A TIMETABLE FOR MUGHALSARAI-GHAZIABAD: WITH ALLOWANCES REDUCED and REDISTRIBUTED

Addendum to report submitted on 21st July, 2017 to RITES Ltd by Prof. Narayan Rangaraj, IEOR, IIT Bombay. Report date: 1st August, 2017

In the previous report (i.e. the one dated 21st July, 2017), we had noted the difference between the two working timetables of 2015 and 2016. These differences are mainly in the distribution of allowance values. This uneven distribution in two consecutive years naturally leads one to question whether the WTT 2016 is too conservative in terms of extent of allowance and the distribution needs more careful planning. Therefore we re-timetable for the entire Mughalsarai-Ghaziabad section with a certain redistribution of allowances and assess the new timetable in terms of quality and/or quantity of the acceptable freight paths.

In this regard, we assume the following:-

- We have taken the departure time of all passenger trains to be the same as mentioned in WTT-2016. This means that the time any train is being introduced into the section remains same as in WTT 2016.
- All the parameters of the passenger trains-such as acceleration, deceleration, length and maximum speed-have been kept the same.
- The number of stops of each passenger train and the halt duration at each station has been kept the same.
- Instead of the allowance distribution in WTT 2016, we have considered all the times required for ER to be between two pairs of stations in each of the major sections. We have delayed all the trains passing between such stations by a specific time which is mentioned in the table below:-

	Up Section	**Block Section**	**ER**	**Dn Section**	**Block Section**	**ER**
1	MGS-ALD	PRE-JHG MNF-UND	5 min 4 min	ALD-MGS	UND-MNF PRE-JHG	4 min 5 min
2	ALD-CNB	ASCE-KUW KSQ-BKO	6 min 6 min	CNB-ALD	BKO-KSQ KUW-ASCE	6 min 6 min
3	CNB-TDL	KNS-PHD SB-JGR	6 min 6 min	TDL-CNB	JGR-SB PHD-KNS	6 min 6 min
4	TDL-GZB	SNS-MXK CHL-WAIR	6 min 6 min	GZB-TDL	WAIR-CHL MXK-SNS	6 min 6 min

Table 1: Distribution of ER time in different major sections

With this modifications, we first schedule/simulate the passenger trains. After passenger trains are scheduled, we simulate the paths of freight trains from Mughalsarai - Ghaziabad.

FREIGHT PATHS WITHOUT MAINTENANCE BLOCK

In this section we simulate the freight trains and analyze the suitability of the paths along with the passenger trains. The schedule of these passenger trains is different from WTT 2016 as allowance times have been redistributed.

For running freight trains from Mughalsarai to Ghaziabad we have taken the following compulsory detention times for freight trains:

Allahabad: 25 minutes
Juhi-GMC: 55 minutes
Tundla: 30 minutes

The characteristics of the freight trains considered are as follows:-

Length: 680 m
Acceleration: 0.047 m/s^2
Deceleration: 0.06 m/s^2
Maximum Speed: 75 kmph

We first evaluate the 32 freight paths that are listed in WTT 2016. Below we provide a plot of the average speed of each train in kmph v/s their firing times from Mughalsarai.

