Advanced Logistic Systems – Theory and Practice, Vol. 14, No. 2 (2020), pp. 15-20.
https://doi.org/10.32971/als.2020.010

POSSIBILITIES OF APPLICATION OF MODERN TRAFFIC SIMULATION AND PLANNING SOFTWARE IN EDUCATION AND RESEARCH

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Abstract: The aim of this publication is to present the application possibilities of modern traffic simulation and planning software in both technical education and research. This article basically implements this using two software, PTV Vissim and PTV Visum, by presenting several transport models created using the two applications. The topic is given special relevance by today's digitalization trend, which also extends to the field of transport planning.
Keywords: transport simulation, transport planning, digitization, education and research, logistics

1. INTRODUCTION

Today, digitalization has become dominant in all areas of the industry and the economy, as has in the various sectors of transport as well. In addition to the fact that various IT solutions play a key role in the creation and operation of modern transport systems, it is becoming increasingly essential to take advantage of the opportunities offered by digitalization in the field of transport planning itself. One of the best examples of this is the use of modern traffic simulation and planning software, which makes it possible to determine the future behavior of complex transport systems much more accurately than before. At the same time, these tools may allow the application of the Industry 4.0 principle in transport planning, especially with regard to the creation of so-called digital twin pairs, which has recently become a common method mainly in production logistics [1, 2].

The publication uses two software of the PTV group, PTV Vissim for traffic simulation and PTV Visum for traffic planning, as examples to present the capabilities of these types of applications (the models presented were made with the demo versions of the software, the latter can be downloaded from the PTV group website after registration [3]). The article focuses primarily on the use in technical education and research, but through these, of course, one can also gain insight into the possibilities of industrial use.

2. POSSIBILITIES OF APPLICATION OF TRAFFIC SIMULATION SOFTWARE

Traffic simulation software, such as PTV Vissim, make it possible to simulate traffic conditions in a given section of the transport network in as much detail as possible. In practice, this means that various intersections (including roundabouts), traffic junctions, larger car parks, local solutions for public and pedestrian transport, local-level intersections in each transport sector, etc. can be modeled with perfect precision. It can also be seen from the above that these types of applications play a very important role mainly in the micro-level simulation of urban traffic, as such environments are most characterized by complex traffic conditions. At the same time, it can be seen that such simulation software can be

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very useful in the technical education of transport systems, as it allows the modeling of relatively well-defined, but in itself sufficiently complex traffic engineering and management solutions, such as traffic light intersections. The following figure shows a part of a simplified three-dimensional simulation of such an intersection, followed by the signal program for the simulation (this model was made mainly for demonstration purpose, but of course, the software itself allows the creation of much more detailed and realistic simulation models as well).

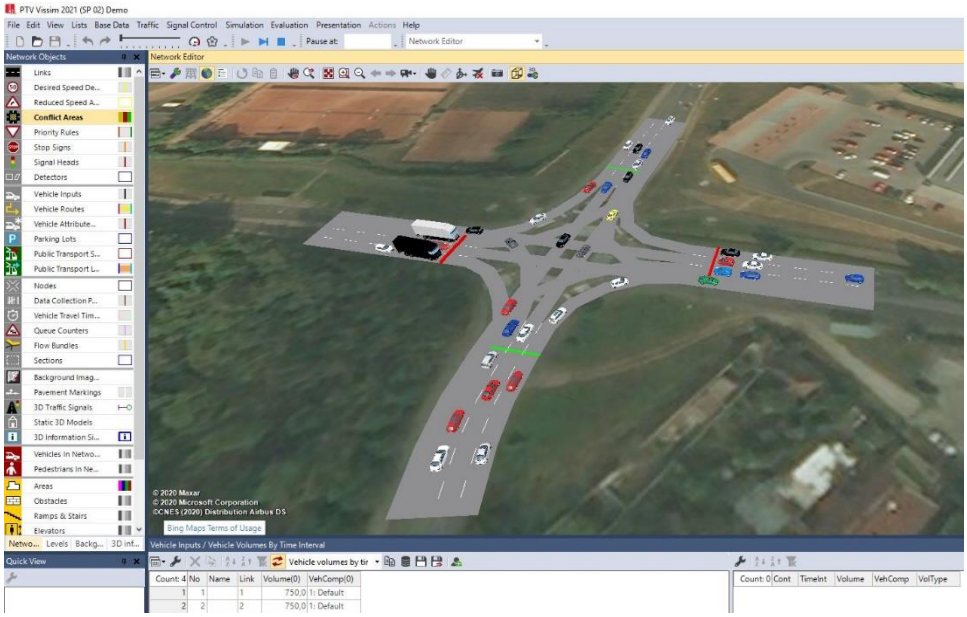

Figure 1. Simplified traffic simulation of a traffic light intersection in a three-dimensional view

