Operational erformance of armoni Transfer oint of the akarta us Rapid Transit Service

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Abstract

The Jakarta Bus Rapid Transit (BRT) service has been in operation in seven lines. The busiest transfer point is the Harmoni stop connecting line 1, line 2 and line 3. To anticipate high activities of both buses and passengers, this stop has a uni ue design compare to the other stops. However the stop has not been well-managed. There is no system to ensure that boarding passengers are in ueue. In order to be able to propose better design of the stop, in this paper the operational performance the stop is evaluated. An observation is made on the Harmoni stop at the normal working from 6.30 to 20.00. The following operational performances are observed, i.e. time headway between buses on each line, stopping duration, number of boarding passengers and number of ueuing passengers. These can be used for designing suitable ueuing system and for optimizing the lay out of Harmoni stop.

1. Introduction

The Jakarta Bus Rapid Transit (BRT) service has been in operation in seven lines for several years. So far, The busiest transfer point is the Harmoni stop (Figure 1). This stop is connecting:

- Line 1 (a North-South line between Blok M and Kota)
- Line 2 (a central-East line between Harmoni and Pulo Gadung)
- Line 3 (a West-central line between Kalideres-Pasar Baru).

To anticipate high activities of both buses and passengers, this stop has a unique design compare to the other stops in the system, e.g. the existence of bus passing lane, sufficiently large boarding and alighting area, etc. However the stop has not been well-managed. There is no system to ensure that boarding passengers are in queue. Only limited signboards are available to direct passengers to their intended boarding area or to the exit gate. In order to be able to propose better design of the stop, in this paper the operational performance the stop is evaluated. Especially considering very limited academic papers has been produced regarding this particular topics in Indonesia. Papers regarding the Jakarta BRT usually discussing the improvement of the busway erformance, for example in [1] or other topics such as mode shift due to the introduction of the BRT in [2].

2. Methodology

An observation was made on the Harmoni stop at the normal working day (Tuesday) from 6.30 to 20.00 p.m. Altogether there were 1900 cases (buses) observed. The following operational performances are observed, i.e.:

- stopping duration (seconds)
- number of boarding passengers
- number of remaining passengers in the queue after boarding

Observation was intended to be grouped hourly, but due to several problems during the observation the resulting time periods were:

- 06.30 to 07.30
- 07.30 to 08.30
- 08.30 to 09.30
- 09.30 to 10.30
-
- 11.30 to 12.30
- 12.30 to 13.30
- 13.30 to 14.30
- 14.30 to 15.30
-
- 17.00 to 18.00
- 18.00 to 19.00
- 19.00 to 20.00

