities. The majority of studies also solely focus on parking characteristics and public transportation conditions[12],[28],[29],[30],[31],[32],[33], especially

during the COVID-19 pandemic. This study is significant because it reveals and investigates in further detail how the community uses P&R facilities and how the COVID-19 pandemic has affected people's commuting habits.

2. Methods

The type of research used in this study is quantitative research. When a discovery is reached by statistical techniques or other measurement-based methods, it is referred to as quantitative research[27]. This is because the factors that have been determined are identified and examined in this study using statistical techniques and further measures. Furthermore, prior to the field survey, this study contained research equipment (data and sample collection methodologies). The data obtained will then be processed using quantitative analysis techniques so as to achieve the research objectives, which is analyzing the influence of the condition of P&R facilities and public transportation on commuters' intentions to use P&R at Sidoarjo Station during the COVID-19 pandemic.

2.1 Sampling

The sample is a small part of the characteristics or the number taken in a population. Sample calculation is the stage of determining the number of samples to be taken when conducting a study. The sample selected or determined must be representative, that is, it has all the characteristics that exist in the population[27]. The sample of Sidoarjo–Surabaya commuters was determined through the recommendation of a minimum sample size based on [34], which determines the minimal sample need by using the maximum number of arrows in a single construct as a guide. The greatest number of indicators in a single variable can be used to determine the maximum number of arrows in a construct (Table 1).

Table 1. The PLS-SEM minimum sample requirement recommendation for 80% statistical power.

Maximum Number of Arrows in One Construct	Significant Level											
	10%				5%				1%			
	0.10	0.25	0.50	0.75	0.10	0.25	0.50	0.75	0.10	0.25	0.50	0.75
2	72	26	11	7	90	33	14	8	130	47	19	10
3	83	30	13	8	103	37	16	9	145	53	22	12
4	92	34	15	9	113	41	18	11	158	58	24	14
5	99	37	17	10	122	45	20	12	169	62	26	15
6	106	40	18	12	130	48	21	13	179	66	28	16
7	112	42	20	13	137	51	23	14	188	69	30	18
8	118	45	21	14	144	54	24	15	196	73	32	19
9	124	47	22	15	150	56	26	16	204	76	34	20
10	129	49	24	16	156	59	27	18	212	79	35	21

Source: [34]

The perceived behavioral control variable in this study had the most indicators—eight in all. Moreover, 144 samples are needed because this study employed a significance level of 5% and a minimum R2 of 0.1. Purposive sampling, a non-probability sampling approach, was used to choose the samples. The authors' concerns of adequate and representative sample criteria serve as the foundation for the sampling technique known as purposeful sampling. The sample criteria in this study include respondents who:

1. Are commuters from Sidoarjo to Surabaya (work in Surabaya City, but live in Sidoarjo Regency);
2. Make round trips every day using private vehicles (motorcycles and cars);
3. Have the purpose of travel work and education
4. Are aged 18 to 50 years;
5. Have a residence within a 4 km radius[27] (ideal P&R service radius) from Sidoarjo Station.

2.2 Variable and indicator

Variables are determined based on the results of the literature review. In the first research objective, which is to identify the effect of public transportation conditions and P&R facilities on commuters' intentions to use P&R during the COVID-19 pandemic, the variables used were obtained based on the results of a literature study. Variables in the form of factors that will affect the intention of commuters to use P&R will be identified based on the Theory of Planned Behavior (TPB). The three main factors in the TPB which comprise attitude, subjective norms, and perceived behavioral control—produce the intention to behave, take an action, or anything that can guide one's behavior. The assumption used in this theory is that the more positive the attitude given, the stronger the role of the surrounding environment; and the greater the perceived behavioral control, the stronger the intention to take action in the manner given.

In this context, to generate commuter motivation or intention to use P&R, the commuter must have a positive attitude towards public transportation and P&R, assume that his actions are appropriate and supported by the surrounding environment, and have the ability to use P&R that is supported by the condition of the transportation

public facilities, parking facilities, and transportation policies. Based on[10], people's intention in using P&R is formed through attitudes, prevailing subjective norms, perceived behavioral control, and beliefs. High enthusiasm, positive subjective norms, and high perceived behavioral control will increase a person's intention to use P&R facilities.

