

# Cloud Railroad Simulator

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**Abstract:** The throughput and carrying capacity is the important characteristics of the railway lines which shows transportation opportunities. This is impossible to plan the freight traffic on the net without it. This paper introduces a simple cloud railroad simulator for cargo trains for calculating the throughput and carrying capacity. For simulation purposes the user need to fill in all necessary data in a browser, and the results will be shown on the server side. Once data has been entered into the program, the system allows to obtain a more accurate representation of reality of the railway system.

## 1 INTRODUCTION

In Kazakhstan railways play an important role for development of economic and industrial areas, also a key role in the formation of international relations between countries (Bekmagambetov M, 2005)

Railway transportation is an integral part of the country's transport system, which needs to be modernized to meet the requirements for passenger and freight traffic.


An important problem that arises when it is necessary to develop increasing the volume of transport is the timely development of the railway infrastructure. The need for large amounts of long-term repayable capital investments raises the task of quantifying the adequacy of the proposed technical and technological solutions at the lowest possible cost. That is why it is very important to test the throughput and the carrying capacity of the railway transportation system before expensive construction has been done.


The throughput of railway section is the largest number of trains (for a single track section - pairs of trains) of the established weight, which can be traversed per unit of time (day, hour) for this section


with the existing technical weapons, adopted by the system of train traffic and labour organization railways. For single track lines with equal dimensions in directions, the throughput is expressed by the number of pairs of trains of the established mass of both directions, and for double-track lines and single-track ones in the unpaired schedule, the number of trains of the established mass for each direction separately.


The number of trains or pairs that can pass along the lines is determined usually per day, and for suburban areas with intensive passenger traffic (due to large unevenness) - for the day and for the period of the maximum loading of the site - peak hour.

When calculating the reserve capacity, the difference of the available railway capacity and the required line capacity of the station is taken into account. The available railway capacity is the maximum size of the train movement, which can be realized depending on its technical equipment. The required line capacity is the number of trains that need to be implemented to fulfil the transportation plan.

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## 2 CLOUD RAILROAD SIMULATOR

Simulation provides an important methods of analysis which can be verified, communicated and understood. It especially valuable for railroad planning. In this section, we represent a simulator for calculating carrying capacity in railway station. A railway station can be decomposed into rail tracks, switches, throat sections, yards and etc.

To simulate the railway station, we need to fill in the following parameters for train and switch objects.

### 2.1 Input Data

Cloud railroad simulator requires data in two objects: train and switch.

Parameters for train object:

- the track length
- the number of passenger trains
- the number of freight trains
- the density of the net

And parameters for switch object: (Fig. 1)

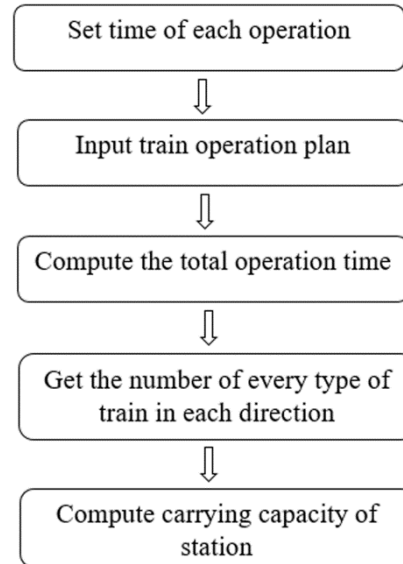
- the track object
- the location of the switch
- the number of tracks on the switch
- the amount of trains which are expected at a separate point
- the density of the net
- the overlocking
- the braking
- the time forward, backward and stationary intervals

Figure 1: Input Data.

### 2.2 Simulation

In order to run a simulation the user specifies train parameters and switch parameters on a preferences browser.

The procedure of calculating carrying capacity is as follows:



The railway power is determined by its throughput and carrying capacity. The throughput of the railway section is simply the daily time budget divided by graph period movement of trains. The duration of the daily time budget depends on the time required for repair and construction works, on the technology of their maintenance, on the number of main roads and type of mechanisms used. And the throughput is calculated based on the formula 1:

$$N = \frac{1440 - T_{pr}}{T_{pg}} a_{ps} \quad (1)$$

$T_{pr}$  - technical operation time, in min;

$T_{pg}$ - graph period movement of trains, in min;

$a_{ps}$ - coefficient of operation reliability of technical means

According to the formula, first, we need to compute the technical operation time  $T_{pr}$ . It is a period of time that is free of trains, provided in the traffic schedule and necessary for performing work on the current maintenance and repair of track devices, contact network, signalling, centralization and interlocking. Then, we need to calculate the graph period  $T_{pg}$ . And finally, we can obtain the throughput of the railway section.