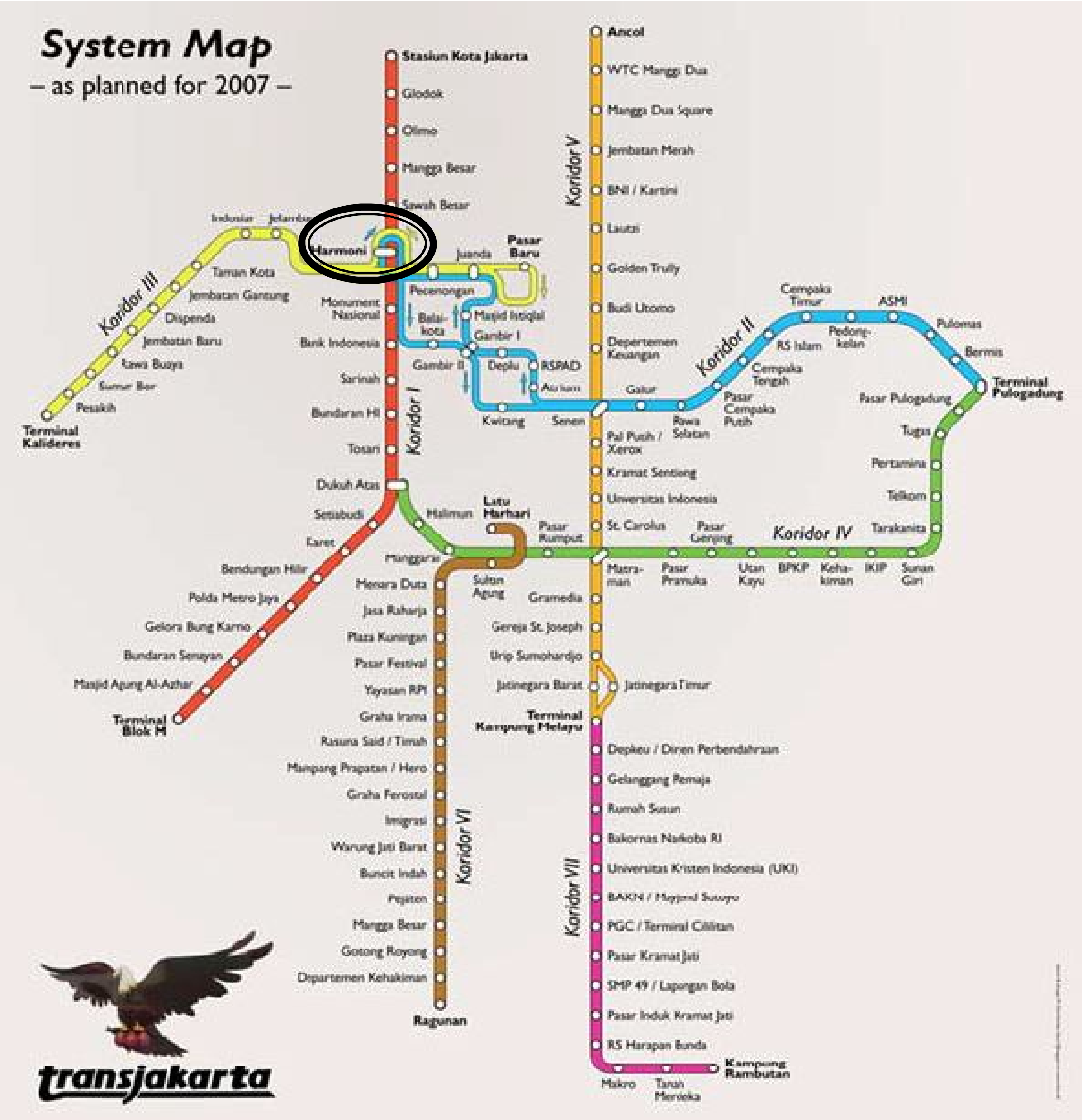

Figure 1. The Jakarta BRT Lines 1 to 7

However such difference was assumed not to affect the analysis significantly since all analysis including the t-test was based on the mean values of each observed characteristics. Besides the three directly observed characteristics as mentioned before, the following characteristics can be calculated:

- mean headway (number of bus divided by length of time period)
- boarding rate (number of boarding passengers divided by stopping duration)
- percentage of remaining passengers in the queue after boarding (number of remaining passengers in the queue after boarding divided by total number of queuing passengers times 100%)

Observation was made in 5 boarding (and/or alighting) gates (Figure 2) as follows:

- A: boarding gate for buses to Pasar Baru (and alighting gate for buses from Kota and Kalideres)
- B: boarding gate for buses to Blok M
- C: boarding gate for buses to Pulogadung
- E: boarding gate for buses to Kalideres
- F: boarding gate for buses to Kota

Other gates were not observed, i.e. D (North exit), G (alighting gate for buses from Blok M and Pulogadung), H (ticket box) and I (South entrance and exit). Since this research is concentrating in the effects of boarding queue in the operation of the Harmoni transfer point, alighting movement was ignored although to some degree affect the characteristics of the boarding movement especially in the stopping duration in the mixed gate (gate A).

A group of observers was assigned to work for four to four and a half hours. Each group consisted of six to seven observers. In each observed gates (A, B, C, E and F), one observer was assigned. The remaining observers replace the assigned observers for toilet breaks or other breaks. In the case for extreme number of queuing passengers only approximation counting could be made.