Table 2. Variables and indicators.

Variable		Indicator	References
	Sub variable		
Attitude		Using P&R is a good idea	[9], [23], [27], [10]
		Using P&R provides many advantages	
		Using P&R supports public pro-transport behavior	
Subjective norm		The people closest to me use P&R	[9], [23], [27]
		The people I look up to use P&R	
		People who are important to me recommend using P&R	
Perceived Behavioral Control	The condition of Park-and-Ride facilities	P&R location is strategic and easy to access	[20], [8]
		Lots of parking capacity available	
		P&R has good service quality	
		The security and safety offered by a P&R facility	
		Information regarding the availability of parking spaces is clear	
	The condition of public transportation	Availability of public transportation around P&R	
		Cleanliness of public transportation during the COVID-19 pandemic	
		The condition of public transportation around P&R during the COVID-19 pandemic made it easier for me to use P&R	
Policy	Vehicle use restrictions	The enforcement of the vehicle usage restriction policy hindered my trip	[26], [25], [35]
		The implementation of the vehicle usage restriction policy prompted me to use P&R	
	Parking restrictions in the city center	The implementation of a parking restriction policy in the city center makes it difficult for me	
		The introduction of a parking restriction policy in the city center prompted me to use P&R	
	The use of public transportation during the COVID-19 pandemic	The policy of using public transportation during the COVID-19 pandemic has been implemented backwards	
		The implementation of public transportation usage policies in accordance with health protocols encouraged me to use P&R	
Intention		Intention to use P&R	[6], [20], [7]

2.3 SWOT Analysis

The SWOT analysis in this study was used to compile the results of previous analyses to identify potentials and problems as one of the bases for determining Park-and-Ride plans at Sidoarjo Station. The stages in the SWOT analysis in this study include:

1. Step 1: Identifying potentials and problems based on the results of the previous analysis, namely SEM analysis, analysis of parking space requirements, and comparative analysis, as well as the results of literature studies.
2. Step 2: Determining the internal and external factors that can support or hinder the planning of P&R at Sidoarjo Station.
3. Step 3: Creating a SWOT matrix based on internal factors (strengths and weaknesses) and external factors (opportunities and threats) consisting of four strategy quadrants.
4. Step 4: Formulating the P&R management strategy at Sidoarjo Station.
5. Step 5: Developing the strategy into a P&R design concept at Sidoarjo Station.