Technical operation time depends on the type of machines and mechanisms used, as well as on the accepted technology of work and is adopted in the calculations of available capacity as:

- on double-track lines and sections with inserts for non-stop crossing of trains - 120 min
- on single-track sections - 60 min

The value of the coefficient reliability of technical means is determined depending on the type of traction and the number of main roads. The coefficient considers the passport reliability of the technical infrastructure facilities and possible failures in their operation during exploitation. The value of  $a_{ps}$  varies in range 0,87 - 0,98 for single-track sections, and 0,86 - 0,98 for double-track lines. In our system we are using  $a_{ps} = 0,96$ .

The graph period is the total time of train movement with braking and overlocking and stationary intervals for separate points. It is:

- on a single-track section - the time of the occupation of the trail characteristic for the given schedule by a group of trains periodically recurring during the day;
- on a double-track section with automatic blocking - the interval between trains;
- on a double-track section with a semi-automatic blocking - the time of one-train distraction and the station interval.

The carrying capacity is determined by the power of road freight transport. This number of tons of cargo trains that the road can carry per unit time in each direction. The carrying capacity in million tons/year can be determined using the following formula 2:

$$C = \frac{365 * Q_{gr} * N_c * \varphi}{10^6} + C_a + C_{pr} \quad (2)$$

The variables used in carrying capacity are defined as follows:

- $N_c$ – available throughput of cargo moving in a given direction, trains/days;
- $Q_{gr}$ - the average gross and net weight of the train, depending on the established mass of the train and the structure of the freight flow;
- $\varphi$ - the ratio of the net weight to the gross weight of the train, depends on the kind of wagons and the structure of the wagon-stream;
- $C_a, C_{pr}$ – respectively amount of cargo transported in accelerated and prefabricated trains, million tons per year.

Based on time table, train arrival flow is not distributed evenly in one day, but occurs intensively in rush hour. Thus, carrying capacity of station throat

is affected by train arrival flow distribution. And for getting the advantage of the simulator, it was employed the number of trains that can wait on each station.

### 2.3 Output

Based on the proposed model, the trains movement simulation is carried out, and the maximum railway carrying capacity is calculated. Since we had filled in all the necessary data: the track length, the track object, the location of the switch, the number of tracks on the switch, the amount of trains, which are expected at a separate point, the braking, the time forward, backward and stationary intervals, the simulator does the following calculations: (Fig. 2)

- the throughput
- capacity without passengers
- the required line capacity
- reserve train pairs
- the reserve capacity
- the carrying capacity of the railway

The simulator produces a number of calculations which is shown in the following figure 2.

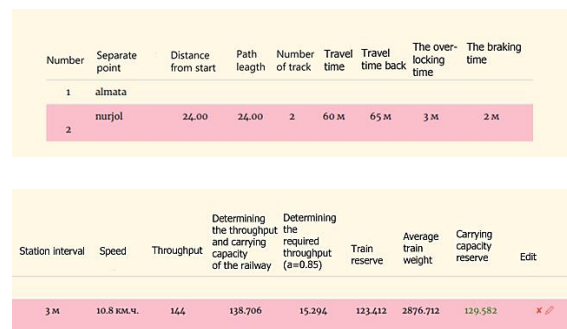


Figure 2: Output Data.

In case of low throughput on this separate point the line is highlighted to red. This makes it visually clear to become work on this part of the way.

The simulator supports the following types of tasks:

- Determining the throughput and carrying capacity of the railway
- Analyzing the capacity of lines and stations
- Determining the required throughput
- Determining the average weight of the train

The following figure 3 shows how the simulation tool works.

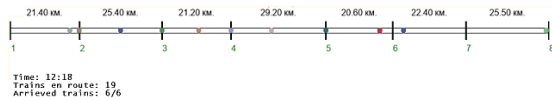


Figure 3: Animation of the simulation.

In this case we have length of way equal to 136,5 and six separate points, and all way is a single track.

Trains run according to the timetable on a railway network. During the simulation, simulator calculates train movements under the input data. After a simulation run, we can analyse and display the resulting data in the form of table and animation

Simulator handles single track simulation runs as well as two-line simulation runs depending on input data.

Using simulator, it is possible to identify separate points at which the throughput and carrying capacity are reduced, thereby helping to plan the number, speed and weight of trains, the optimal departure schedule and station interval.

Also using the simulator, you can define separate points where the construction of double-track line will significantly increase the overall throughput and carrying capacity.

The simulator has already been used for Kazakhstan Railways. Thereby they have done a number of calculations which increased the throughput and carrying capacity.

### 3 CONCLUSIONS

Cloud simulator is an efficient and effective railroad program. It has been used successfully in Kazakhstan railways. The program use Python web framework Django, Bootstrap, JQuery and published on the cloud platform Pythonanywhere with a full Python environment. All entered and computed data is stored on PostgreSQL database server, object-relational database management system. Therefore, it is recommended to use for railway simulation because it cover a possible output data that can be used in decision making process.

### ACKNOWLEDGEMENTS

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