DEVELOPMENT OF COMPUTER SIMULATION MODEL OF MUDANJIANG RAILWAY JUNCTION AND ITS RESULTS

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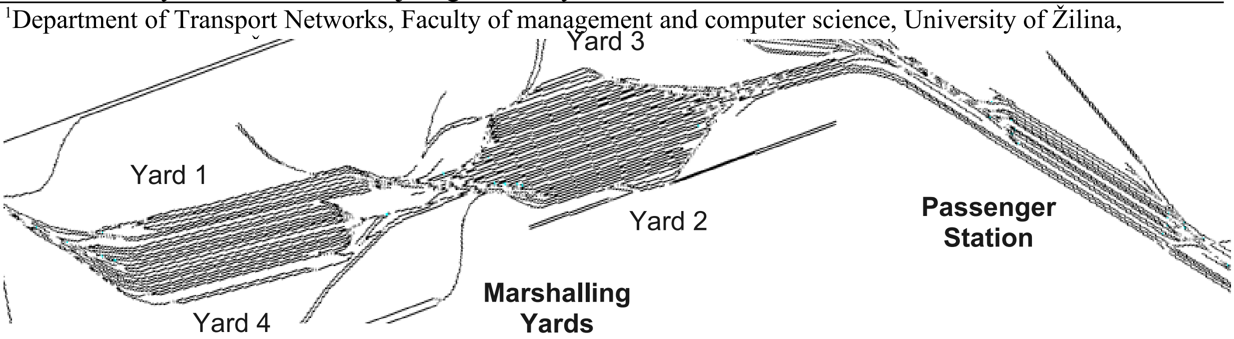
Zhrnutie: Článok informuje o slovensko-čínskej spolupráci na poli počítačovej simulácie prevádzky železničných staníc.

1. Introduction

Computer simulation model of Mudanjiang railway junction was developed in frame of international project named „Simulation models of railway junctions". Departments of the Faculty of Management Science and Informatics from the University of Žilina, the Simcon Ltd. company from Žilina (Slovakia), and the TDJ Research Center from Harbin (People's Republic of China) took part in this project. It was supported by Ministry of Education of the Slovak Republic.
Development of the simulation model was a preliminary phase of the Slovak-Chinese cooperation on this field. Thanks to the developed model, it was possible to publish potentials and advantages of railway traffic computer simulation to experts and specialists in the Chinese Railway, academic and business administration.
Main goal of this project was to verify availability of a simulation tool called Villon in conditions of Chinese railways.

2. Mudanjiang Railway junction

The Mudanjiang railway junction is situated in northeast China (province Heilongjiang). There is a passenger station and a marshalling yard in the junction. Thanks to this fact, it was possible to make simulation of passenger and freight railway traffic in one model. This fact was the main criterion, when selecting this railway junction as a sample for the simulation model. The task was to verify all potentials and possibilities of the used software tool.
Picture 1 Layout of the Mudanjiang Railway Junction



The Mudanjiang railway junction (see the picture 1) is situated in network of Northeast Railway with seat in Harbin. It is connected to the Chinese railway network by lines from all points of the compass. Passenger station is composed of one yard with direct lines with platforms and passenger wagons depot. Marshalling yard is composed of four separate yards.

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“Yard 1” performs function of reception yard for freight trains from west. “Yard 2” serves as reception yard for freight trains from north, east and south, transit yard for west to north and north to west and departure yard for freight trains to south. “Yard 3” serves as classification and departure yard for freight trains that depart to north and east. “Yard 4” performs function of classification and departure yard for freight trains that depart to west. Between Yard 1 and Yard 3 and between Yard 2 and Yard 4, there are humps. They are equipped with retarders made by the TDJ Research Center Harbin. There is a locomotive depot, a freight wagons depot, two loading areas and more than 10 groups of industry tracks.

3. Development of model

The Mudanjiang railway junction simulation model was developed in environment of the Villon simulation tool. This simulation tool is already known from previous conferences. Its characteristics were already published in many papers [1], [2], [3], [4], [5]. After several successful European projects came the Villon simulation tool in the Asian territory.