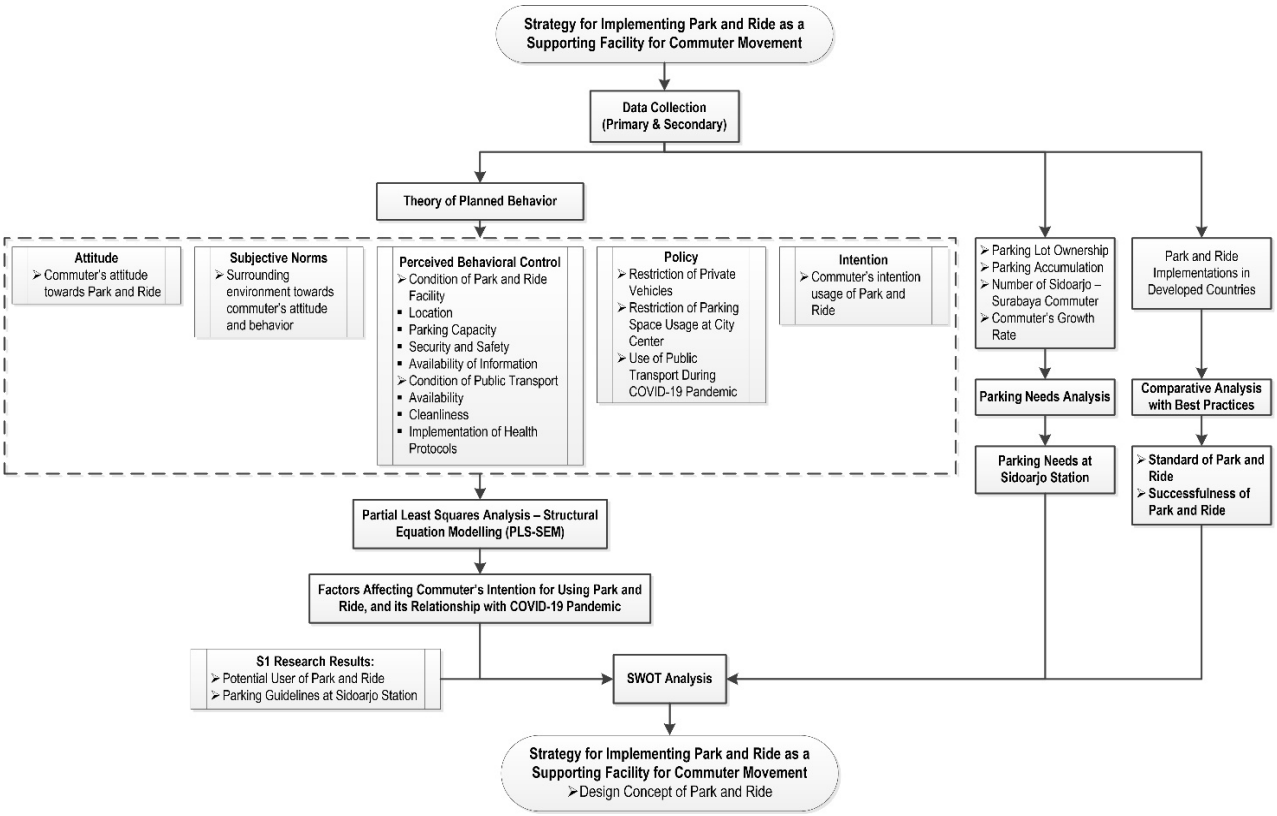

Fig. 1: Research framework.

2.4 Structural Equation Modelling Analysis

Structural Equation Model (SEM) analysis is included in a form of multivariate analysis method. SEM is often used to explain the relationship or interrelationship between indicators, as observed variables and latent variables simultaneously. Latent variables are variables that cannot be measured or identified directly, so they require several indicators as measuring tools. SEM can also be defined as a combined multivariate statistical technique (factor analysis and regression), which aims to test the relationship between variables in a model [27]. This study uses PLS-SEM to identify the factors that influence commuters' intentions to use P&R as well as the interrelationships between the variables. The Partial Least Squares – Structural Equation Model (PLS-SEM) analysis stage using Smart PLS software [27],[34], includes:

1. Determine indicators based on their type (reflective and formative) and classification of data that will be used to assess each indicator. Classification is carried out using a Likert scale of 1 to 5, where 5 is the highest value.
2. Open the SmartPLS application and enter research data into the framework that has been created.
3. Create path model specifications in the structural model. This stage includes creating a sequence of constructs and predicting the relationships between constructs. The sequence of constructs in the path model is based on theory, logical reasoning, and practical experience from researchers.
4. Create a measurement model specification that shows the relationship between the constructs and the measuring indicators.
5. Evaluate the results of measurement model testing. Evaluation can be done by selecting the "calculate" button, then "PLS Algorithm" which is on the top right side.
6. The next step is to assess the validity and reliability of the measurement model. If there are indicators that are not in accordance with the PLS-SEM standard based on[34], indicators are eliminated. Models that comply with standards can be said to be valid and reliable, so that they can carry out the next stage, namely structural model evaluation.

3. Result and Discussion

The formulation of the strategy and concept for the development of P&R at Sidoarjo Station was obtained through the identification of potentials and problems using the SWOT analysis (Table 3). The SWOT analysis is an analytical technique used to solve a problem based on an analysis of the strategic environment that can support the achievement of goals, consisting of the external environment (opportunities and threats) and the internal environment (strengths and weaknesses)[36].

Table 3. Potentials and problems of implementing Park-and-Ride at Sidoarjo Station.

