Time integration analysis of Soekarno-Hatta International Airport (SHIA) Train with Skytrain

D Viarsyah and J Sumabrata
Civil Engineering Program, Department of Civil Engineering, Faculty of Engineering, Universitas Indonesia, Jl. Margonda Raya, Pondok Cina, Beji, Kota Depok, Jawa Barat 16424 - Indonesia
dviarsyah@gmail.com

Abstract. The sustainability of transportation systems in Jakarta is under threat from climate change. Better integration and planning of public transportation is an alternative to support land transportation and to solve the congestion problem when heading to Soekarno-Hatta International Airport. Hence, PT Railink, PT Angkasa Pura II, PT Kereta Api Indonesia with its BUMN synergy built rail-based transportation called Airport Train. Moreover, Airport Train is connected with Skytrain in an integrated building as a transferring point. This study analyzes the time integration to travel using the Airport Train from BNI City Station to the Skytrain to reach the passenger destination terminal by observing additional time factors in the integration building or vice versa on the Skytrain – Airport Train trips. The results of the analysis in the form of Train Travel Charts show both on Airport Train - Skytrain trip and Skytrain - Airport Train trip after paying attention to integration factors, there are several schedule conditions that require passengers to depart for the next Airport Train or Skytrain, and worse not accommodate each other at certain times.

Keywords: Airport Train Schedule, Skytrain Schedule, Time Integration, Walking Time, Waiting Time

1. Introduction
All this time access to Soekarno-Hatta International Airport can only be reached by bus, taxi, private car, DAMRI, or various other private buses that move daily to fill the area of Airport. On that basis, the existence of the Soekarno-Hatta International Airport Train that was carried out by PT Railink, PT Angkasa Pura II, PT Kereta Api Indonesia with synergy with BUMN, is expected to help reduce these problems (Ridha Kurniawan, Samuel Petros Sebhatu, Sara Davoudi 2017).

In addition to the Airport Trains, it has been operated in advance namely the Automated People Mover System (APMS) and a shorter called Skytrain which is a mode of transportation between train-based terminals without a driver at Soekarno-Hatta International Airport (Nesyamia Yala Widhasuna, Danang Parikesit, 2018). The construction of the Skytrain is intended to take over the role of the Shuttle Bus to carry out inter-terminal movements at Soekarno-Hatta Airport. On that basis also, the construction of railroad-based Skytrain facilities and Shelter infrastructures that are above the ground level will not interfere with other modes of transportation and help break down traffic congestion at Terminals 1, 2 and 3 at Soekarno-Hatta International Airport.

In its implementation, Soekarno-Hatta International Airport Train and Skytrain are two interconnected modes of transportation in the Integrated Building as can be seen on Figure 1. The
existence of these two modes can be used by the community to go to SHIA to the destination terminal or vice versa. The existing conditions of Airport Train and Skytrain in the form of travel schedules, operating patterns and factors that influence travel in the integration building will be analyzed on the Airport Train - Skytrain and Skytrain - Airport Train trips. This research is intended to see how integration in terms of time (schedule) affects the journey of passengers using Airport and Skytrain. Further analysis is included in a Train Travel Chart from and to each terminal at Soekarno-Hatta Airport. With the factors that influence travel time, it is a challenge for both modes of transportation regarding how time integration can still be done.

2. Theoretical Review

In this study the focus of the discussion is on schedule integration (time). Time integration is in the form of suitability of arrival and departure schedules between well-informed transportation modes, allowing reduced passenger waiting times when moving transportation (Givoni M., Banister D. 2010, Hull A. 2005, Ibrahim M. 2003, May et al 2006, Saliara, 2014). In the case of the integration of Airport Train with Skytrain, different operational schedules, the existence of an integration building that causes additional times also determines when the best time to do multimode. (Laplace, I., Marzuoli, A., Féron, ´E., 2014, Vespermann. and Wald. 2011, Milbredt, Rudolp, Grunewald and Christ, 2017).

![Diagram](image_url)

**Figure 1.** The overall component of the trip in this study

In this study the origin of the trip using the Airport Train to Soekarno-Hatta Airport Station focused on BNI City Station and then continued the journey with Skytrain. Likewise, the trip from the Skytrain and continued by the Airport Train from Soekarno-Hatta Airport Station until it ends at BNI City Station. Travel time from and to Soekarno-Hatta Airport using the Airport Train is 46 minutes with a departure interval every 30 minutes. While the duration of ticket purchases with vending machines in the integration building is considered to be a factor influencing the integration of Skytrain - Airport Train trips. For more details consider figure 2.

