RAILWAY PROJECT

Train Traffic Study

23.10.2017

INDEX

1 INTRODUCTION

In the study is described a functionality of the track network specified in the Railway Project. The objective of the study is to show that there is a sufficient track capacity for all the estimated trains to operate on the route from Montevideo to Paso de Los Toros.

The main results of the study are:
- a scheduled standard timetable for the estimated train volume
- a capacity utilization rate at the track sections
- a traffic simulation and travel times
- conclusions

2 ESTIMATED TRAIN VOLUMES

Estimated train volumes used in the study are shown in the table 1. The freight trains in the study are categorized in three categories. The categories are used in timetable planning for the capacity priorization. The capacity is reserved the first for the higher priority trains and the lower priority trains use time slots which are available after that.

The estimated freight train volume from Montevideo to Mill Site/Paso de Los Toros is based on the requirement of 4 Mton cargo transportation a year. The 4 Mton cargo can be transported with 18+18 freight trains loaded in 650 net ton and operated in 350 days a year. The maximum capacity of the freight train with one locomotive is 1200 net ton. One full loaded train pair (1+1 trains) can transport approximately 0,4 Mton cargo annually.

The estimated passenger train volume from Montevideo to 25 de Agosto is the same than the current passenger train volume at the route.

The estimated passenger train volume from Montevideo to Progreso is the objective, which has been set up during the Railway Project. The current passenger train volume to Progreso is 9+9 train in a day. As a result of the Railway Project passenger traffic to Progreso can be developed significantly.

The estimated freight train volume from Montevideo to eastern Uruguay via Sayago is based on the available track capacity at the track section Carnelli–Sayago in the case when passenger trains operate in every 30 minute (2+2 passenger trains / hour).

Table 1. Estimated train volumes

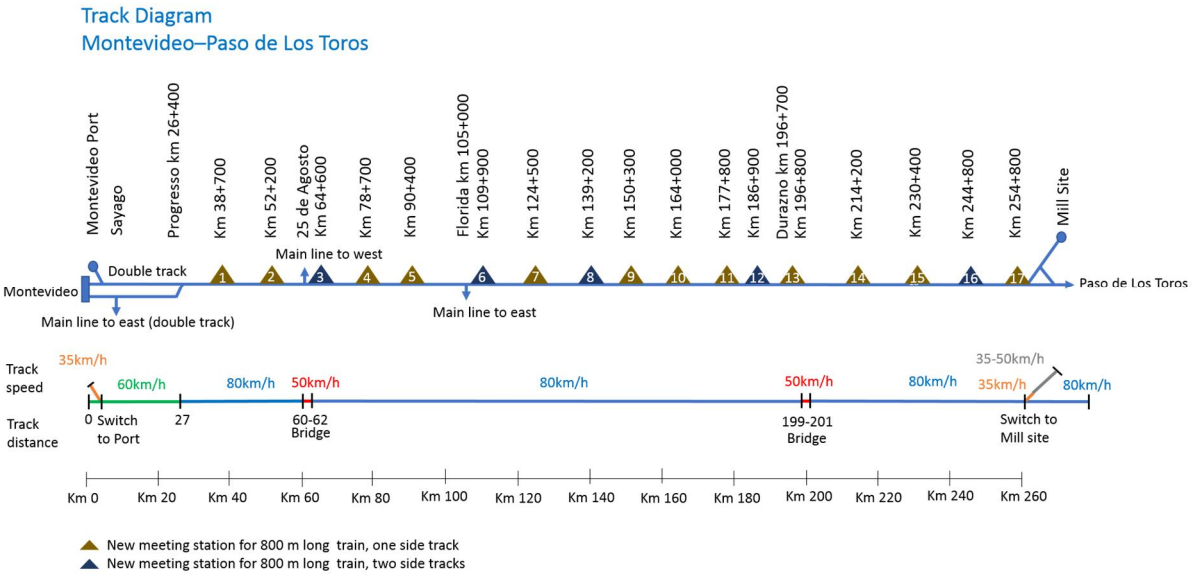
Train type	**Train volume**
First priority freight trains Montevideo–Mill Site	6 + 6 trains / day
Second priority freight trains Montevideo–Paso de Los Toros	6 + 6 trains / day
Third priority freight trains Montevideo–Paso de Los Toros	6 + 6 trains / day
Passenger trains Montevideo–25 de Agosto	2 + 2 trains / day
Passenger trains Montevideo–Progreso	29 + 29 trains / day
Freight trains Montevideo–Eastern Uruguay	12 + 12 trains / day

3 TRACK NETWORK

In the Railway Project the track is improved all the way from Montevideo to Paso de Los Toros. The Railway Project consists improvement and construction measures:

- constructing double track section Montevideo–Progreso
- improving single track section Progreso–Paso de Los Toros
- constructing 17 meeting stations for 800-meter-long trains in the track section Progreso–Paso de Los Toros
- improving maximum track speed to the 80 km/h

Picture 1 shows an overview of the improved track network in the Railway Project. The detailed track network used in the traffic study is shown in the Appendix O3-502 (*Track diagram MVD-PdT*). The amount of new meeting stations has been determined by the capacity demand of the estimated train volume. The meeting stations are located along the track in the best possible way by taking into consideration constraints caused by the track geometry, level crossings and other existing track structures.



