Minimizing Conflict of Routes from Switcher for Freight Train and Rail Transport Operations

A. Ariel Anta, A. Titiek Masdini(✉), and Natriya Faisal Rachman

Indonesian Railway Polytechnic, Jalan Tirta Raya, Nambangan Lor, Manguharjo, Jiwan, Madiun 63132, Indonesia

titiek@ppi.ac.id

Abstract. Safety in train operations is a very important aspect of the operation of railways. Along with the increasing demand for goods and services, train trips are increasing. This condition causes increased activity at the station, which has a function: to get up and down passengers or load and unload goods. Arjowinangun Station, originally planned only to be used to get on and off passengers, has now increased its function for loading and unloading goods and as a departure and stop station for the transportation of cement goods. This causes the level of conflict in rail operations to be very high. Calculating the level of conflict routes that occur both for operating trains and existing sling trains is obtained by 17% and for switcher trains by 6.5%. By engineering the operation pattern 1, the conflict route rate for the operating train is 24.4%, and for the shunt, the train is 1.9%. Furthermore, if it is carried out by engineering operation pattern II and adding to the locomotive storage line in lane four, then the conflict route rate is 15%, and the shunt train is 1.5%. By engineering operation pattern 2, the minimum level of conflict routes is obtained for operating trains of 15% and switcher monkeys of 1.5%. If it is assumed that 136 trains pass a day, 23 trains are affected by conflicted routes at Arjawinangun Station.

Keywords: stations · conflict routes · operating trains · switcher trains

1 Introduction

The implementation of train operations is required to provide services safely, comfortably, quickly, smoothly, and on time. Arjawinangun Station, at the beginning of its construction, only functioned as a passenger boarding station. Still, in its development during the construction of a double track on the northern route, it built a V line here to provide ballast. After completion of construction, then line V will function as a loading line by PT KAI for the transportation of cement goods. So that currently, the services provided are 35 (thirty-five) for both passenger and freight transportation. With details of 6 (six) passenger trains, 26 (twenty-six) freight trains, and 3 (three) cement freight trains departing and ending at Arjawinangun station, so the total frequency of trains operating is 136 trains in one day. The function of this Arjawinangun station, in addition to functioning as up and down passengers, loading, and unloading of goods, are also

W. A. Wirawan et al. (Eds.): ICORT 2022, AER 220, pp. 78–88, 2023.
https://doi.org/10.2991/978-94-6463-126-5_9

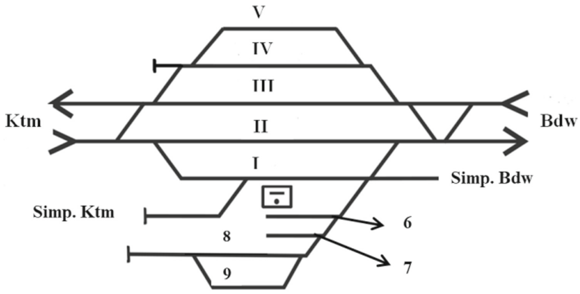

Fig. 1. Arjawinangun Station Emplacement

Table 1. Functions of each Arjawinangun Station Line

Lines	Information
I	Turning lines for Train stop from Jakarta to Surabaya
II	Straight line train to Surabaya
III	Straight line train to Jakarta
IV	Turning lines for Train stop from Surabaya to Jakarta
V	Line To Load Cement
6	Depo Line
7	Depo Line
8	Parking Lot/Storing Carriage
9	Parking Lot/Storing Carriage
Intersection Ktm	The line for Storing Means
Intersection Bdw	Parking Lot/Storing Carriages and Lanes For Depo and Lanes 8/9
Slide IV	Slide Track

(Source: PDPS Stasiun Arjawinangun)

activities for shifting and changing drivers. For goods transportation activities other than loading and unloading activities because there are departing and arriving activities, there are also empty carriage stabling activities and loading activities. This is the cause of the dipo in it. The emplacement of Arjawinangun station can be seen in Fig. 1.

Line 5, 6, 7, 8, and 9 are additional lines that must provide due to increased freight transport services at Arjawinangun station. The development of the services provided can explain the function of the existing lines in Table 1.