Several analysis was carried out, i.e.:

- descriptive analysis of observed variables (mean and maximum values)
- t-test of mean difference of observed variables (by destination and by group of time periods)

3. Descriptive Statistics

Pasar Baru boarding gate was the less busy gate because trip to Pasar Baru is only 3 stops away. The second less busy gate was Kota boarding gate for similar reason (it is only 5 stops away from Kota). It seems that the highest number of boarding passengers was in the afternoon peak hour especially for gates serving to residential area destinations in the South (Blok M) and in the West (Kalideres).

Serious queuing problems arose at Kalideres and Blok M gates both in terms of mean and maximum number of remaining passengers in the queue after boarding. In Kalideres gate during the peak queue between 18.00 and 19.00 the mean and maximum number of remaining passengers in the queue after boarding was about 200 and 600 respectively (Figure 3).

Figure 4 shows mean percentage of remaining passengers in the queue after boarding. It can be seen that in most cases at least more than 40% of the queue can not be carried by the recently coming buses. This indicates limited carrying capacity of buses operating in these three lines.

In general the mean stopping duration was about 40 to 60 seconds. From separate analysis, stopping duration correlates with number of boarding passengers ($r=0.713$ significant at $\alpha=0.01$). This shows that although the boarding staff to some extent control the stopping duration, a demand driven stopping duration might also applied. Very long stopping duration as high as 250 seconds occured.

In general the boarding rate was about 1 to 2 passengers/ second. However in an extremely peak condition an incredible boarding rate as high as 14 passengers/ second can happened presumably carried out in forced platoon manner.

The mean headway was between 2 and 3 minutes. It seems to be a satisfactory headway for public transport. However in many cases more than one bus going for same destination approached the boarding gate, resulting in a very short headway with a large idle carrying capacity.