Picture 1. The improved track network.

4 SCHEDULED TIMETABLE

The freight train scheduling Montevideo–Paso de Los Toros has been done by planning a standard timetable. The standard timetable shows primarily the capacity of planned track infrastructure. The timetable shows the maximum amount of freight trains a day which can operate at the track. In the operational scheduling trains can be planned multiple different ways compared to the standard timetable.

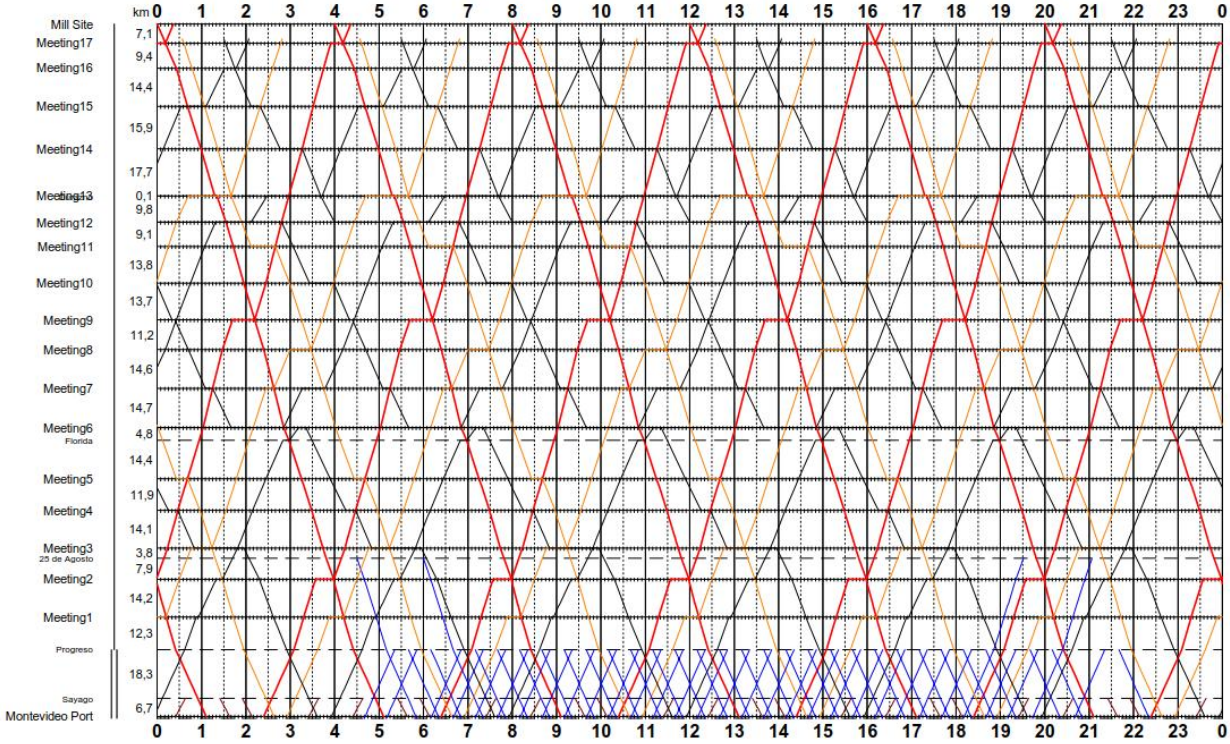
The standard timetable has been done according to following specifications:

- used estimated train volume
- used the track network specified in the Railway Project
- the freight train running times according to traffic simulation with 80 % performance
- three freight trains priority categories in the scheduling
- the first priority trains operate from Mill site to Montevideo port every 4 hours
- the occupation time of the first priority trains in the Montevideo port is minimized
- the second and third priority freight trains operate from Lorenzo Carnelli to Paso de Los Toros or via Sayago to the east.
- the maximum speed of first and second priority freight trains is 80 km/h
- the maximum speed of third priority freight trains is 60 km/h.

The standard timetable is shown in the picture 2 and appendix O3-503. Timetable chart shows that first priority freight trains have smooth running conditions all the way from the mill site to the port. Also, the second priority freight trains can operate without major additional stopping times from Montevideo to Paso de Los Toros. The third priority freight trains can operate smoothly only some specific parts of the whole track course. Third priority trains will have longer additional waiting times because of train passing in the specific meeting stations when running the whole track at a time.

Passenger trains can operate at the double track section Montevideo–Progreso in every 30 minutes. The scheduled passenger traffic can be handled with four train units. The first two units stay a night at Montevideo and the other two in 25 de Agosto.

There is the enough capacity for the dense passenger traffic in the double track section if the signaling system forms enough short block sections that two consecutive trains can operate 7–8 min frequency. For the passenger trains to 25 de Agosto it is difficult to find the perfect running slots in the standard timetable. If passenger traffic to 25 de Agosto increases from the current amount 2+2 trains a day in the future, constructing meeting station 1 with two side track will be profitable.



Picture 2. Scheduled timetable Montevideo–Mill Site. First priority freight trains are in red, second priority freight trains in yellow, third priority freight trains in black, passenger trains in blue and freight trains from Montevideo to the east in violet.