With the existence of freight trains that depart and end at Arjawinangun station, a significant increase in the past process will inevitably occur. This is because, at this station, there is no locomotive loop facility available. This shunt activity has a very significant effect on the train operation plan. As regulated in Service Regulation 19 article 117 paragraph 2, it is stated that slashing activities carried out through a route connected to the path to be passed by a passing train must be stopped to avoid intersecting. Taking into account the layout of the existing emplacement, all swiping activities at the station to shunt official locomotives for cement freight trains and inserting carriages into the loading lines must stop if there are operating trains crossing from each direction because the swiping movement of this freight transport will cross the main line that will be passed by the operating train. Due to these provisions and some delays in the switcher train, this study aims to minimize the conflicting route between the freight transport switcher train and switcher train at Arjawinangun station by engineering the operating train traffic and impacting the switcher train. It was coupled with the incident that occurred on May 13, 2022, where there was a delay in going to the official Locomotive for up to 38 min because they had to wait until the lane was safe. The route is considered safe if, within twenty minutes from the start of the switcher, there are no trains that will pass (Arjawinangun Station, PT KAI, Terminal Waiting Time table).

2 Methodology

The data needed in this study are primary data obtained by observation in the form of swivel movement time data. And secondary data obtained from institutional surveys from PT KAI, as well as Arjawinangun stations, namely the emplacement design data, supporting data for Train operation and management (GAPEKA) facilities in 2021, data on the formation of operational train routes, data on the formation of shunt routes, tracklist data, time data for trains passing by and passing times based on Terminal Waiting Time (WTT). The arrangement of train traffic at the Arjawinangun station is carried out based on the emplacement design as a reference for route analysis which is formed based on the available lines and money orders. Route analysis consists of formed routes based on lines and money orders, used routes based on routes traversed by train trips that pass directly or trains that stop to pick up and drop passengers, and conflicting routes consisting of self-correlation, convergent, divergent, and crossing. This route analyst will do a simple simulation using the Conflict Level Matrix Table. Furthermore, entering the number of trains in each route passed by the train will obtain the level of route loading against the frequency of train trips. Determine the level of efficiency. It is obtained by comparing the value of the conflicting route level and the level of route loading on the train journey.

According to Pachl Joern, 2002, it is stated that to calculate the level of conflicted routes if there are differences in the number of train frequencies that pass on each route formed, use the following formula $\eta_w = \Sigma\left(\mathrm{C_{ij}}\right).\mathrm{f_{ij}}$.

For explanation, ηw = conflict route loading, Cij = route state (conflict 1, otherwise conflict 0), and Fij = relative frequency of route combination i. Meanwhile, to calculate the relative frequency of the combination of routes i and j, the formula is as follows:

$$\mathrm{f_{ij}} = \mathrm{n_i}.\mathrm{n_j}/n^2$$

For explanation, ni = number of trains on route j, NJ = the number of trains on route I, and n = total number of trains. While the routes that it can form with the current emplacement layout design can be seen in Table 2, where each route has a different number of frequencies of use:

Table 2. Number of Train Frequency on Formed Routes

Route	Frequency of Use
A	3
B	63
C	51
D	13
E	3
F	3
Total	136

(Source: Awn Station Line List)

3 Switcher Process

The freight train for cement transportation with the Arjawinangun – Purwokerto connection consists of 3 (three) frequencies with the numbers KA 2734, 2736, and 2718 or 8008. Starting from KA 2735 (without passengers), which arrives at the Arjawinangun station, is entered on line I and removes the official Locomotive. Furthermore, the existing shunt/standby on line V moves to line I to carry out swiping activities on empty carriages stored on line 8. For the loading process, the empty carriages on line 8 will be shunted to line V and carry out the loading process on line V. Then, the service locomotive enters line I and proceeds to slither from line II to line V, and prepares for departure for the already filled circuit to the destination station. Another route that causes conflict besides the operational train is the route used for swarming. For the slash route, it can be seen in Table 3, the table of the list of slash movements carried out:

The method used is capacity research/study, which serves to calculate the number of trains that can be served in an emplacement system. From the existing operating pattern, 2 (two) scenarios of changing the operating pattern were carried out, including:

1. Operational Pattern 1 is a plan to change line I which is used for the stabling of cement train wagons, to line IV to make it easier for the loading process (no need to cross the highway). And the route that will be used for the follow-up of the train to Jakarta has been moved to line I.
2. Operational Pattern 2 is a plan to change line I, which is used for stabling empty carriages of cement transport trains, directly to line V (loading line), and add a line extension on line IV, which is used for stabling official locomotives, at least 35.2 meters long.