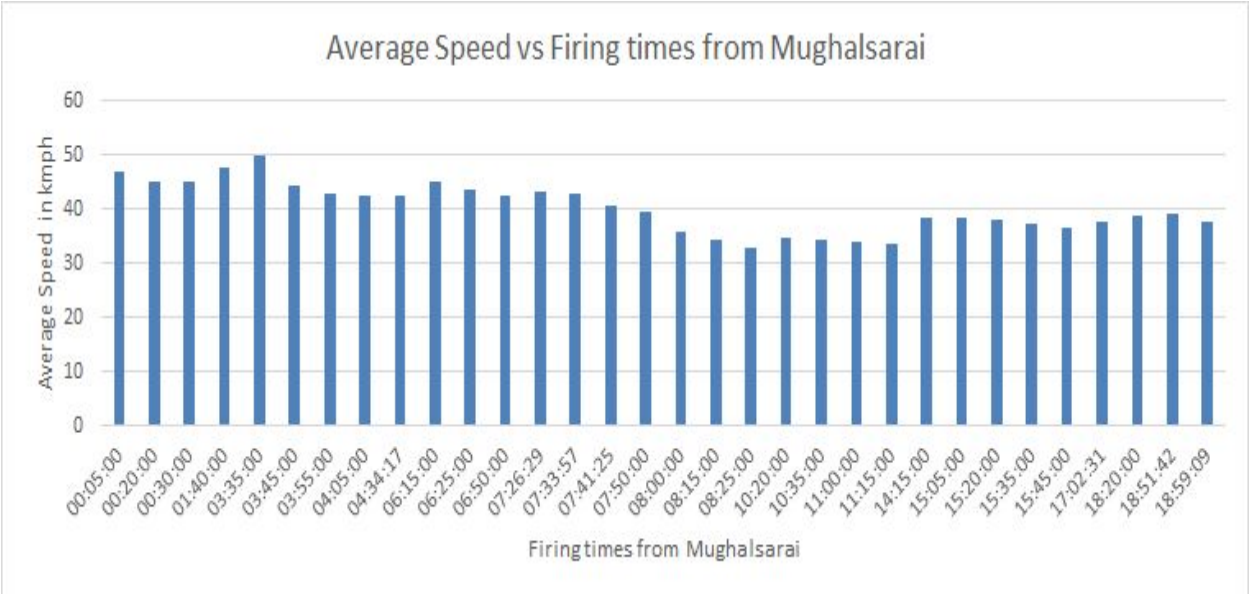

Fig 1: Average Speed in kmph vs Firing times from Mughalsarai

We now add 8 more paths to those above and plot the Average speed vs Firing times curve. This is displayed below:-

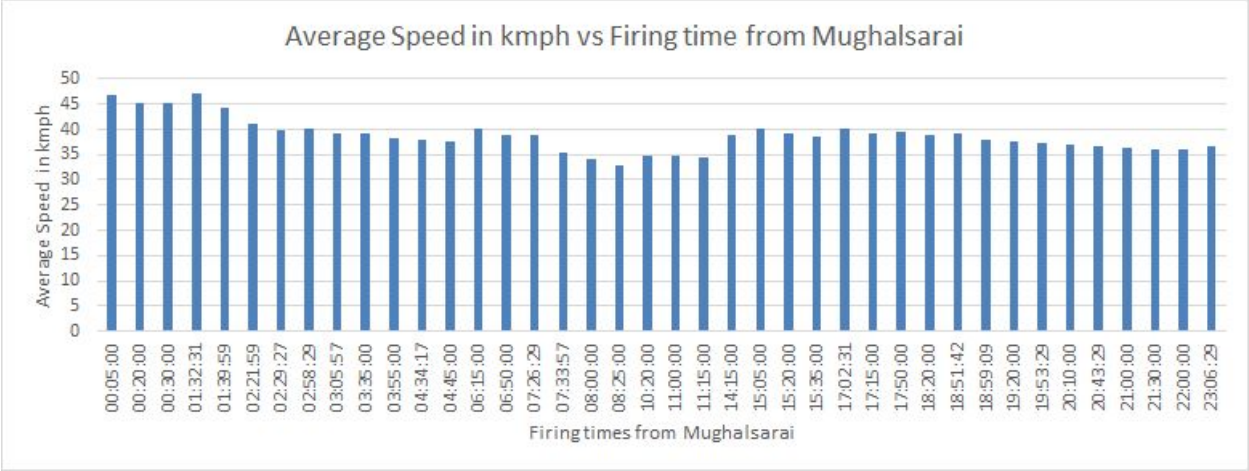

Fig 2: Average Speed in kmph for 40 freight trains vs Firing times from Mughalsarai

We now provide a comparison of the quality of these freight paths in the two situations- one when the passenger trains are running in accordance WTT 2016 and another in the new proposed timetable.