5 TRACK CAPACITY

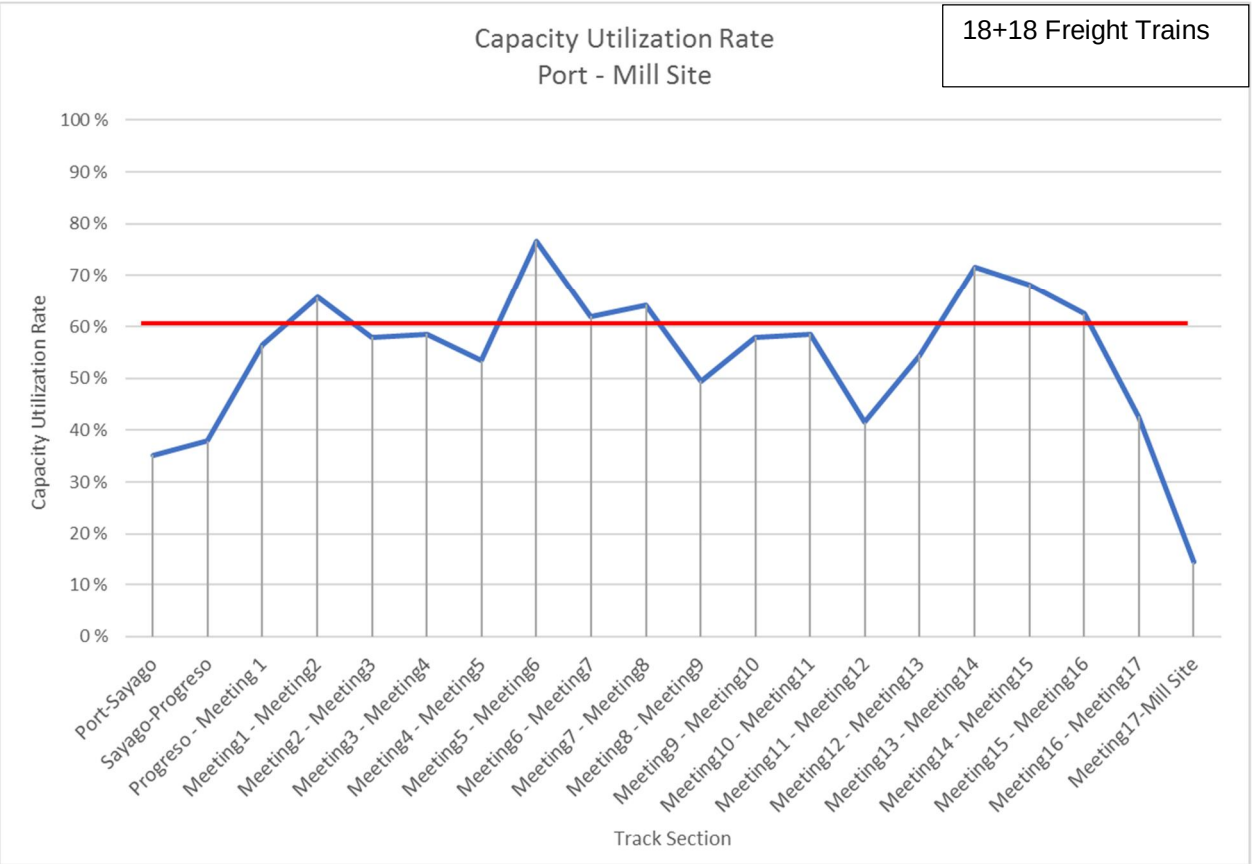
Capacity utilization rate (table 2) is calculated for all the track sections using traffic volume shown in the scheduled timetable (picture 2). The explanation of capacity utilization rate figures is the following:

- 0–40 % track has a plenty of unused capacity
- 40–60 % track capacity use is well balanced
- 60–80 % track capacity is full in use and traffic ability to recover from disturbances is restricted
- 80–100 % lack of track capacity

Table 2 and picture 3 shows that the track section between meeting stations 5 and 6 is the most congested. The reason for this is that the distance between meeting stations with 800-meter-long side track is the longest in that section, due to vertical- and horizontal geometry limits. Total freight volume 18+18 trains a day leads to the situation that there are together seven track sections where capacity is full in use and traffic ability to recover from disturbances is restricted.