3.1 Path List of Operation Pattern

Calculation of the level of conflict routes that cross the existing emplacement design can be seen in Table 4.

From Table 4, it is obtained that the percentage value of the Conflict Level for Operational Trains with the existing emplacement design is 17%, where if the trains that

Table 3. List of Switcher Movements

Train Number	SF	Route Switcher	Switcher Time	Locomotive Name
2734	16	Route 1A, 1B	20.05–20.25	Switcher Locomotive
		Route 3B, 3C		Service Locomotive from 2735
2736	16	Route 1A, 1B	04.11–04.31	Switcher Locomotive
		Route 3B, 3C		Service Locomotive from 2735
2718	20	Route 1A, 1B	15.35–15.55	Switcher Locomotive
		Route 3B, 3D		Service Locomotive from Cn
8008	20	Route 1A, 1B	15.35–15.55	Switcher Locomotive
		Route 3B, 3D		Locomotive Cn
2733	16	Route 3A, 3B	02.46–03.06	Service Locomotive
		Route 2A, 2B, 2C, 2D		Switcher Locomotive
2735	16	Route 3A, 3B	14.21–14.41	Service Locomotive
		Route 2A, 2B, 2C, 2D		Switcher Locomotive
2718 Odd Date	20	Route 3A, 3B	22.45–23.05	Service Locomotive to Cn
		Route 2A, 2B, 2C, 2D		Switcher Locomotive
8007 Even Date	20	Route 3A, 3B	16.00–16.20	Service Locomotive to Cn
		Route 2A, 2B, 2C, 2D		Switcher Locomotive

(Source: Arjawinangun Station WTT Table)

Table 4. Operation Train Conflict Level Matrix

Rute		A	B	C	D	E	F	SUM
	KA	3	63	51	13	3	3	136
A	3		0,0102			0,0005	0,0005	0,0112
B	63	0,0102				0,0102	0,0107	0,0311
C	51				0,0358	0,0083	0,0083	0,0524
D	13			0,0358				0,0358
E	3	0,0005	0,0102	0,0083			0,0005	0,0195
F	3	0,0005	0,0107	0,0083		0,0005		0,0200
	136	0,0112	0,0311	0,0524	0,0358	0,0195	0,0200	0,1700

Table 5. Shunt Conflict Route Table

Name of Locomotive	Pattern	Frequency	Conflict
	1A	3	0.012
	1B	3	0.010
Route Switcher Locomotive	3A	3	0.010
	3B	3	0.001
	3C	2	0.007
	3D	1	0.001
Route Switcher Freight Locomotive	Route	Free	Konflik
Switcher for Parking Locomotive	2A	3	0.022
	2B	3	0.010
	2C	3	0
Route Switcher Freight Locomotive	**Route**	**Free**	**Konflik**
	2D	3	0
			0.065

(Source: Processing Results)

pass at the station are 136 frequencies, then 23 trains are found in conflict. Meanwhile, the conflict level matrix for the Switcher Locomotive can be seen in Table 5.

It can be seen from the Table 5 that the conflicted route on the shunt train is 6.5%. If it is assumed that the operating trains are 136 trains, then the number of trains that have an impact is 10 trains. And the accumulation of conflicting routes on the existing design is 23.5%, with the number of affected trains being 32 trains.

3.2 Traffic Changes with Scenario of the Pattern I Operation

The operating pattern of the scenario can be defined by planning to change line I, which is used for stabilizing the cement train wagons, to line IV, with consideration to make it easier for the loading process (no need to cross the highway). And the route that it will use for the follow-up of the train to Jakarta has been moved to the line I (Fig. 2).

Operational railway conflict level matrix table.

Based on Table 6, the processing results, the percentage value is 24.5%, or if it is assumed that as many as 136 trains pass, there will be 33 trains affected by conflicting routes. As for the conflict level matrix for Switcher Locomotive, it can be seen in Table 7.

Based on the processing results, the percentage value is 1.9% or assuming that 136 trains pass, there will be 3 trains affected by conflicting routes. In operation pattern scenario I, the percentage value of the conflicting route is 24.4% for operating trains and 1.9% for passing trains, resulting in an accumulation of conflicted routes of 26.4%. If it is assumed that 136 trains pass in one day, then the conflicted route will occur in 36 trains.