For development of simulation model, different basic documents were used. These basic documents were provided by the Chinese railways. List of the basic documents follows:

a) Layout of the Mudanjiang railway junction in 1:1000 scale,
b) List of personnel professions, including job description,
c) List of shunting locomotives, including job description,
d) Output files from information system of freight transport – files contained list of arrival trains in a period of 11 days, including wagon lists of these trains,
e) List of departing freight trains from the Mudanjiang marshalling yard according to train-formation diagram,
f) List of industry tracks and schedule of their attendance,
g) List of Chinese railways stations with authority to register wagon-load consignment,
h) List of relations and them assigned destination stations valid for the Mudanjiang marshalling yard according to train-formation diagram,
i) Basic rules for group train formation,
j) List of passenger trains valid for the Mudanjiang passenger station,
k) Passenger and freight wagon catalog.

Documents a), d), g), h) and k) were provided in electronic form. It was possible to import information from these documents in modules of the Villon simulation tool after little modifications.

Documents b), c), e), f), i) and j) were provided in paper form.

The whole project took 2 years, from October 2000 until September 2002. During this time, several two common visits in the Mudanjiang railway junction and several common workshops took place. These meetings helped to clarify especially technological processes in Mudanjiang, particularities of the Chinese railway traffic, and from this resulting modifications of the Villon simulation software.

Work on the model development was divided to several phases:

1. Defining and entering data,
2. Development of a complex simulation model,
3. Verification of results of the complex model,
4. Preparation of a simplified simulation model,
5. Preparation of simulation experiments based on the simplified simulation model,
6. Processing of results of the simulation experiments.

The phase of data defining and entering took 6 months. After this phase, the phase of development of complex simulation model followed. In complex simulation model, 3 days of railway junction traffic are simulated. There is the whole traffic included, i.e.:

- Arrivals, transits and departures of passenger trains according to timetable,
- Movements of passenger train sets from and to passenger wagon depot,
- Attendance of arrival, transit and departure freight trains,
- Formation of group train,
- Attendance of industry tracks, sorting of wagons from and for industry tracks.

Development of the complex simulation model took about one year, including modifications to the Villon simulation tool. After this phase, the preparation of simplified experiments followed. More detailed explanation follows in the next part of this paper. This project phase took about one year too.

4. Results of complex simulation model and simulation experiments

As written in the previous part of paper, complex simulation model represents the whole traffic in the Mudanjiang railway junction. For the purpose of availability verification of the Villon simulation tool, simulation outputs were made during simulation runs. All of them handle the freight wagons traffic in marshalling yards.

The complex simulation model was also introduced to the regional management of the Northern Railway in Mudanjiang. During the introduction, simulation results were compared was with official statistics made every day by personnel of Mudanjiang railway junction.

From the complex simulation model, the following simulation outputs were created:

- Average time of a wagon stay in the station,
- Quantity of loaded wagons in station at 6:00 P.M. by relations,
- Quantity of wagons in station by type,
- Analysis of technological processes,
- Utilization of personnel and other station resources.

After development of the complex simulation model and verification of its simulation results, the simplified simulation model was created. Its task was to give a base for preparation of 11 simulation experiments. Task of the experiments was to simulate impact of:

- Operating failures,
- Accidents,
- Increased train input flow,

to continuous traffic of the railway junction.

Simplification of the model consists in excluding of some of traffic processes from simulation:

- Passenger station operation,
- Industry tracks attendance,
- Group trains formation.

The full list of simulation experiments follows:

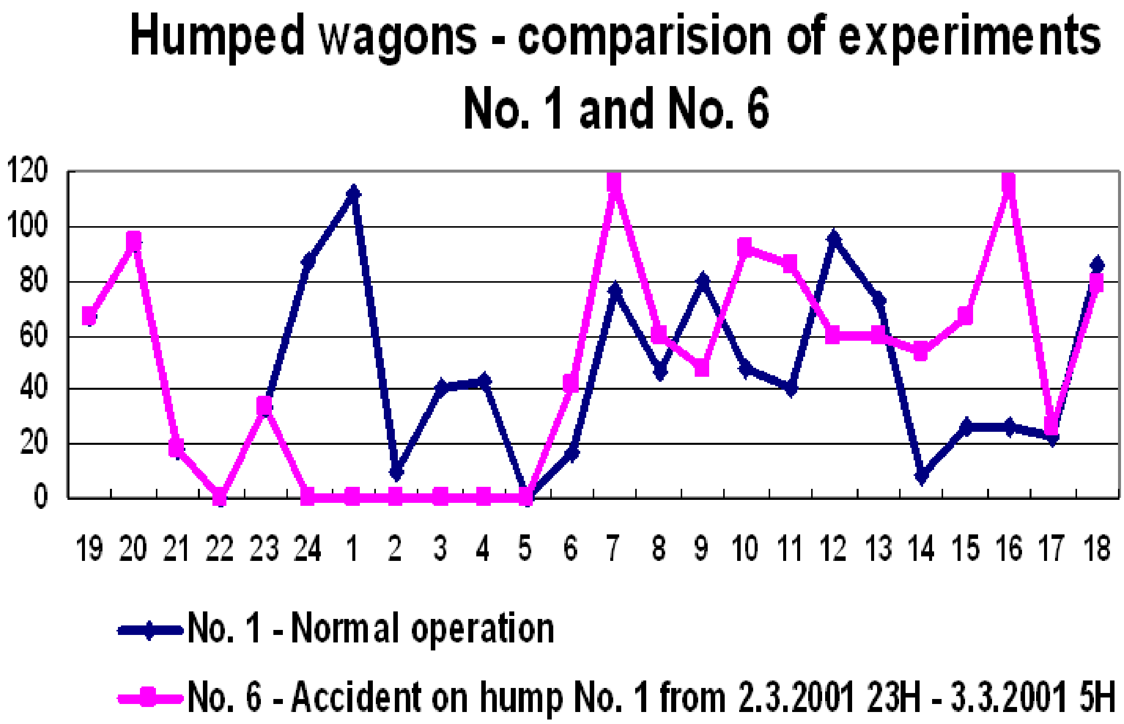
1) Planned closing of a part of equipment of railway station:
   a) Closing of a track in the Yard 1 for the whole simulation time,
   b) Closing of a track in the Yard 2 for the whole simulation time,
   c) Closing of a double slip switch on the east end of the Yard 1 for the whole simulation time.
2) Incidental closing of a part of equipment of railway station:
   a) Accident on the hump between the yards 2 and 4 and consecutive interruption of trains humping for 3 hours in a night shift,
   b) Accident on the hump between the yards 2 and 4 and consecutive interruption of trains humping for 6 hours in a night shift (See simulation result on the picture 2),
   c) Accident on a chosen switch for 3 hours in a night shift,

d) Accident on a chosen switch for 4 hours in a day shift.

3) Increased train input flow:
   a) About 30% of additional arrival trains by humping speed of 1,2 m/s,
   b) About 30% of additional arrival trains by humping speed of 1,4 m/s,
   c) About 30% of additional wagons in arrival trains (train numbers not changed) by humping speed of 1,2 m/s,
   d) About 30% of additional wagons in arrival trains (train numbers not changed) by humping speed of 1,4 m/s,

Impact of the simulated events in named simulation experiments was analyzed and evaluated by comparison of simplified simulation model results and simulation experiments results. There were the following characteristics compared:

- Impact of events to the average time that a wagon stays in the station,
- Quantity of trains waiting in front of the station on the ground of operating failures, accidents and increased input train flow,
- Quantity of setting of selected switches,
- Input and output wagon flow within 24 hours.



Picture 2: Comparison of simplified simulation model and simulation experiment with accident on hump

5. Summary

Cooperation on development of the Mudanjiang railway junction simulation model was a very interesting experience for all of involved parts. For the Slovak side, it was a very agreeable surprise to get to know the stage of railway transport improvement in People‘s Republic of China.

We can conclude that cooperation on the project led to a successful result. The Villon simulation tool was proved at all points. Thanks to its usage in the project, its simulation results module was enlarged in several statistical outputs, usage of which is more common for the Chinese railways. However, they can give a lot of useful information for railway technologists in Europe too.

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