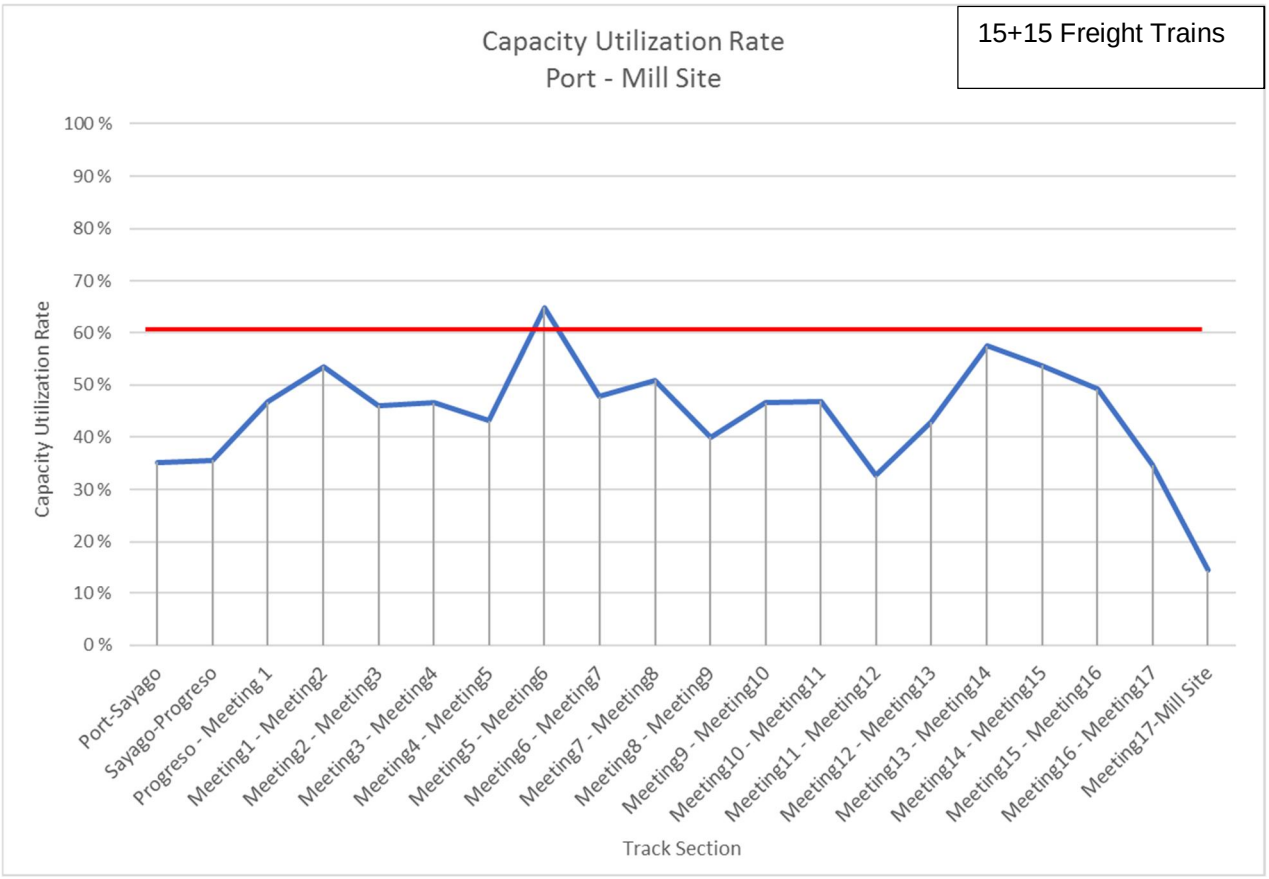
Table 2. Capacity utilization rate for 18+18 freight trains Montevideo–Paso de Los Toros/Mill Site. The track sections where the capacity is full in use are highlighted.

Track Section	Track Type	Freight Train Volume	Passenger Train Volume	Capacity Utilization Rate
Montevideo - Sayago	Double Track	30+30	31+31	35 %
Sayago – Progreso	Double Track	18+18	31+31	37 %
Progreso – Meeting 1	Single Track	18+18	2+2	56 %
Meeting 1–2	Single Track	18+18	2+2	66 %
Meeting 2–3	Single Track	18+18	-	58 %
Meeting 3–4	Single Track	18+18	-	59 %
Meeting 4–5	Single Track	18+18	-	53 %
Meeting 5–6	Single Track	18+18	-	77 %
Meeting 5–7	Single Track	18+18	-	62 %
Meeting 7–8	Single Track	18+18	-	64 %
Meeting 8–9	Single Track	18+18	-	49 %
Meeting 9–10	Single Track	18+18	-	58 %
Meeting 10–11	Single Track	18+18	-	59 %
Meeting 11–12	Single Track	18+18	-	41 %
Meeting 12–13	Single Track	18+18	-	55 %
Meeting 13–14	Single Track	18+18	-	72 %
Meeting 14–15	Single Track	18+18	-	68 %
Meeting 15–16	Single Track	18+18	-	63 %
Meeting 16–17	Single Track	18+18	-	43 %
Meeting 17–Mill Site	Single Track	7+7		15 %



Picture 3. Capacity Utilization Rate for 18+18 freight trains Montevideo–Paso de Los Toros/Mill Site.

The 4 Mton annual cargo transportation is possible to reach if daily amount of freight trains is 15+15 operating in 350 days a year. In this option average load of one train is 750 net ton. The capacity utilization rate for 15+15 freight trains is shown in the picture 4. The capacity utilization rate stays under 60 % except the track section meeting 5–6, where it is still a little bit over 60 %. To conclude, the standard timetable planning and capacity utilization evaluation shows that there is enough capacity for the 18+18 freight trains at the track, but the traffic disturbances begins to increase if traffic volume exceeds 15+15 freight trains a day.