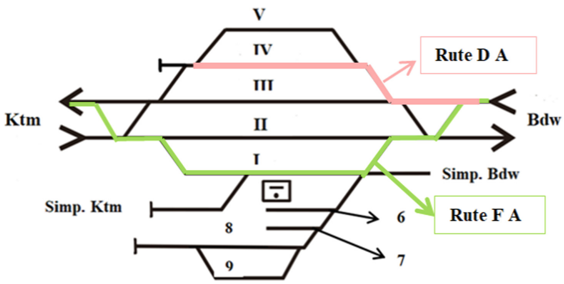

Fig. 2. Route Pattern 1 Operation (Source: Data Processing)

Table 6. Matrix Operational Conflict Route of Pattern 1

Rute		A	B	C	D	E	F A	SUM
	KA	3	63	51	3	3	13	136
A	3		0,010			0,00049	0,00211	0,0128
B	63	0,010				0,0102	0,0443	0,0647
C	51				0,0083	0,0083	0,0358	0,0524
D	3			0,0083		0,0005		0,0088
E	3	0,0005	0,0102	0,0083	0,0005		0,0021	0,0216
F A	13	0,002109	0,0443	0,0358		0,0021		0,0843
	136	0,0128	0,0647	0,0524	0,0088	0,0216	0,0843	0,2446

(Source: Processing Results)

Table 7. Matrix of Levels of Conflict Switcher Locomotive of Pattern 1

Route Switcher Freight Locomotive	Pattern	Frequency	
	1C	3	0.0005
	1D	3	0.011
	1E	3	0.001
Route Switcher Locomotive	3E	2	0.006
	3F	2	0.002
	3D	1	0.000
Switcher for Parking Locomotive	N/A		
			0.019

(Source: Processing Results)

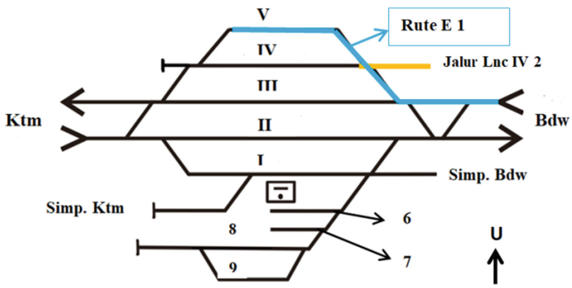

Fig. 3. Route Pattern 2 Operation (Source: Processing Results)

Table 8. Conflicting Route Operation of Pattern 2

Rute		**A**	**B**	**C**	**D**	**E**	**E 1**	**SUM**
	KA	3	63	51	13	3	3	136
A	3		0,0102			0,0005		0,0107
B	63	0,0102				0,0102		0,0204
C	51				0,0358	0,0083	0,0083	0,0524
D	13			0,0358		0,0021	0,0021	0,0401
E	3	0,0005	0,0102	0,0083	0,0021		0,0005	0,0216
E A	3			0,0083	0,0021	0,0005		0,0109
	136	0,0107	0,0204	0,0524	0,0401	0,0216	0,0109	0,1560

(Source: Processing Results)

3.3 Traffic Changes with Scenario of the Pattern II Operation

The scenario plan for Operation Pattern II is to change line I, which is used for empty stabling carriages of cement transport trains, directly to line V (load line) and add an extension to line IV, which is used for stabling official locomotives, at least 35.2 m long (Fig. 3).

3.4 Operational Railway Conflict Level Matrix Table

From Table 8, the percentage value of the Operational Train level is 15.6%, or it can be interpreted that if it is assumed that 136 trains pass, then there will be 21 trains affected by the conflicting route.

As for the conflict level matrix for switcher Locomotive, it can be seen in Table 9.

Based on the processing results, the percentage value of the conflicted route level on the stranded train is 1.5%, or if it is assumed that 136 trains pass, then there will be two trains affected by the conflicting route. In the operating pattern II scenario, the conflicting route's percentage value is 15.6% for operating trains and 1.5% for shunt trains, resulting in an accumulation of conflicted routes of 17.1%. Assuming as many as 136 trains pass in one day, the conflicted route will occur in 23 trains.