Environment (Factor)		No	Potential and Problems	Data source
Internal	Strength	S1	The condition of P&R is one of the factors that influence commuters' intentions to use P&R. The better the condition of the P&R, the higher the community's intention to use the facility (the public's enthusiasm for the facility is quite high).	▪ SEM-PLS analysis (Driver Intention)
		S2	In the existing conditions, the parking facilities at Sidoarjo Station have met 16 of the 25 parking standards based on the Decree of the Director General of Land Transportation Number 272/hk.105/DRJD/96 concerning Technical Guidelines for the Implementation of Parking Facilities, as well as P&R Guidelines.	▪ Primary survey ▪ Analysis of parking standards[37]
		S3	Parking facilities at Sidoarjo Station are under the management of PT Reska Multi Usaha and has been operating using the e-reska parking system.	▪ Primary survey
		S4	The potential for P&R users at Sidoarjo Station is 44.3%, and it can become 82.91% if it is supported by improving the quality of public transportation, enforcing transportation policies, and providing public transportation fare subsidies	▪ [37]
		S5	Sidoarjo Station is located in a residential area with quite high generation potential	▪ [37],[38]
		S6	The existence of P&R at Sidoarjo Station can be easily integrated with public transportation (train)	
		S7	Sidoarjo Station has good accessibility because it can be accessed by passenger vehicles and pedestrians.	▪ [38]
	Weakness	W1	Part of the Indonesian Railway Company asset is used by the community to construct residential buildings	▪ Secondary survey
		W2	Parking facilities at Sidoarjo Station have not been equipped with sufficient lighting	▪ Analysis of Parking Standards and the Kano Model[37]
		W3	In the parking facilities at Sidoarjo Station, there is no dedicated CCTV system used to monitor the security and safety of parking users	▪ Analysis of Parking Standards and the Kano Model[37]
		W4	There is a conflict between pedestrians and vehicle users at Sidoarjo Station	▪ Analysis of Parking Standards[37]
		W5	There is a need for additional parking area because the parking facilities at Sidoarjo Station have exceeded the available parking capacity, resulting in several new parking locations that are not suitable and cause new problems	▪ Parking Needs Analysis ▪ Analysis of Parking Characteristics[37]
		W6	Parking facilities at Sidoarjo Station are not equipped with information boards regarding the location and availability of parking	▪ Comparative analysis
		W7	Technology utilization in parking facilities at Sidoarjo Station is still low	
		W8	The payment system for public transportation and parking has not yet been integrated	
External	Opportunity	O1	Sidoarjo Station is one of the recommended locations for the development of P&R	▪ Secondary survey
		O2	There is a plan to develop parking facilities at Sidoarjo Station	▪ Secondary survey
		O3	There is a plan to build a P&R facility at Sidoarjo	▪ Secondary survey

Environment (Factor)		No	Potential and Problems	Data source
			Station	
		O4	Sidoarjo Regency is the area of origin of commuters with the largest percentage, namely 40% of the total commuters in Surabaya City	▪ Secondary survey
		O5	The construction of the Surabaya Regional Railway Line will be planned to connect Surabaya and Sidoarjo and become an alternative mode of transportation that serves the movement of commuters	▪ Secondary survey
	Threat	T1	There is no policy that regulates vehicle ownership restrictions and parking restrictions in East Java Province	▪ Secondary survey
		T2	There is low interest of commuters in using public transportation, where only 4% of all Sidoarjo–Surabaya commuters use trains as the main mode of transportation	▪ Secondary survey
		T3	There isn't yet optimal quality of public transportation, especially trains that can serve the movement of commuters	▪ [37)]
		T4	There is unofficial parking located around Sidoarjo Station	▪ Primary survey
		T5	The growth rate of Gerbangkertasusila commuters is quite high, namely 0.5% annually	▪ Secondary survey

Furthermore, each internal and external factor will be analyzed using the SWOT matrix to determine the strategy for implementing P&R at Sidoarjo Station. The SWOT strategy that has been prepared can be seen in the Table 4. From the SWOT matrix in Table 4, strategic points are obtained from efforts to make use of the potentials to overcome existing problems. In general, there are two types of strategies that can be implemented, namely the physical and non-physical strategy of implementing P&R.

Table 4. SWOT strategy.