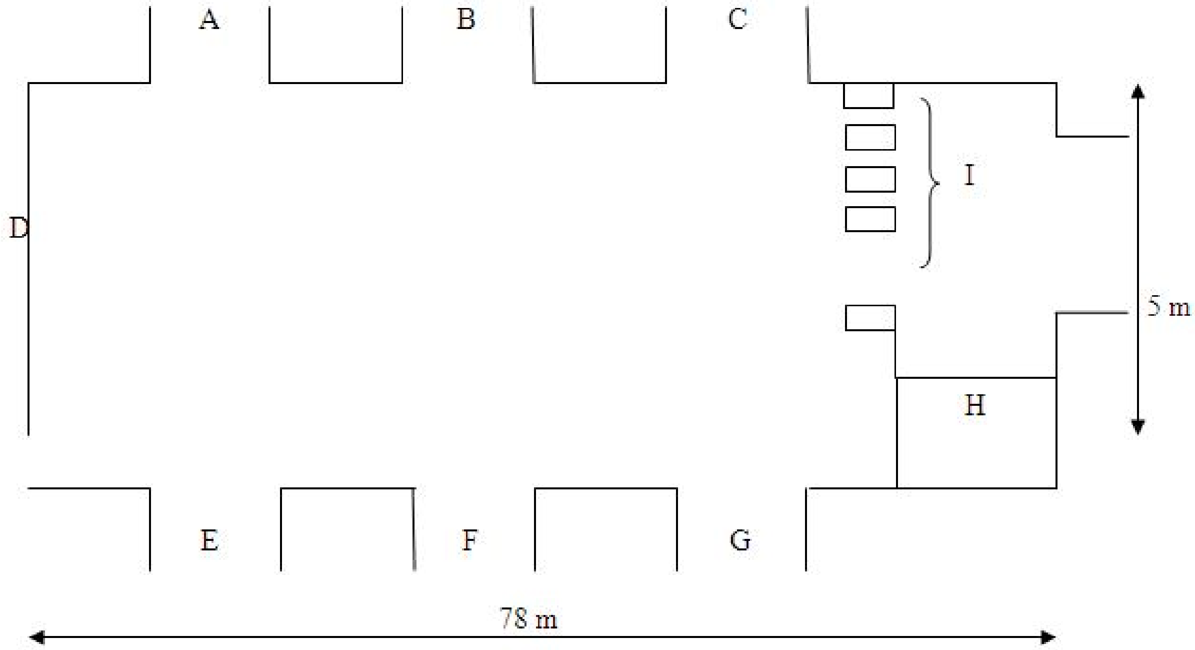

Figure 2. Gates in the Harmoni Transfer Point

Figure 3. Passengers Queuing for Buses to Kalideres in the Afternoon Peak Period

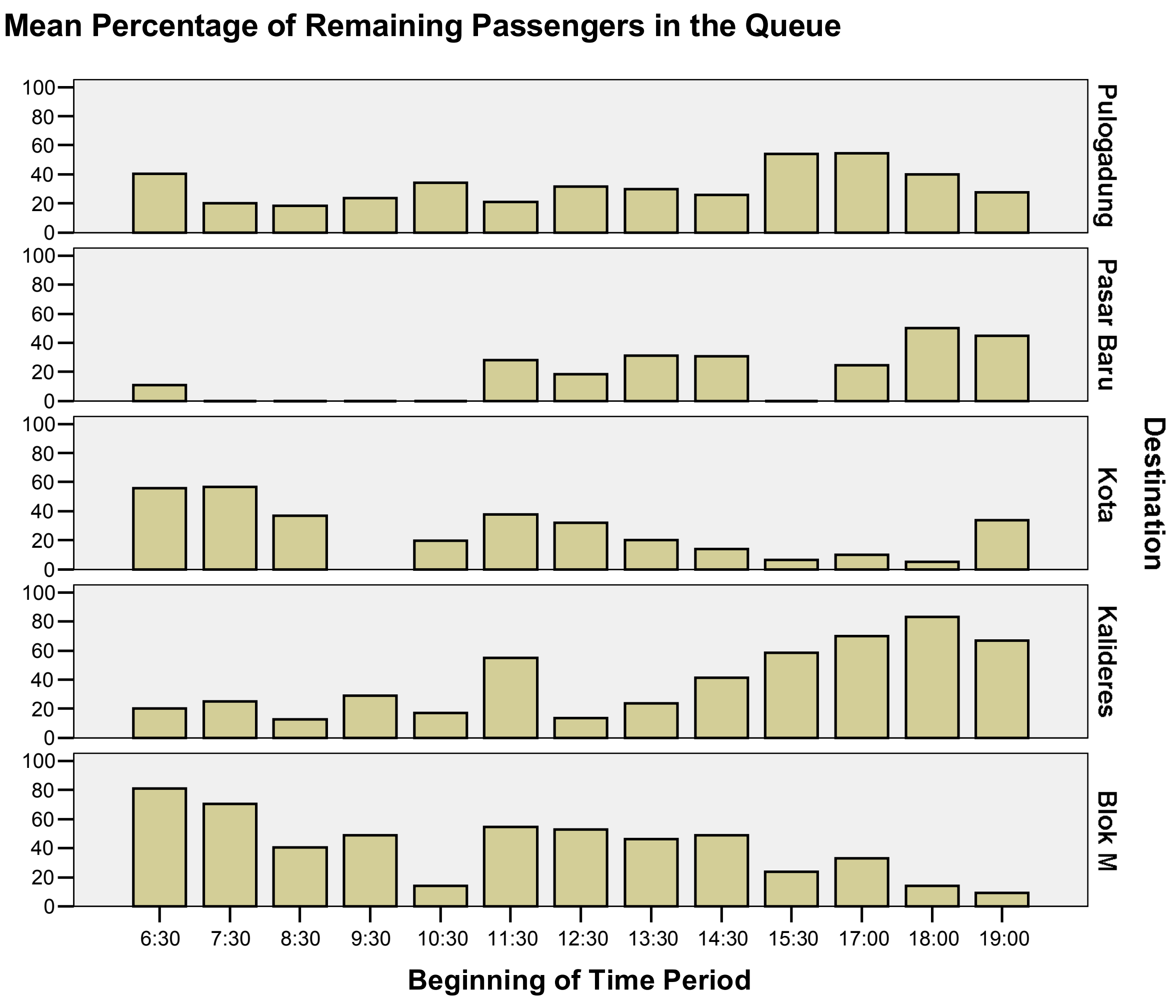

Figure 4. Mean Percentage of Remaining Passengers in the Queue after Boarding

4. T-Test of Mean Difference of Observed ariables

Large mean of number of boarding passengers was found in gates with relatively longer distance to the final destination such as Blok M, Kalideres and Pulogadung. All of the mean difference of number of boarding passengers from pairs of gates was significant at α=0.05, meaning that in terms of mean of number of boarding passengers the characteristics of each gate was different.