The Skytrain at Soekarno-Hatta Airport currently has two series which are divided on line A and line B with different routes based on the itinerary. The presence of Skytrain on two lines affects the capacity and reduces the waiting time of passengers who want to travel from and to the IB Shelter (Integrated Building) to the destination terminal. In the same time as the line B Skytrain, and the origin is set from the IB Shelter, line A Skytrain will first move towards Terminal 1 Shelter, then return to IB Shelter, move towards Terminal 2 Shelter, and end at Terminal 3 Shelter. After that Skytrain departs from T3 Shelter to T2, IB, and T1. And so on the travel route that applies to Skytrain line A. While on line B, with the origin of the Airport Train Shelter (IB), Skytrain will move towards the T2 Shelter, T3 Shelter then back through the T2 Shelter, IB Shelter, until finally arriving at the T1 Shelter.
Understanding of the operations of the Airport Train and Skytrain are not sufficient to analyze the time integration between the two transportation modes. The existence of building integration (Integrated Building/IB) as a transfer point both on Airport Train - Skytrain trip or Skytrain - Airport Train trip, be the deciding factor that influences the departure time of the Skytrain or Airport Train that a person can ride. Among these factors, namely the possibility of late arrival Airport Train at Soekarno-Hatta Airport Train Station, the walking time from the Airport Train Station to the IB Shelter, as well as the waiting time with the Skytrain schedule the closest Skytrain departure towards the destination terminal passengers. And on Skytrain - Airport Train trips, in addition to the travel time from the IB Shelter to Soekarno-Hatta Airport Station, there is a duration of ticket purchases that also need to be taken into account, and Airport Train waiting time and posed with the closest departure schedule.

3. Research Methods

In addition to determining the identification of problems with searching the literature study, it is important to conduct a survey of existing conditions to understand in advance how an Airport Train and Skytrain operations take place. The median observation – average number of Train passengers walk area of the airport, in terms of integration, building up to the time of purchase of the Airport Train is worthy of note for helpful information on research before doing the survey data collection it actually was. Then at the stage of data collection, differentiated into the primary data and secondary data.

Secondary data is obtained from the latest information issued by the relevant agencies in the form of Airport Train schedules, Skytrain schedules, including the route and travel time of the Airport Train set by PT Railink by looking at the departure time from BNI City Station until the arrival time at Soekarno-Hatta Airport Station based on the schedule 46 minutes. There is additional data derived from secondary data, namely the waiting time for Airport Train and Skytrain which is a domino effect from the previous trip series.

Whereas in the primary data, the survey of the arrival or departure realization of the Airport Train or Skytrain is needed to indicate whether there is an average delay that can affect the integration in the end. Then the survey did not escape the calculation of walking time in the integration building either on the Airport Train trip - Skytrain or Skytrain - Airport Train. Furthermore, no less important is the duration survey of the purchase of Airport Train tickets in the integration building for analysis of time integration on Skytrain - Airport Train trips.

Analysis is divided into Airport Train trips to use Line A or Line B Skytrain, and line A or Line B Skytrain trips to use Airport Trains. The influencing factors as mentioned earlier are poured into the data processing tab to be added in the travel time. All possible schedules that occur are analyzed and illustrated in a Train Travel Chart.
4. Research Results

4.1 Time Integration Analysis of Airport Train – Skytrain Trips

It should be understood again that the operating pattern of Skytrain line A is IB - T1 - IB - T2 - T3 while the B line is IB - T2 - T3 - IB - T1. Schedule conditions are made each departing from IB. So after paying attention to the Airport Train delay time which is an average of + 3 minutes, the average walking time is 6 minutes, the results of the analysis show in table 1:

| BNC  | SHA       | Delays (+3 min) | Waking Time (+6 min) | Impact to Waiting Time (min) | LINE A |
|------|-----------|-----------------|----------------------|-----------------------------|--------|
|      |           |                 |                      |                             | IB     |
|      |           |                 |                      |                             | T1     |
|      |           |                 |                      |                             | IB     |
|      |           |                 |                      |                             | T2     |
|      |           |                 |                      |                             | T3     |
| IB   | IB T1     |                 |                      |                             | IB     |
|      | IB T2     |                 |                      |                             | IB     |
|      | IB T3     |                 |                      |                             | IB     |

The table 1 shows piece of table from several departure schedules with origin BNC and followed by a trip using line A Skytrain. When passengers from the Airport Train want to use the Skytrain towards T1, the passenger will be directed to the Skytrain on departure 5.53 at the IB, so there is a 7 minute waiting time. Passengers who want to go to Terminal 2 or 3, can take the Skytrain on departure at 6.01. This means that passengers will wait longer in the shelter IB waiting area because they do not need to go to terminal 1 first (15 minutes). But if we pay attention to the following:

| BNC  | SHA       | Delays (+3 min) | Walking Time (+6 min) | Impact to Waiting Time (min) | LINE B |
|------|-----------|-----------------|-----------------------|-----------------------------|--------|
|      |           |                 |                      |                             | IB     |
|      |           |                 |                      |                             | T1     |
|      |           |                 |                      |                             | IB     |
|      |           |                 |                      |                             | T2     |
|      |           |                 |                      |                             | T3     |