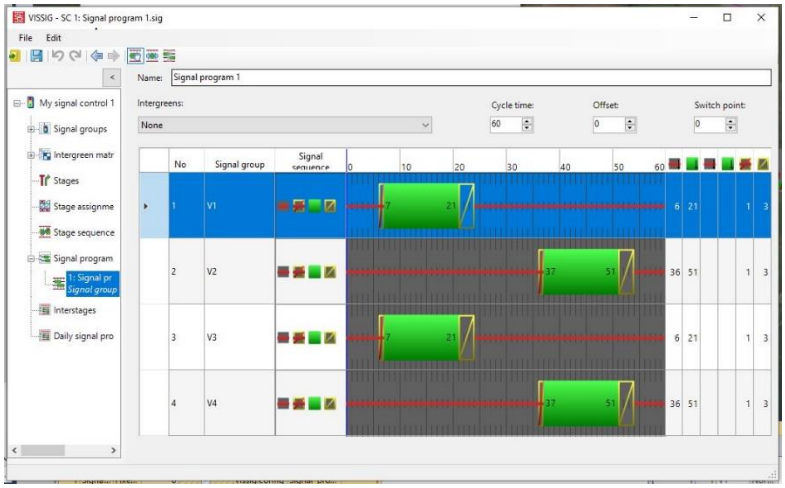

Figure 2. Signal program for the simplified traffic simulation of the traffic light intersection

The following figure shows a top-view simulation of a roundabout in which the green-red fields indicate the so-called conflict areas in which vehicles from different directions may encounter (therefore priority rules must be defined in such zones):

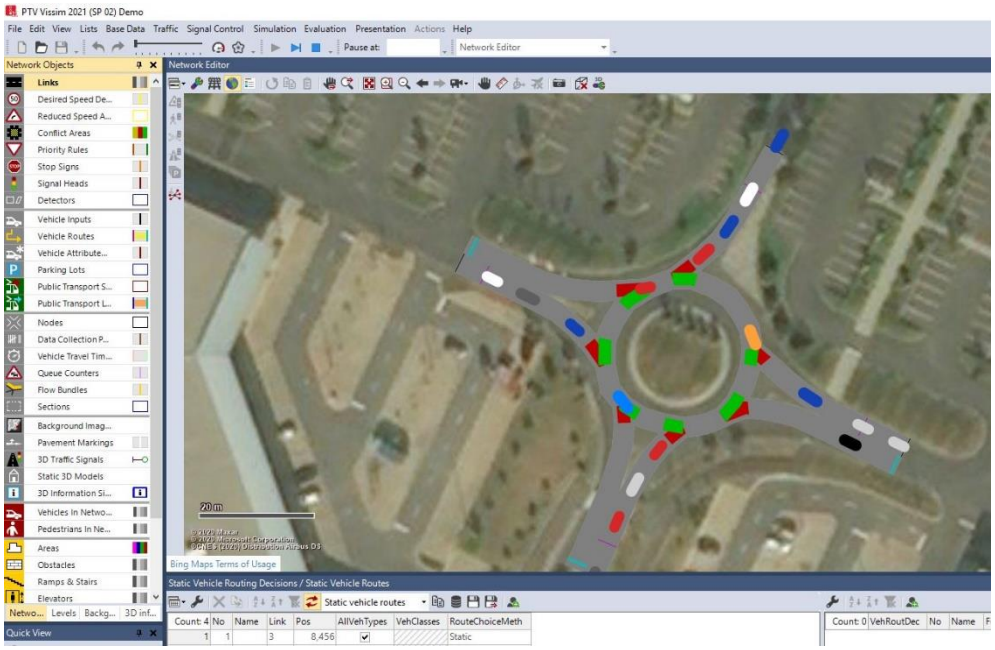

Figure 3. Simplified roundabout traffic simulation in top view

As can be seen in the examples, the design process itself is done using a graphical interface based on the use of a real map, which allows the mapping of the real transport system with virtually arbitrary accuracy, as the geometry of each road segment can be refined to any extent by the user. At the same time, it makes it possible to establish arbitrarily complex traffic connections, as well as to define the complex priority rule systems and traffic light programs required for their operation. Of course, the amount of traffic is also set by the user, which can be specified with the use of constants, but also by using more complex functions. In addition, of course, the routing decisions of the vehicles can also be set, in the case of the latter it is also possible to use several types of decision-making mechanisms. In addition, it is possible to place various sensors and detectors on the road sections, on the one hand to implement more complex traffic management models, and on the other hand to collect data that can be extracted from the simulation.