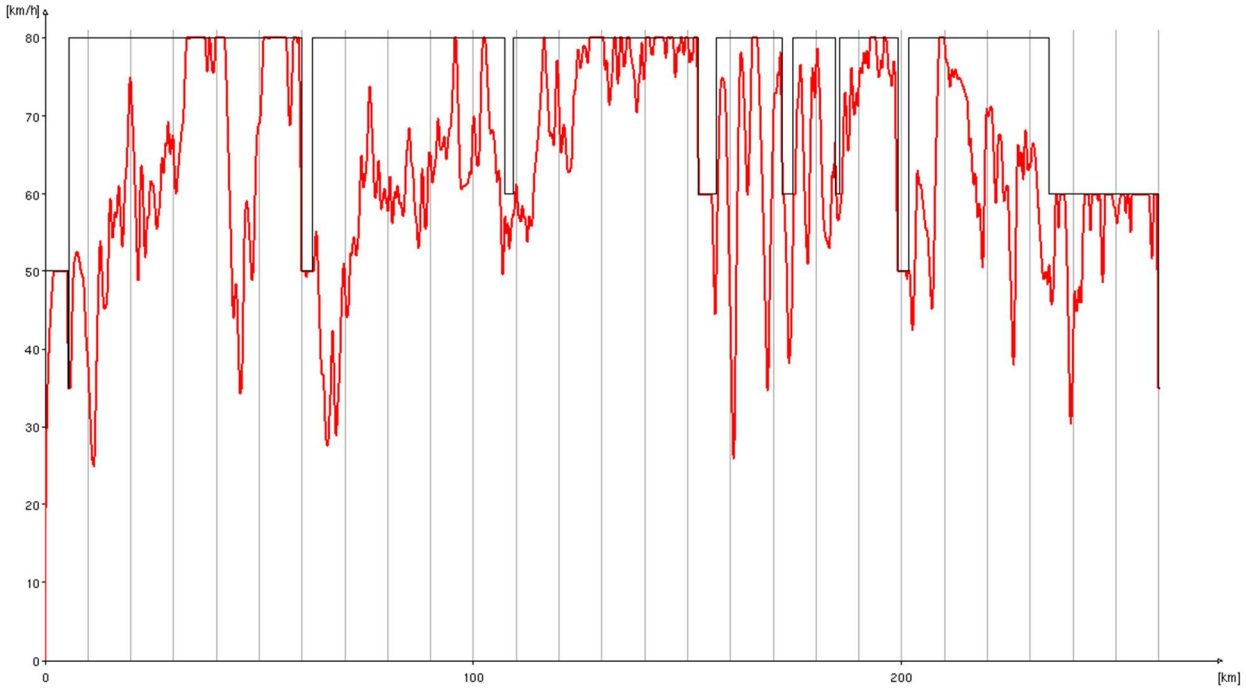


Picture 4. Capacity Utilization Rate for 15+15 freight trains Montevideo–Paso de Los Toros/Mill Site.

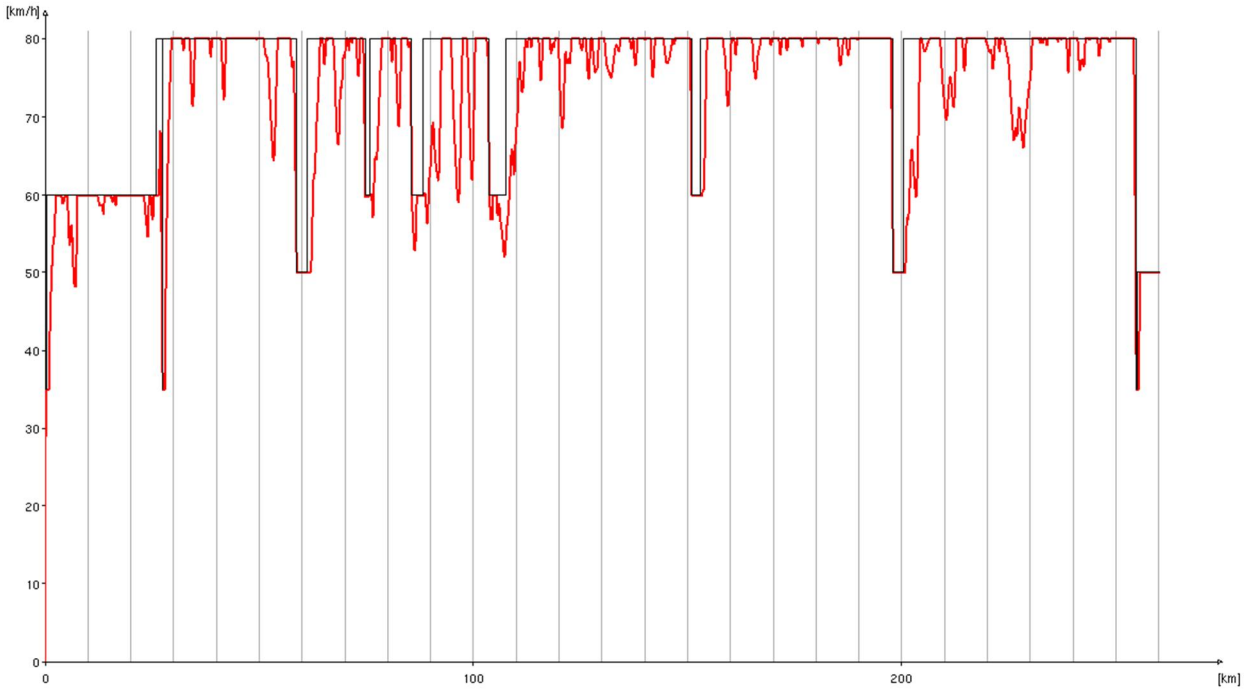
6 TRAFFIC SIMULATION

Pictures 5 and 6 shows a speed-distance diagrams for loaded and empty first priority trains. The loaded train gross mass is 2000 t and empty train 800 t. In the pictures can be seen that the loaded train speed is affected by a track geometry more than empty trains. The pictures 5 and 6 show the maximum 100 % performance of the freight train.