Passengers from Soekarno-Hatta Airport (SHA) Station who want to go to Terminal 2 or 3 can be accommodated by Skytrain on line B, which is at 5.49 departing from IB Shelter. This means that passengers only need a waiting time of 3 minutes to be able to ride the Skytrain to Terminal 2 or 3 (faster than conditions on line A schedule). If the arrival of the Airport Train at SHA Station is more than 3 minutes or if the passenger needs to walk longer than 6 minutes, passengers will board the Skytrain to Terminal 2 or 3 on line A at departure 6.01 from the IB Shelter (Table 1), so the waiting time is 15 minutes. This pattern applies continuously depending on where the terminal aims and how passengers
use their time to switch modes from the Airport Train to the Skytrain so that it ends with the line A Skytrain or with line B.

4.2 Time Integration Analysis of Skytrain – Airport Train Trips
Both on lines A and B, the results of the analysis show that with the travel time factor of +3 minutes walking, the Airport Train ticket purchasing duration in integrated building is +3 minutes, there is an Airport Train schedule that cannot accommodate passengers from the Skytrain which is marked with a column that is blocked in Table 3. When passengers from the Skytrain cannot be accommodated with the departure schedule of the nearest Airport Train, passengers will board the Airport Train on the next schedule. For example, consider the table 3:

| Table 3. A Piece of Table from Time Integration Analysis of Skytrain (LINE A) – Airport Train |
|-------------------------------------------------|-------------------------------------------------|-------------------------------------------------|
| T3     | T2     | IB* | IB** | IB* | IB** | SHA | BNC |
| 4:27   | 4:32   | 4:35 | 4:39 | 4:43 | 4:46 | 4:49 | 91 |
| 4:53   | 4:58   | 5:01 | 5:05 | 5:09 | 5:04 | 5:07 | 73 |
| 5:19   | 5:24   | 5:27 | 5:31 | 5:35 | 5:30 | 5:33 | 47 |
| 5:45   | 5:50   | 5:53 | 5:57 | 6:01 | 5:56 | 5:59 | 21 |
| 6:16   | 6:23   | 6:27 | 6:27 | 6:22 | 6:25 | -5  | 6:30 | 6:33 | -13 | 6:20 | 7:06 |
| 6:37   | 6:49   | 6:53 | 6:57 | 6:48 | 6:51 | -1  | 6:56 | 6:59  | -9  | 6:50 | 7:36 |
| 7:03   | 7:14   | 7:17 | 7:25 | 7:14 | 7:17 | 3   | 7:22 | 7:25  | -5  | 7:20 | 8:06 |
| 7:29   | 7:45   | 7:45 | 7:45 | 7:40 | 7:43 | 7   | 7:48 | 7:51  | -1  | 7:50 | 8:36 |
| 7:55   | 8:07   | 8:11 | 8:11 | 8:06 | 8:09 | 11  | 8:14 | 8:17  | 3   | 8:20 | 9:06 |

IB* = IB Shelter, carries passengers from T3 and T2
IB** = IB Shelter, carries passengers from T1
IB* = Origin at Line A

Walking Time Factor = $W_{WT}$
Duration of Ticket Purchase = $DTP$
Waiting Time = $W_{WT}$

On line A, the Skytrain departs from T3 Shelter at 6.11 WIB to T2 and arrives at the IB Shelter at 6.19 WIB. The arrival of the Skytrain at the IB at that time means carrying passengers coming from terminal 3 and terminal 2. Then the passengers walk on the integration building for 3 minutes and finish buying tickets at 6.25. On the schedule there is the departure of the Airport Train at 6.20 WIB, it means that passengers are 5 minutes late so they have to wait for the next departure of Airport Train at 6.50 WIB. Pay attention to the following scheme:

Arrival of Skytrain at IB Shelter (6.19)  
 Departure of Airport Train at SHA Station (6.20)  
1 minute interval

Whereas,

Arrival of Skytrain at IB Shelter (6.19)  
Walking Time Factor + Duration of Ticket Purchase (6.25)  
Need 6 minute intervals
Passengers arriving at a transit building, in this case the integration building, are assumed to only require "the shortest time" to be able to switch modes of transportation. The shortest time on a Skytrain - Airport Train trip when in the integration building is the time to walk (3 minutes) and the duration of ticket purchase (3 minutes). When Skytrain passengers arrive early at the Airport Train shelter, but after they finish buying tickets there is no scheduled departure for the Airport Train, then this condition is referred to as waiting time.