The two examples described above are a good representation of how traffic simulation software can be used to model traffic engineering and management solutions in engineering education. Of course, the application spectrum of these types of software is even wider in the case of research and actual engineering (adding that education-only software versions are, of course, usually more limited than commercial versions for industrial use). Most engineering-level problems usually require a simulation of an entire traffic area, which includes a number of intersections and several high-traffic junctions, where appropriate road and fixed track transport intersections, pedestrian traffic, the related traffic control and

management solutions, parking areas, a large number of data collection points, etc. If the input data used are sufficiently accurate, such simulations can provide accurate statistics on traffic behavior (waiting times, size and frequency of congestion, etc.), which allow the identification of bottlenecks in the transport system and thus contribute significantly to the optimal design of the system.

3. POSSIBILITIES OF APPLICATION OF TRAFFIC PLANNING SOFTWARE

While traffic simulation software is primarily used to simulate traffic as accurately as possible at the micro level, traffic planning software helps to design comprehensive transport networks (so to speak, they are tools designed to support macro-level planning). This type of software usually implements accurate and detailed modeling of the traffic conditions of large-scale transport systems using complex, multi-component and multi-level mathematical modeling procedures. The aim is usually to forecast traffic conditions as accurately as possible, which can serve as an essential basis for the future development of the transport network. The literature distinguishes between so-called traffic generation, traffic distribution, traffic sharing and traffic load sub-models, which implement successive modeling steps [4].

In the case of the PTV Visum software itself, there are many different mathematical methods to choose from to implement traffic distribution. As in Vissim, the design of Visum is carried out with the help of a graphical interface based on a real map, on which road networks and transport systems reflecting reality can be created with arbitrary accuracy. The constructed mathematical model can then be applied to the completed transport network, as a result of which the traffic distribution on the network is born. The magnitude of the distributed traffic loads is typically represented by traffic flow diagrams in addition to the specific values. The following is the result of a traffic distribution performed using a non-stochastic (ie deterministic) model for the northern and southern parts of a limited downtown personal (car based) transport network (the model is based on the center of the city of Miskolc using a simplified traffic demand matrix).