S.No	Number of freight paths	Average Speed in kmph (WTT 2016)	Average Speed in kmph in proposed timetable
1	32	37.56	40.24
2	40	37.16	38.77

Table 2: Comparison of freight paths in WTT 2016 and proposed timetable

In the above table that characteristics for freight trains running according to WTT 2016 are as follows:-

Length: 680 m
Acceleration: 0.047 m/s^2
Deceleration: 0.06 m/s^2
Maximum Speed: 50 kmph

We note that the average speed of 40 trains in the new timetable with modified characteristics is higher than that of 32 freight paths in the old timetable

We now modify the characteristics of the freight trains and schedule them along with passenger trains which are running according to the present schedule. We compare the average speeds between them in the following table

Number of freight paths	**Maximum Speed in kmph**	**Average speed in kmph in existing timetable**	**Average Speed in kmph in suggested timetable with redistributed allowances**
32	75	43.27	40.24
40	75	40.68	38.77

Table 3: Comparison of freight train performance if max speed is increased

INFERENCES DRAWN FROM THE ABOVE EXPERIMENTS

From the above table we note that average speeds of freight trains are more in the present timetable after an increase in the maximum speed of the freight trains. The increase in the maximum speed of the freight trains has two effects:

- the average speed increases and
- the speed differential with passenger trains reduces and there are more good quality paths available.

There is an overall improvement in the average speed of the freight trains on the section.

From Tables 2 and 3 we conclude that although passenger train re-timetabling may improve the freight train performance, the improvement is not very significant. On the other hand, if the present freight trains are allowed maximum speed of 75 kmph in place of 50 kmph, the quality of the freight paths will be much better. Needless to say, both these initiatives can be attempted simultaneously and independently and each of these initiatives should be done to improve the overall running.

FREIGHT PATHS WITH MAINTENANCE BLOCK

After getting the passenger train timetable, we identify gaps in the passenger train timetable, because in these gaps we can schedule maintenance activities. The maintenance blocks that we have used for the up direction are mentioned in the following table:

Sections	Start time	End time	Duration
Mughalsarai-Allahabad	12:30	14:30	2 hours
Allahabad-Kanpur	13:30	15:30	2 hours
Kanpur-Tundla	10:45	12:15	1 hour 30 minutes

Tundla-Khurja Jn	12:30	14:00	1 hour 30 minutes
Khurja Jn-Ghaziabad	13:10	14:40	1 hour 30 minutes

Table 4: Maintenance blocks considered

These are clear time windows and if required, there are other slots available in the timetable, after passenger trains are run.

After introducing the maintenance blocks on each section, we run the same 32 and 40 freight paths as in the previous section. We present the plots of average speed vs firing times for these two cases below:-