	Strenght	**Weakness**
	S1. The condition of P&R is one of the factors that influence commuters' intentions to use Park-and-Ride **S2.** Parking facilities at Sidoarjo Station comply with 16 of the 25 applicable parking standards **S3.** Parking facilities at Sidoarjo Station are under the management of PT Reska Multi Usaha and has been operating using the e-reska parking system **S4.** The potential for P&R users at Sidoarjo Station is 44.3%, and it can become 82.91% if it is supported by improving the quality of public transportation, enforcing transportation policies, and providing public transportation fare subsidies **S5.** Sidoarjo Station is located in a residential area with quite high generation potential **S6.** The existence of P&R at Sidoarjo Station can be easily integrated with public transportation (train) **S7.** Sidoarjo Station has good accessibility, because it can be accessed by	**W1.** Part of the Indonesian Railway Company's asset is used by the community to construct residential buildings **W2.** Parking facilities at Sidoarjo Station have not been equipped with sufficient lighting **W3.** In the parking facilities at Sidoarjo Station there is no dedicated CCTV system used to monitor the security and safety of parking users **W4.** There is a conflict between pedestrians and vehicle users at Sidoarjo Station **W5.** The need for additional parking area because the parking facilities at Sidoarjo Station have exceeded the available parking capacity, resulting in several new parking locations that are not suitable and cause new problems **W6.** Parking facilities at Sidoarjo Station are not equipped with information boards regarding the location and availability of parking

	passenger vehicles and pedestrians	**W7.** Technology utilization in parking facilities at Sidoarjo Station is still low **W8.** The payment system for public transportation and parking has not yet been integrated
Threats **T1.** There is no policy that regulates vehicle ownership restrictions and parking restrictions in East PT Province **T2.** There is low interest of commuters in using public transportation, only 4% of all Sidoarjo–Surabaya commuters use trains as the main mode of transportation **T3.** There isn't yet optimal quality of public transportation, especially trains that can serve the movement of commuters **T4.** There is unofficial parking located around Sidoarjo Station **T5.** The growth rate of Gerbangkertasusila commuters is quite high, namely 0.5% annually	• Providing parking facilities that are integrated with public transportation • Improving the quality of public transportation, especially trains as a mode of public transportation that can serve the movement of Sidoarjo–Surabaya commuters • Providing parking facilities equipped with supporting facilities, such as lighting, CCTV, and so on with good quality service • Recommending the direction of parking planning and implementation of P&R to the government as one of the considerations in formulating transportation policies • Coordinating and cooperating between the community and PTPT Reska Multi Usaha to manage parking around Sidoarjo Station	• Provide parking lots that can accommodate increased demands, both for station visitors and commuters when the P&R facility is operational • Creating an integrated payment system between public transportation and parking facilities through the use of technology • Coordinating and collaborating with the Indonesian Railway Company to provide information to the community and carry out land acquisition • Coordinating and cooperating between the community and PT Reska Multi Usaha to manage parking around Sidoarjo Station • Repairing and complementing the lack of availability of complementary parking facilities, so as to improve the quality of parking facilities at Sidoarjo Station
Opportunity **O1.** Sidoarjo Station is one of the recommended locations for the development of P&R **O2.** There is a plan to develop parking facilities at Sidoarjo Station **O3.** There is a plan to build a P&R facility at Sidoarjo Station **O4.** Sidoarjo Regency is the area of origin of commuters with the largest percentage, namely 40% of the total commuters in Surabaya City **O5.** The construction of the Surabaya Regional Railway Line will be planned to connect Surabaya - Sidoarjo and become an alternative mode of transportation that serves the movement of commuters.	• Building P&R facilities in accordance with parking standards based on Decree of the Director General of Land Transportation Number 272/hk.105/DRJD/96 concerning Technical Guidelines for the Implementation of Parking Facilities, as well as P&R Guidelines • Improving the service quality of P&R facilities through the provision of complementary facilities that make it easier for commuters to use them • Collaborating with the local government in building P&R facilities at Sidoarjo Station • Creating a circulation path that can increase the accessibility of Sidoarjo Station	• Coordinating with the Indonesian Railway Company and the local government to provide outreach to the community regarding the land acquisition plan • Building P&R facilities in accordance with parking standards based on Decree of the Director General of Land Transportation Number 272/hk.105/DRJD/96 concerning Technical Guidelines for the Implementation of Parking Facilities, as well as P&R Guidelines • Providing parking information systems through the use of technology