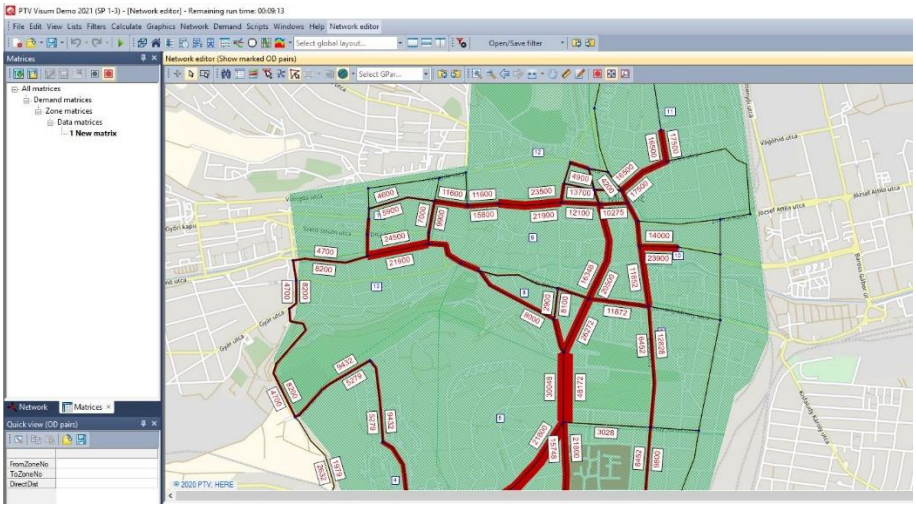

Figure 4. Northern part of road passenger transport network with traffic loads

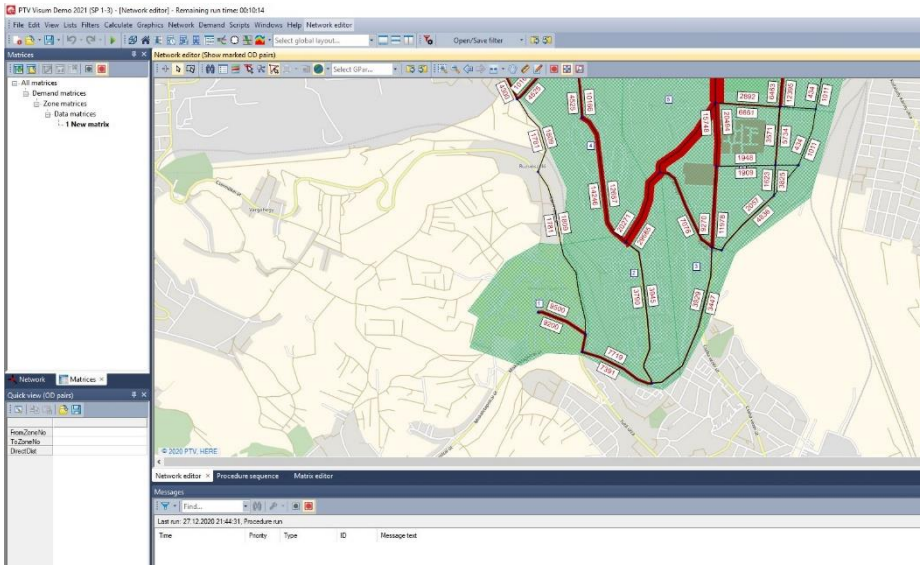

Figure 5. Southern part of road passenger transport network with traffic loads

The software provides the ability to solve problems of almost any scale, from mapping simple transport systems involving only a few traffic zones to designing complete transport networks covering many thousands of traffic areas in large cities (each version of the application allows different ceilings for the number of objects in a given model). This also shows that, like in the case of traffic simulation software, traffic planning applications can also be used both in university education and in solving extremely complex engineering and traffic planning problems which require state-of-the-art transport network modeling (in the latter case, of course, commercial versions of the software are required). Another feature of such software is that, in addition to determining traffic volumes, they allow the mapping and analysis of traffic over time using appropriate mathematical procedures, which is a very important capability for the operation of urban transport networks, where intermittent congestion poses one of the biggest problems.

In addition, traffic planning software can be particularly useful in research in that, with sufficient IT knowledge, they could in principle allow the testing of individual mathematical models in certain aspects of traffic planning. Thus, such applications could theoretically be used as test environments in operations research, allowing the comparison of the efficiency of different algorithms as well as the development and testing of unique algorithms not previously used in traffic planning.

It is especially important to mention the issue of public transport, as it is one of the most dominant forms of transport in the urban environment. Of course, traffic planning software also allows the determination of traffic loads on public transport networks, as well as the possibility of using multimodal models, which distribute the traffic on both personal and public transport networks at the same time. The figure on the next page shows the public transport network of the city of Miskolc (minimally expanded in the northern direction), on which the traffic loads were distributed based on a simplified traffic demand model (the public transport network was created by importing a publicly accessible database of the city's real public transport network [5]).

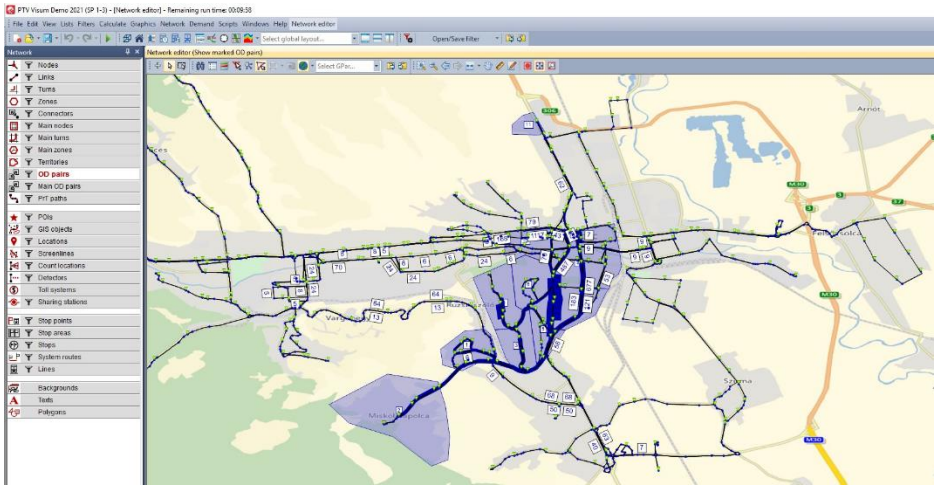

Figure 6. The road public transport network of the city of Miskolc with traffic loads from a simplified transport model

7. SUMMARY

The article describes the most important applications of traffic simulation and planning software in the fields of engineering training, traffic planning and scientific research. In this context, some simpler transport models created with the PTV Vissim and PTV Visum software were also presented, which served as examples of some of the basic applications, while also providing an insight into the additional possibilities of exploiting the higher-level functions of the software in more complex and realistic use-cases. Overall, with the further advancement of digitalization trends, the importance of the use of state-of-the-art software in transport planning will become even more important, especially in view of the growing importance of using digital twins in the overall field of engineering.

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