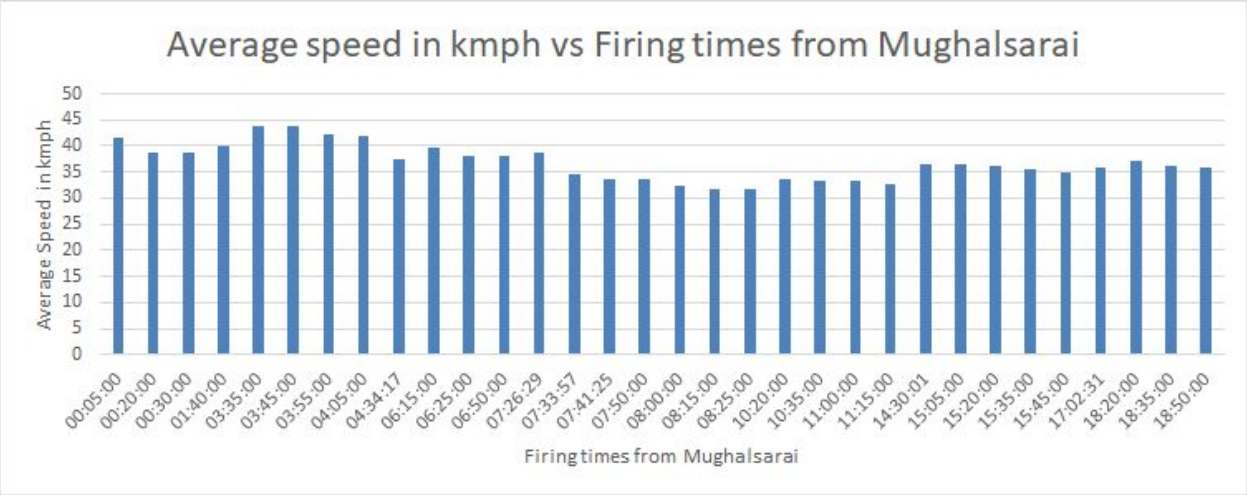

Fig 3: Average Speed of 32 freight trains in kmph vs Firing times from Mughalsarai after adding maintenance blocks

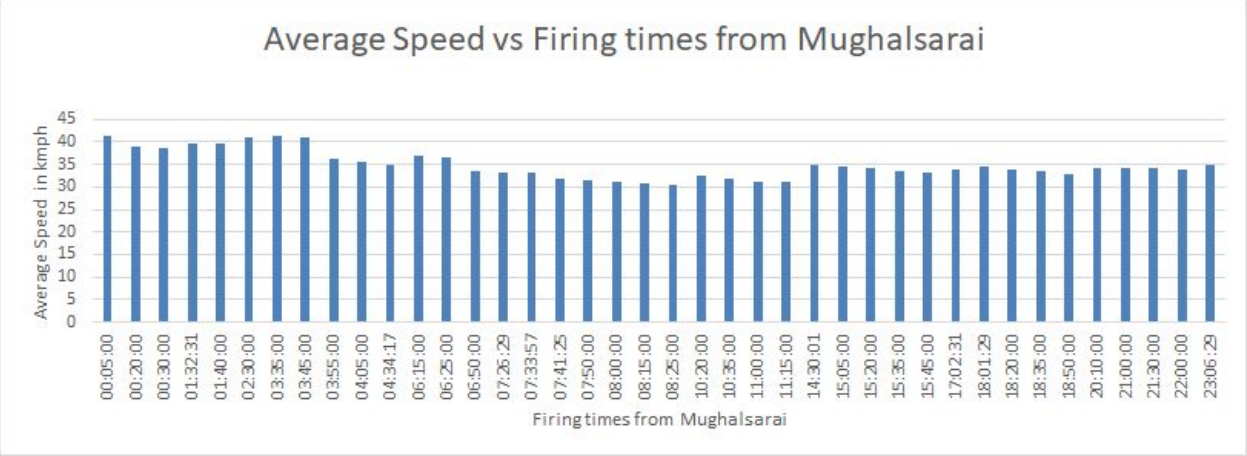

Fig 4: Average Speed of 40 freight trains in kmph vs Firing times from Mughalsarai after adding maintenance blocks

In order to show the effect of maintenance blocks we compare the average speed of 32 and 40 freight trains before and after addition of maintenance blocks.

Serial no.	Number of freight trains	Average speed before addition of maintenance blocks (kmph)	Average speed after addition of maintenance blocks (kmph)
1	32	40.24	36.78
2	40	38.77	34.88

Table 5: Comparison of average speeds before and after addition of maintenance blocks

The new freight paths in addition to those suggested in WTT 2016 are as follows:-

Firing time from Mughalsarai	Average Speed in kmph
01:32:00	39.62
02:30:00	40.91
18:01:00	34.59
20:10:00	34.14
21:00:00	34.32
21:30:00	34.31
22:00:00	33.99
23:06:00	34.91

Table 6: Average speed of trains with new firing times