With a minimum interval or the shortest time needed is 6 minutes, causing the Airport Train occupancy on the next itinerary is the accumulation of passengers who did not have time to rise on the previous schedule plus passengers who still have time from the Skytrain to finish buying Airport Train tickets at SHA Station.

4.3 Train Travel Charts
Train travel charts are made to show Airport Train travel schedules to their integration with Skytrain or vice versa. Horizontal lines explain the time span from 00.00 to 24.00. Vertical lines describe the names of Airport Train stations or Skytrain shelters that stop to pick and deliver passengers. While the blue slashes from left to right explains the train itinerary of the Airport Train to the Shelters by Skytrain, and the red slashes from left to right explains the itinerary of the Skytrain Shelters to the Airport Train.

Train Travel Chart was made after adding several factors i.e the average delay in arrival of the Airport Train at SHA Station, the walking time in the integration building to get to the IB Shelter or vice versa, the duration of ticket purchase and the Skytrain waiting time generated at IB Shelter or Airport Train waiting time generated at SHA Station. Train Travel Chart can be seen in the figure 3, figure 4 and figure 5:

![Train Travel Chart](image1)

**Figure 3.** Travel Chart to and from T1 Shelter (LINE A or LINE B)
- **Blue**: BNC - T1
- **Red**: T1 - BNC
Figure 4. Travel Chart to and from T2 Shelter (LINE A or LINE B):

- BNC – T2
- T2 – BNC

Figure 5. Travel Chart to and from T3 Shelter (LINE A or LINE B):

- BNC – T3
- T3 – BNC
Horizontal lines of varying lengths indicate variations in waiting times for Skytrain at IB Shelter or Airport Trains at SHA Station. This does not escape the influence of additional time, i.e. the average delay in arrival of the Airport Train at SHA Station (3 mins), the individual journey time is walking time in the integration building either on the Airport Train – Skytrain for 6 mins, or vice versa Skytrain - Airport Train for 3 mins. Thus, the waiting time caused is the time interval of passengers arriving at the waiting area of the Skytrain or the Airport Train waiting area with the nearest Airport Train schedule or the first arrival of the Skytrain with the passenger destination terminal.

The conditions of the A and B line trajectories are distinguished from the Skytrain operating pattern for passing Terminal 1, 2, and 3 based on the timetable departing from the IB Shelter. Graphs show that there are interchangeable patterns in waiting times for Airport Trains or Skytrain. Where on the condition of Airport Train travel to use Skytrain with line A at a certain time to one of the destination terminals, causing a shorter waiting time than using Skytrain on line B. Then for the next time to one of the destination terminals, the use of the Skytrain on line B causes a shorter waiting time than line A. This applies on all conditions of the Skytrain departure schedule at IB Shelter or waiting time generated when waiting for the departure of the Airport Train in the waiting area of SHA Station due to the use of line A Skytrain or line B.

Actually the waiting time caused is the influence of how the individual journey takes place, in this case the integration is started when finished using the Airport Train to then walk towards the IB Shelter. Or vice versa from the IB Shelter walk to the ticket purchase area at the SHA Station.

No less interesting is the graph of all trips from Terminal 1, 2 or 3 Shelter at 23:00 WIB and above with the arrival Skytrain at IB Shelter on line A and line B indicating that the journey cannot continue using Airport Train. This is an important analysis that in order to establish two modes of transportation that are mutually integrated, it should be noted whether the two modes can accommodate each other in time and even better with good integration can reduce passenger waiting times to ride the Airport Train or Skytrain.

5. Conclusions
Analysis shows the different operational patterns of Line A and Line B Skytrain affecting time integration. Then the additional time on the time integration factors for Airport Train - Skytrain and Skytrain - Airport Train affect the departure schedule of Airport Train or Skytrain that can be boarded.

It can also be concluded that the journey from the Airport Train to the T3 Shelter is longer than the trip when heading to the T2 Shelter or T1 Shelter. Both on line A and line B in all travel charts due to time integration analysis factors, causing different waiting time variations in each schedule condition. When the Skytrain in the IB Shelter line A that goes to the destination terminal of the passenger arrives first, then the passenger will join the Skytrain so the waiting time for the Skytrain decreases. And also the Skytrain schedule of the T1 Shelter, T2 Shelter, T3 Shelter at 23:00 WIB and above is not available Airport Train that can accommodate passengers to BNI City Station.

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