The concept and design of P&R was obtained by considering the strategy of physically implementing Park-and-Ride, which focuses on the development of parking facilities. The following is a summary of the strategies for implementing P&R at Sidoarjo Station:

A. Physical Planning
   1. Providing parking facilities that are integrated with public transportation
   2. Improving the quality of public transportation, especially trains as a mode of public transportation that can serve the movement of Sidoarjo–Surabaya commuters
   3. Ensuring parking lots that can accommodate increased demand, both for station visitors and commuters when the P&R facility is operational
   4. Creating an integrated payment system between public transportation and parking facilities through

the use of technology
5. Building P&R facilities in accordance with parking standards based on Decree of the Director General of Land Transportation Number 272/hk.105/DRJD/96 concerning Technical Guidelines for the Implementation of Parking Facilities, as well as P&R Guidelines.

B. Non-Physical Planning
1. Recommending the direction of parking planning and implementation of P&R to the government as one of the considerations in formulating transportation policies
2. Coordinating and cooperating between the community and PT Reska Multi Usaha to manage parking around Sidoarjo Station
3. Coordinating and cooperating with the Indonesian Railway Company and the government to provide dissemination to the community and carry out land acquisition
4. Collaborating with the local government in building P&R facilities at Sidoarjo Station

Along with the development of technology from time to time, Park-and-Ride facilities have begun to experience development from the original form in the form of large parking lots and conventional parking to smart parking through the use of technology and modification of parking forms according to regional conditions. In this study, the design concept of Park-and-Ride at Sidoarjo Station was obtained through the development of a strategy from the results of the previous analysis, as well as the literature study conducted. In general, there are two alternatives that can be developed as the basic concepts of P&R design, which are conventional parking and smart parking (automated parking system) [38], [39], [40]. Table 5 is an explanation of each alternative:

Table 5. The difference between conventional parking and smart parking.

Aspects	Conventional Parking	Smart Parking
Land requirements	• Requires more land for circulation paths and ramps	• Requires less land because it uses an elevator to park the vehicle, thereby not requiring a ramp.
Parking Capacity	• There is more limited parking capacity provided in the same land area • In this study, the area of land that can be developed for a parking area is 75 x 25 m^2. With this parking area, the parking capacity that can be provided through a three-floor conventional parking system is: Motorcycles: 356 Parking Space Units Car :102 Parking Space Units	• Parking facilities can provide more parking capacity • In this study, the area of land that can be developed for a parking area is 75 x 25 m2. With this parking area, the parking capacity that can be provided through a three-floor automatic parking system is: Motorcycles: 432 Parking Space Units Car : 152 Parking Space Units
Technology	• Most of them still use conventional systems without utilizing technology • Parking payments are made manually, namely through the ticket counter at the entrance to the parking area, as well as giving a parking ticket as proof of payment	• It already utilizes technology, both for information systems through IoT, AI, and so on, as well as automatic parking systems through parking machines that can park vehicles • Parking payments can already be made online through a parking application that is integrated with public transportation or via a smart card that is scanned when entering and leaving the parking area
Energy	• Conventional parking areas require more energy for lighting. However, in parking buildings this condition can be overcome through designs that have lots of natural lighting • Meanwhile, the amount of energy released by motorized vehicles during the vehicle parking process tends to be greater when using conventional systems.	• Parking areas with smart parking can use an automatic lighting system. In parking buildings these conditions can also be strengthened by designs that have lots of natural lighting • Smart parking using an automated parking system can save 20% to 80% of the energy released by motorized vehicles during the vehicle parking process.
Development and Operational Costs	• The cost of constructing a parking lot with a conventional system tends to be less, while the operational costs that must be incurred are higher because it requires additional costs for electricity, employee salaries, accident insurance, and security.	• The cost of building parking with smart parking tends to be greater for the use of technology, but can save expenses on land and construction materials. Meanwhile, the operational costs incurred are smaller even though there is maintenance for the parking machines used because there are no maintenance costs for the parking area.

In addition to the aspects described in Table 5, the use of smart parking is also considered safer for parking users because it reduces opportunities for criminal acts (theft, etc.) and minimizes accidents and car damage. Smart parking can solve the problem of parking difficulties and save time (the time to find available parking locations and park the vehicle). Based on several considerations, the use of smart parking (automated parking system) has more advantages compared to conventional systems, such as from the aspect of providing parking capacity, saving energy, and public satisfaction due to the efficient use of parking.