Table 9. Route Conflicting Alignment of Pattern 2

Route Switcher Freight Locomotive	Pattern	Frequency	Conflict
	3G	3	0.003
	3H	3	0.003
Route Switcher Service Locomotive	3I	3	0.002
	3D	1	0.006
Total			0.015

(Source: Processing Results)

Table 10. Comparison of the Conflicting Routes Percentage

Operation Pattern	Conflict Route	
	Train Operation	Shunt
Existing Operation Pattern • Arrival line of carriages on line I • Carriage parking lane on line 8 • Carriage loading lines on the V line	17%	6,5%
Operation Pattern 1 • The carriage parking line has changed from line I to line IV • The track for follow-up changed from the original path IV to track I	24,4%	1,9%
Operation Pattern II • The carriage parking line changed from line I to line V • Added a save line to line IV	15,6%	1,5%

4 Conclusion

From the results of the above calculations, each application of operations, both from existing conditions and scenarios of changes in operating patterns I and II, produces a different percentage value of conflicting routes. The smaller the value of the conflict level, the smaller the conflicting operation train. Changes in the percentage value of the conflicted route level from the three operating patterns can be seen in Table 10.

It can be concluded by comparing the three engineering operations that provide a minimum value for the level of conflicted routes by applying the scenario of the pattern of operation II with the level of conflict on the operating train being 15.6% and the conflict rate on the switcher train being 1.5%. If 136 trains are operating and crossing the Arjawinangun station in a day, then there are 23 trains affected by the conflicting route. This is because inserting empty wagons directly into the loading line can reduce the need for shunts and reduce shunt activities that intersect on the highway. For the construction of a station in which there are services for passenger transportation and goods transportation, including the location of loading/unloading goods, it is better if the supporting facilities are built on the same side as the line used for loading to reduce the potential for sliding for loading/unloading activities. The shunt movement that does not go through the route used for passing railway services reduces the percentage of conflicting route values between shunt activities and passing train services. In addition, the track used for shunts is designed not to directly intersect with the track used by operating trains to reduce the potential for shunt delays or is referred to as an isolation track.

Suggestion

For the construction of a station that is focused on the location of loading/unloading goods, it is better if the supporting facilities are built on the same side as the path used for loading to reduce the potential for sliding for loading/unloading goods. The shunt movement that does not go through the route used for passing railway services reduces the percentage of conflicting route values between shunt activities and passing train services. In addition, the path used for shunts is designed not to directly intersect with the path used by the operating train that passes to reduce the potential for shunt delays or is referred to as an isolation path.

Bibliography

Arikunto. 2006. *Prosedur Penelitian: Suatu Pendekatan Praktek*. Jakarta: PT. Rineka Cipta.

Departemen Pendidikan Nasional. 2008. *Kamus Indonesia.* Jakarta: Pusat Bahasa Departemen Pendidikan Nasional.

Hanif, M., Hary Moetriono, and Sri Wiwoho Mudjanarko. 2020a. "Analisis Route Operasi Kereta Api Di Stasiun Surabaya Gubeng." 6:1–15.

Menteri Perhubungan. 2017. *Peraturan Menteri No. 121 Tentang Lalu Lintas Kereta Api*. Jakarta: Kementerian Perhubungan.

Pachl, Joern. 2009. *Railway Operation and Control*. Second Ed. Braunschweig: VTD Rail Publishing.

PT. Kereta Api Indonesia. 2011. *Peraturan Dinas 19 JILID I Tentang Perjalanan Kereta Api Dan Urusan Langsir*. Bandung: PT Kereta Api Indonesia (PERSERO).

PT Kereta Api Indonesia Daop III. 2020b. *Peraturan Dinas Pengamanan Setempat Stasiun Arjawinangun.Pdf*. Cirebon: PT Kereta Api Indonesia (PERSERO) DAOP III Cirebon.

Setiawan, Dian, Imam Muthohar, and Djoko Murwono. 2015. "Analisis Conflict Rate Pada Perhitungan Kapasitas Sistem Interlocking Yang Mempengaruhi Penyusunan Formulasi Kapasitas Stasiun." *The 18th FSTPT International Symposium, Universitas Lampung* (July 2017):27–30.

Setiawan M, Dian, Rahardhita Luthfiana Devi P, and Sri Atmaja P Rosyidi. 2018. "Pengaturan Lalulintas Kereta Api Di Stasiun Cicalengka Untuk Mendukung Pengoperasian Jalur Ganda Kereta Api Bandung-Cibatu." *Semesta Teknika* 21(1). https://doi.org/10.18196/st.211205.

Utomo, Suryo Hapsoro Tri. 2009. *Jalan Rel*. Yogyakarta: Beta Offset Yogyakarta.