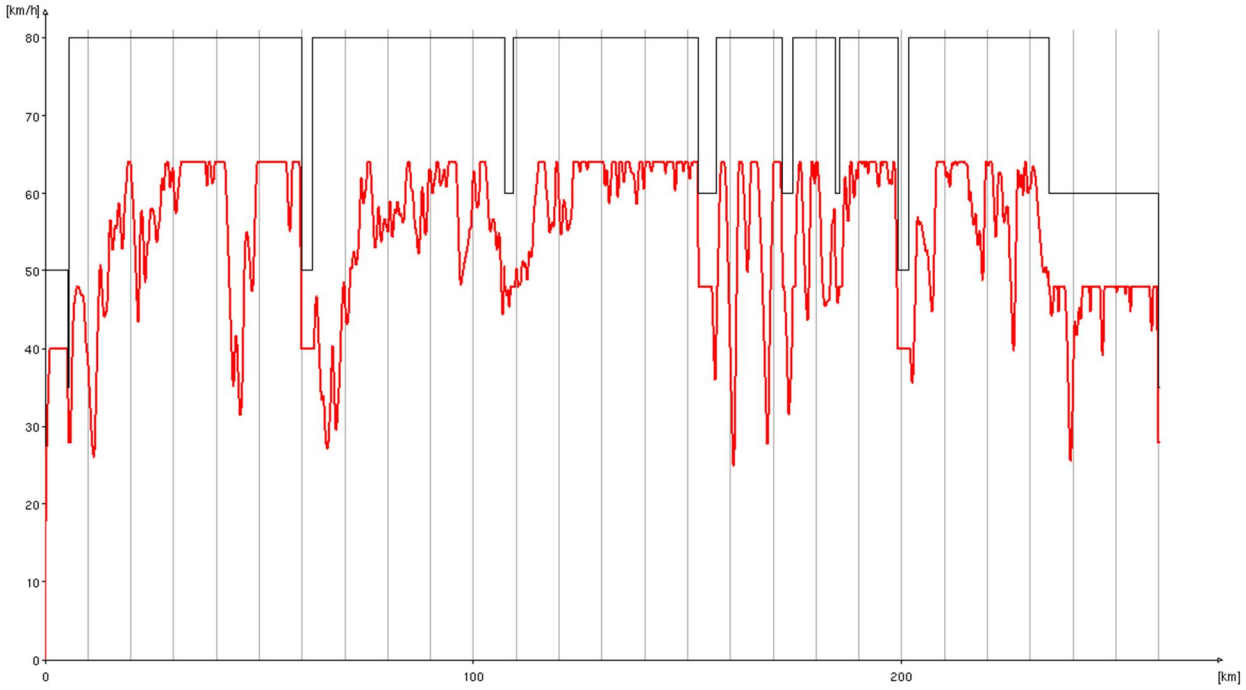
The traffic simulation and travel time estimations has been made by 80 % freight train performance. It means that there is a buffer time in the timetable and trains will not be delayed immediately in the destinations if minor disturbances occur during the journey. The pictures 7 and 8 show the train speeds in the traffic simulation.



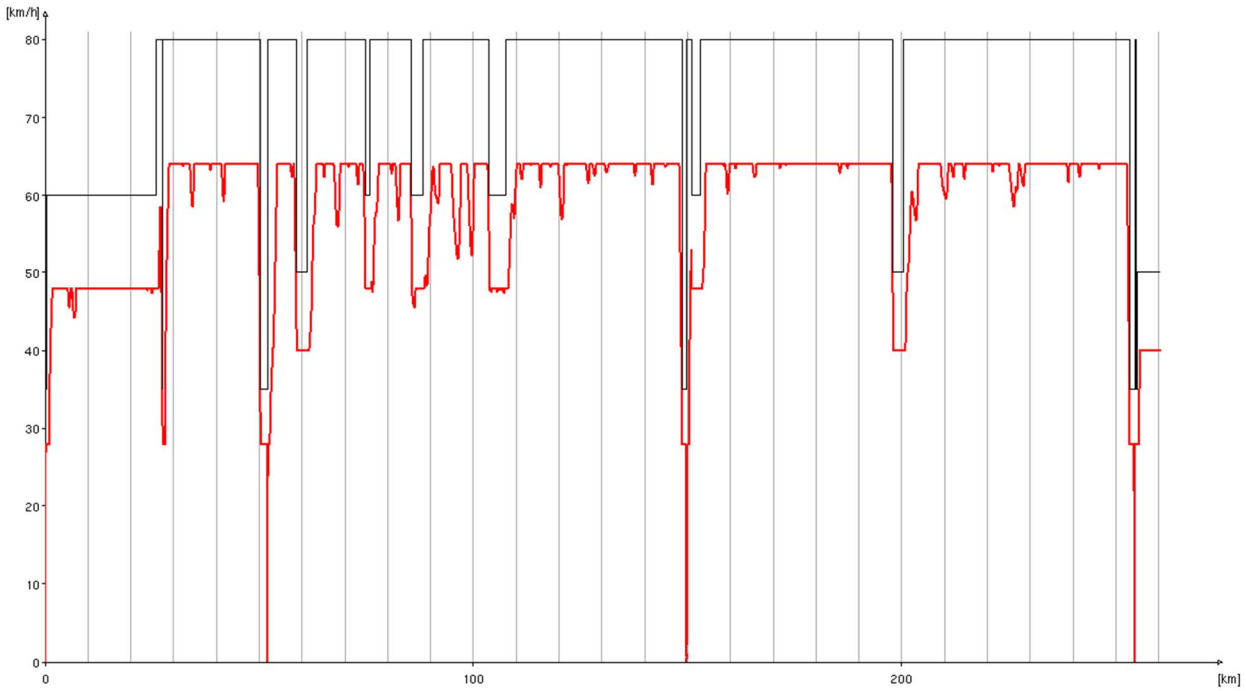
Picture 5. Maximum speed for loaded first priority train total mass 2000 t at the route Mill site–Montevideo port. In the y-axis speed km/h and x-axis distance from the origin. Red line shows a train speed and black line a maximum track speed.