Large mean of number of remaining passengers in the queue was found in gates with relatively longer distance to the final destination such as Blok M, Kalideres and Pulogadung. All of the mean difference of number of boarding passengers from pairs of gates was significant at α=0.05, meaning that in terms of mean of number of remaining passengers in the queue the characteristics of each gate was different.

Large mean of percentage of remaining passengers in the queue was found in gates with relatively longer distance to the final destination such as Blok M, Kalideres and Pulogadung. All of the mean difference of percentage of boarding passengers from pairs of gates was significant at α=0.05, meaning that in terms of mean of percentage of remaining passengers in the queue the characteristics of each gate was different.

Except for the mean difference of stopping duration between Kalideres gate and Pulogadung gate, all of the mean difference of stopping duration from pairs of gates was significant at α=0.05, meaning that in terms of mean of stopping duration the characteristics of each gate was in general different.

Some pairs of boarding rates was not significant at α=0.05, meaning that in terms of mean of boarding rate the characteristics of each gate in general was not different. However Blok M gate was having the highest rate, whilst Pasar Baru was having the lowest rate. The last was due to the limited number of boarding passengers. Meanwhile, the boarding rates in Kalideres, Kota anda Pulogadung gates were not significantly different, i.e. about 0.8 to 0.9 passengers/ second.

Except for the mean headway between Kalideres gate and Pasar Baru gate, all of the mean difference of headway from pairs of gates was significant at α=0.05, meaning that in terms of mean of headway the characteristics of each gate was in general different.

Table 1 shows the mean difference of number of boarding passengers by groups of time periods. It can be seen that in all pairs of observation period, mean number of boarding passengers were significantly different at α<0.001. Afternoon period might be attributed as peak period in terms of number of boarding passengers, whilst noon period might be attributed as off-peak period in terms of number of boarding passengers.

Table 2 shows the mean difference of number of remaining passengers in the queue by groups of time periods. It can be seen that in terms of number of remaining passengers in the queue the morning and afternoon periods were similarly quite high, whilst in the noon period the remaining passengers in the queue was relatively low. However in terms of percentage of remaining passengers in the queue, in general there was no difference between groups of time periods (Table 3).

Table 4 shows the mean difference of stopping duration by groups of time periods. It can be seen that in all pairs of observation period, mean stopping duration were significantly different at α=0.05. Confirming the hypothesis that the stopping duration was affected by demand it can be seen that in the afternoon period which was peak period in terms of number of boarding passengers the stopping duration was the longest, whilst in the noon period which was off-peak period in terms of number of boarding passengers, the stopping duration was the shortest.

Table 5 shows that boarding rate was not significantly different between morning and afternoon peak periods. However in noon period which the number of boarding passengers was relatively low the boarding rate was significantly low compare to the morning and afternoon peak periods.

Table 6 shows that mean headway was significantly different between morning, noon and afternoon periods. The headway became longest in the afternoon period presumably because of the extreme congestion which affect the performance of the BRT due to non-exclusive right of way in the junction, whilst shortest headway was found in the noon off-peak period.

Table 17. Mean Difference of Number of Boarding Passengers by Groups of Time Periods

Observation Period	Number of Boarding Passengers	Mean Difference with Number of Boarding Pasengers from Observation Period	
		Noon	Afternoon
Morning	30	7 (<0.001)	-7 (<0.001)
Noon	23	-	-14 (<0.001)
Afternoon	37	-	-

Table 2. Mean Difference of Number Remaining Passengers by Groups of Time Periods

Observation Period	Number of Remaining Passengers in the Queue	Mean Difference with Number of Remaining Pasengers in the Queue from Observation Period	
		Noon	Afternoon
Morning	46	22 (<0.001)	1 (0.856)
Noon	24	-	-21 (<0.001)
Afternoon	45	-	-