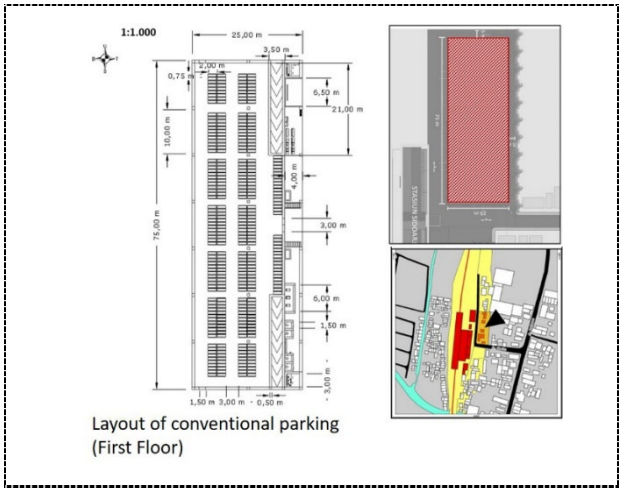

Fig. 2: Layout of convensional parking

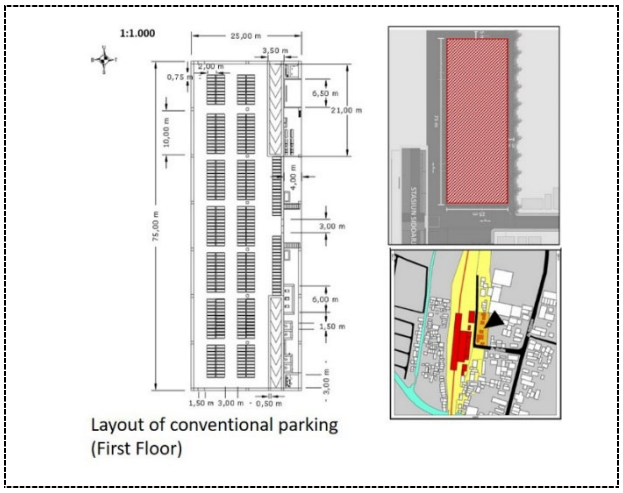

Fig. 3: Parking layout with automated parking system

In addition, the use of smart parking can also overcome the problem of limited land for the development of parking lots at Sidoarjo Station. Even though developing countries like Indonesia show that the use of smart parking takes longer for people to adapt, this system can be expected to overcome parking problems and increase land use efficiency in urban areas and its surroundings. Therefore, in this research, P&R Sidoarjo Station will be planned to use smart parking. The following is an explanation of the Sidoarjo Station P&R design concept, which consists of the exterior and interior of the building.

In general, the exterior of P&R at Sidoarjo Station describes the plan for the shape of the building and circulation routes. The concept of the P&R plan was obtained through the development of a strategy from the results of the previous analysis and the conducted literature study. The available land area for parking development is 75 x 25 m^2, located in front of the station building. This location is also in accordance with the zoning regulations in the Sidoarjo Regency 2019–2039 in the Detailed City Spatial Plan document, namely the zone of public transportation service facilities. The shape of the P&R building is rectangular and consists of three floors. The number of floors was obtained by identifying the surrounding conditions, where, on average, the the highest buildings around Sidoarjo Station have three floors.

Fig. 4: Design of the front of the P&R building at Sidoarjo Station.

In the existing conditions, there are problems regarding the existence of conflicts between the parking of motorbikes, cars, and station visitors at Sidoarjo Station. This problem is further exacerbated by vehicles turning around when they want to go out of the parking location and the pick-up point for station visitors. Therefore, an addition of a new road is planned, which functions to facilitate the circulation of vehicles and visitors in the station. The road is planned to have a width of 5 m, located in the north and east of the P&R building, as well as designating the vehicle pick-up point, which is in the western part of the P&R building.