Picture 6. Maximum speed for empty first priority train total mass 800 t at the route Montevideo port–Mill site. In the y-axis speed km/h and x-axis distance from the origin. Red line shows a train speed and black line a maximum track speed.



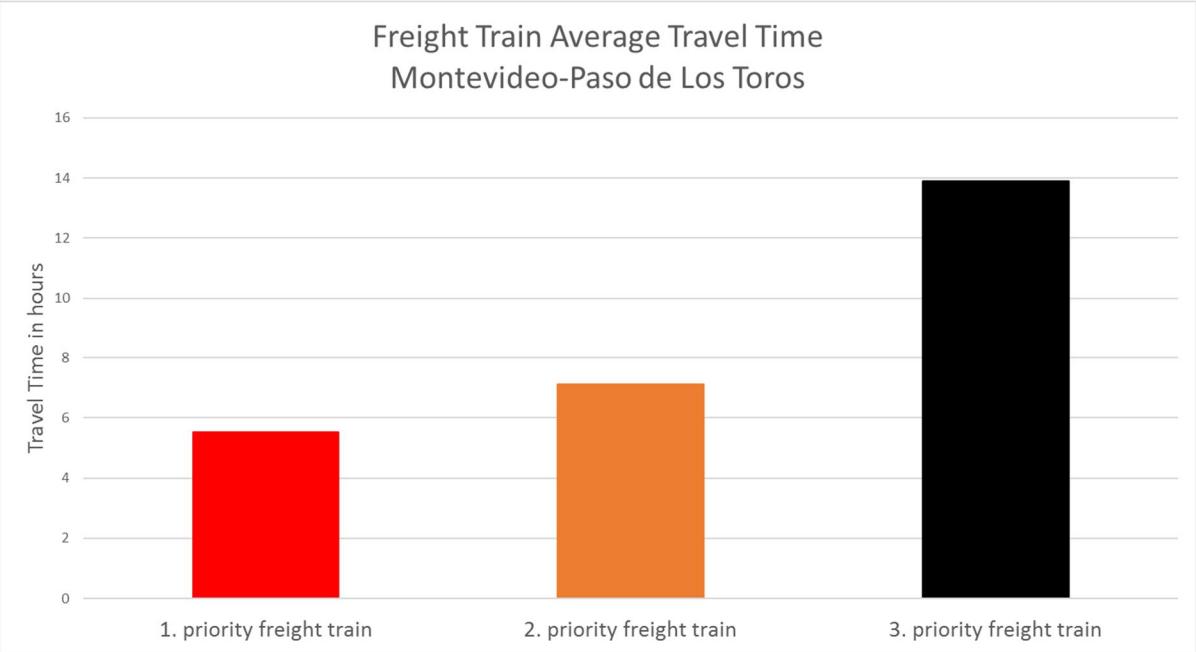
Picture 5. Speed in traffic simulation with running performance 80 % for loaded first priority train total mass 2000 t at the route Mill site–Montevideo port. In the y-axis speed km/h and x-axis distance from the origin. Red line shows a train speed and black line a maximum track speed.



Picture 6. Speed in traffic simulation with running performance 80 % for empty first priority train total mass 800 t at the route Montevideo port–Mill site. In the y-axis speed km/h and x-axis distance from the origin. Red line shows a train speed and black line a maximum track speed.