Table 3. Mean Difference of Percentage Remaining Passengers by Groups of Time Periods

Observation Period	Percentage of Remaining Passengers in the Queue	Mean Difference with Percentage of Remaining Pasengers in the Queue from Observation Period	
		Noon	Afternoon
Morning	37	4 (0.012)	4 (0.061)
Noon	33	-	0 (0.657)
Afternoon	33	-	-

Table 4. Mean Difference of Number Stopping Duration by Groups of Time Periods

Observation Period	Stopping Duration	Mean Difference with Stopping Duration from Observation Period	
		Noon	Afternoon
Morning	40	3 (0.021)	-4 (0.002)
Noon	37	-	-7 (<0.001)
Afternoon	44	-	-

Table 5. Mean Difference of Number Boarding Rate by Groups of Time Periods

Observation Period	Number of Boarding Rate	Mean Difference with Number of Boarding Rate from Observation Period	
		Noon	Afternoon
Morning	0.9	0.2 (<0.001)	-0.1 (0.196)
Noon	0.7	-	-0.3 (<0.001)
Afternoon	1.0	-	-

Table 6. Mean Difference of Headway (Minutes) by Groups of Time Periods

Observation Period	Headway	Mean Difference with Headway from Observation Period	
		Noon	Afternoon
Morning	2.0	0.2 (<0.001)	-0.5 (<0.001)
Noon	1.8	-	-0.7 (<0.001)
Afternoon	2.5	-	-

5. Conlusions and Reccomendations

From the analysis in this paper, several conclusions can be made as follows:

- The highest number of boarding passengers was in the afternoon peak hour especially for gates serving to residential area destinations.
- There were serious queuing problems arose at Kalideres and Blok M gates both in terms of mean and maximum number of remaining passengers in the queue after boarding.
- In most cases at least more than 40% of the queue can not be carried by the recently coming buses. This indicates limited carrying capacity of buses operating in the lines.
- Stopping duration correlates significantly with number of boarding passengers.
- In general the boarding rate was about 1 to 2 passengers/ second.

- The mean headway was between 2 and 3 minutes. However in many cases more than one bus going for same destination approached the boarding gate, resulting in a very short headway with a large idle carrying capacity.
- Large mean of number of boarding passengers and number/ percentage of remaining passengers in the queue was found in gates with relatively longer distance to the final destination such as Blok M, Kalideres and Pulogadung.
- In terms of mean of stopping duration the characteristics of each gate was in general different.
- In terms of mean of boarding rate the characteristics of each gate in general was not different.
- In terms of mean of headway the characteristics of each gate was in general different.
- Afternoon period might be attributed as peak period in terms of number of boarding passengers, whilst noon period might be attributed as off-peak period in terms of number of boarding passengers.
- In terms of number of remaining passengers in the queue the morning and afternoon periods were similarly quite high, whilst in the noon period the remaining passengers in the queue was relatively low. However in terms of percentage of remaining passengers in the queue, in general there was no difference between groups of time periods.
- In the afternoon period which was peak period in terms of number of boarding passengers the stopping duration was the longest, whilst in the noon period which was off-peak period in terms of number of boarding passengers, the stopping duration was the shortest.
- Boarding rate was not significantly different between morning and afternoon peak periods. However in noon period which the number of boarding passengers was relatively low the boarding rate was significantly low compare to the morning and afternoon peak periods.
- Mean headway was significantly different between morning, noon and afternoon periods. The headway became longest in the afternoon period presumably because of the extreme congestion which affect the performance of the BRT due to non-exclusive right of way in the junction, whilst shortest headway was found in the noon off-peak period.

Based on the conclusions, several recommendations can be suggested as follows:

- The dimension and the lay out of the Harmoni transfer point should be adjusted to accommodate long queue in the peak hours. There are space for extention to the North. Busier gates should get more space for the queue.
- Queuing system should be established to ensure comfort and safety of the passengers.
- Passengers transferring between line 2 and line 3 should be informed that they can also make transfer in Pecenongan and Juanda stations.
- Since consistent headway will help to control the queue, every operational effort that can improve the reliability of the bus schedule should be carried out.

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R F R C S

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