The P&R building has one entrance and one exit separately for each type of vehicle. The dimension of the entrance and exit of the motorcycle parking is 2 x 2.5 m, while the dimension of the entrance and exit of the car park is 2 x 5 m. The motorcycle parking entrance is in the southern part of the parking building, and the motorcycle exit is in the north, parallel to the entrance. Meanwhile, the car park entrance to the car lift is in the southwest of the parking building and the exit is in the northwest. Furthermore, to exit the station area, users of motorized vehicles, both motorbikes and cars, can pass through the new road on the side of the parking building to be directed back to Station Street.

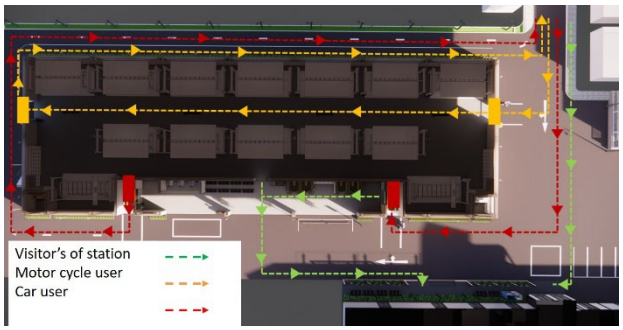

Fig. 5: Parking circulation at P&R Sidoarjo Station.

Furthermore, in the interior of P&R at Sidoarjo Station, it generally explains the planned parking area, circulation routes, and complementary facilities. The concept of the P&R plan was also obtained through the development of a strategy from the results of the previous analysis and the conducted literature study. The three-floored P&R building with an area of 75 x 25 m^2 provides a parking capacity of 432 Parking Space Unit (PSU) motorcycles on the 1st floor and 152 PSU cars (76 PSU cars on the 2nd floor and 76 PSU cars on the 3rd floor).

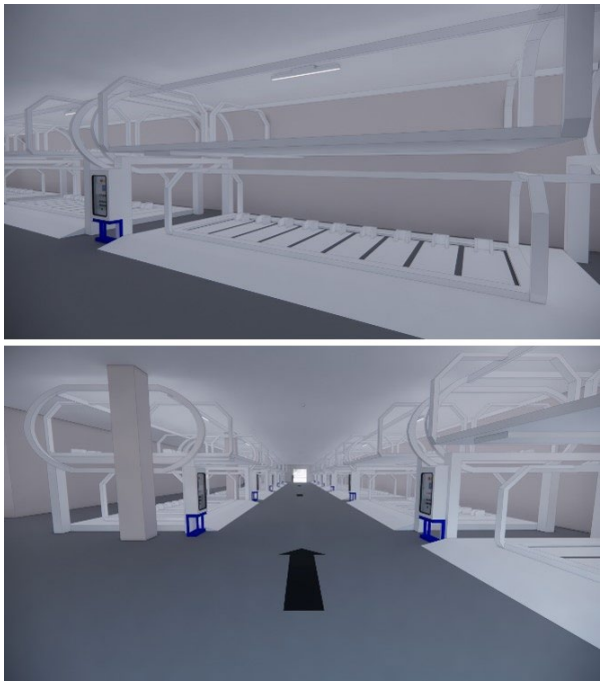

Fig. 6: Car parking.

The parking system at Sidoarjo Station P&R uses an automated parking system, where parking users can park their vehicles automatically. Motorcycle parking at Sidoarjo Station P&R is planned to use a carousel rotary parking machine with a capacity of 27 motorbikes in one machine. This technology has been used in China and Taiwan to meet the increasing needs of public parking but is constrained by limited space. The following is the parking layout and circulation paths inside the Park-and-Ride building (Fig. 6).

4. Conclusion

There are several aspects that need to be developed in the implementation of P&R at Sidoarjo Station based on the results of a comparative analysis, such as using technology for providing parking, providing and optimizing information systems, and installing a parking payment system that is integrated with public transportation. In addition, the results of the SWOT analysis resulted in several strategies for implementing P&R at Sidoarjo Station, including providing parking lots that can accommodate the needs of commuters and station visitors, building P&R facilities in accordance with parking standards, and ensuring Park-and-Ride supporting facilities, which can increase commuters' trust and satisfaction. Therefore, these strategies can encourage commuters' intentions to use P&R at Sidoarjo Station.

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