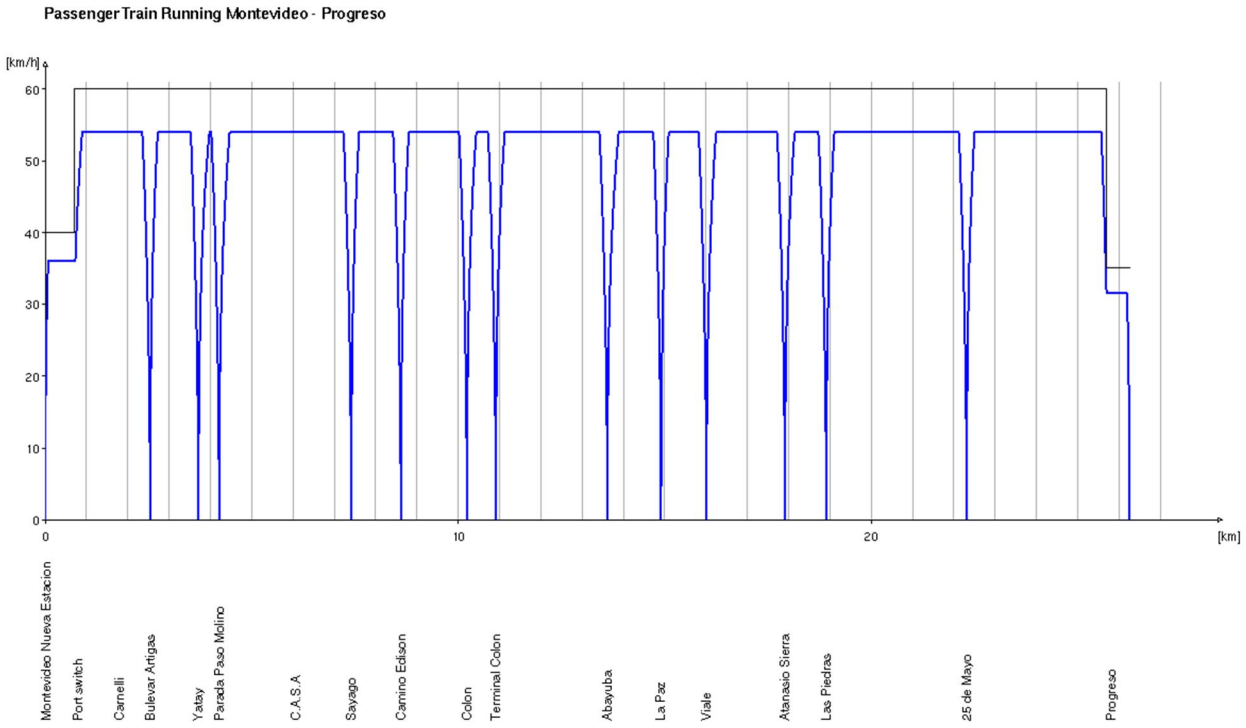
Travel time for loaded first priority trains from the mill site to the port is approximately 5 hours and for empty trains from the port back to the mill site approximately 6 hours. The difference in travel times is caused by the empty trains stopping at the meeting station when passing the loaded train.

Average travel time in prioritization classes is shown in the picture 7. In the picture can be seen that for the first and second priority freight trains can be reserved sufficient amount of the track capacity for running all the route at a time. Third prioritized freight trains have to wait for longer times to get the track capacity in use. As a result, average travel time enables 24 hours the rolling stock rotation time between Montevideo and Paso de Los Toros for the 1. and 2. priority freight trains.



Picture 7. Average freight train travel time Montevideo–Paso de Los Toros.

Passenger train travel time from Montevideo to Progreso decreases due to the track improvement measures. The current travel time in timetable is 48 minutes. The simulated travel time at the improved double track is 41 minutes. The picture 8 shows the passenger train simulation from Montevideo to Progreso with 90 % performance.



Picture 8. Speed in traffic simulation with running performance 90 % for passenger train from Montevideo to Progreso. In the y-axis speed km/h and x-axis distance from the origin. Blue line shows a train speed between station stops and black line a maximum track speed.

7 CONCLUSIONS

The improved railway offers the smooth traffic conditions to the first priority trains. Travel time from mill site to the port is approximately 5-6 hours and 24h rotation time for the rolling stock is possible. In addition to the first priority trains the improved track offers the smooth traffic conditions to the 2. priority freight trains with travel time less than 8 hours.

In the Railway Project improved track offers enough capacity for 18+18 daily freight trains. However, the track capacity is in this case full in use and delays caused by traffic disturbances begins to increase. The amount of 15+15 daily freight trains is a limit when the track capacity utilization is still well balanced.

In the planned track the most significant capacity bottleneck for 800 meters long train is the track section between meeting stations 5 and 6. The current Florida station is located in that track section. The track capacity can be improved by constructing a side track in Florida for a low prioritized freight trains. In the study has been assumed that the part of the third priority trains can use the side track in the Florida.

According to the scheduled standard timetable there is a need for at least two side tracks at the meeting stations 3, 6 and 12 because of more than one scheduled simultaneous train passing. In addition to the demand caused by scheduled traffic, more meeting stations with two side are needed for managing the traffic in the case of disturbances. There shall be at least one meeting station with two side track also at the track sections between meeting stations from 6 to 12 and from 12 to Paso de Los Toros. As a result, minimum amount of meeting stations with two side tracks is five locations. In the Railway Project it is designed the meeting stations with two side tracks in locations 3, 6, 8, 12 and 16.

If passenger traffic to 25 de Agosto increases from the current amount 2+2 trains a day in the future, constructing meeting station 1 with two side track will be profitable.

As a result of the constructing double track and improving the signaling system, the passenger traffic to Progreso can be developed significantly. The passenger train travel time from Montevideo to Progreso

will decrease. The current travel time in timetable is 48 minutes. The simulated travel time at the double track is 41 minutes. The dense passenger traffic (2+2 passenger trains/hour) requires short block sections. The short block section enables that the distance between two consecutive trains shall not be too long. Minimum headway between trains should not be more than 7–8 minutes.

8 APPENDIX

Appendix O3-502. Track Diagram MVD-PdT
Appendix O3-503. Standard traffic timetable