**Criterion:** Social relevance

**Reference and authors:** VAŠÍK, P.; ERYGANOV, I.; HRABEC, P.; KISELA, T.; HRDINA, J.; NÁVRAT, A.; ZATOČILOVÁ, J.: Software na optimalizaci trasování; Software na optimalizaci trasování. Wereldo.com, s.r.o., Purkyňova 127, 612 00 Brno. URL: https://www.wereldo.com/wereldo-trasovac. (Software)

**Location:** https://www.wereldo.com/wereldo-trasovac

## Description:

This software was created based on the cooperation of the IM FME BUT with the company Wereldo.com as a result of the MIT Application VII project called Advanced Tracing Software for Various Types of Trucks, reg. no. CZ.01.1.02/0.0/0.0/ 19_262/0020200, from 2021-2023.

The research team from BUT was responsible for designing the optimization and search algorithm and its implementation and testing. Although mostly well-known methods were used, their appropriate combination and adaptation to a specific problem already falls within applied mathematics and will be the subject of publication in the future. The algorithm's advantage is the variability of the considered transportation parameters, which simultaneously has minimal memory and computational requirements to update the entire graphic representation, which is a time- and energy-intensive process. The update can be divided into individual layers, and only the given layer can be recalculated. The back-end components designed by the IM FME BUT team are not used in any known functional software to such an extent.

Subsequently, the algorithm was purchased by Wereldo.com as part of the Agreement on the Use of Results for 1 million CZK and is currently used for tracking various types of freight transport. Wereldo.com estimates that it will save up to 15% of costs. In particular, in the case of their main customer's (DHL) turnover (up to 2 billion CZK), the estimated savings will constitute approximately 300 million CZK. This partnership with a well-known foreign logistics company at such a level proves the international significance of the result, with the potential for further growth, since other international companies will be interested in potential savings, which is currently the main competitive advantage of Wereldo.com due to the usage of the result in question.

The software also makes it possible to add emissions and carbon footprint of vehicles, which is expected to play a fundamental role in determining the price of transport or obeying low emission zones' restrictions. Negotiations are underway with representatives of the Transport Association of the Czech Republic regarding this potential algorithm application.

## Detailed description of the result:

Logistics is a neglected part of Industry 4.0. Companies are neglecting digitization and efficiency in transport. Currently, logistics companies have to purchase map documents for route planning and, if there is a change, then also their updates. The most suitable route is selected according to the number of kilometers and the dispatcher's experience. The result, "Software for tracing optimization," is focused on the goods transportation market, mainly by manufacturing and distribution companies, emphasizing aspects of Industry 4.0.

The software is an ICT solution for tracing routes for different types of trucks. Transport routing is not based on mileage but on the total transportation cost. Furthermore, other parameters are included in the routing, such as different heights and weight limits of different types of cars, external influences such as weather, elevation, road gradient, and traffic data (number of traffic lights, detours, historical and current traffic, etc.). The basis of the backend is the Contraction Hierarchies (CH) algorithm [1]. CH is intended to speed up the search for the shortest path between two arbitrary points through graph preprocessing (many-to-many problems can also be solved). Speedup is achieved by creating virtual shortcuts, which are then used to search the graph bidirectionally. The software results from cooperation between the young and already successful logistics company Wereldo.com and the Faculty of Mechanical Engineering of the BUT, specifically the Institute of Mathematics.

Manufacturing, distribution, and transportation companies currently use several available transportation planning solutions. However, these already existing solutions do not consider various important parameters, resulting in reduced logistics quality. The software eliminates the shortcomings of current solutions that:

- do not support trucks (Google, OpenStreetMap),
- do not address weight and height limits and other limits such as the slope and curvature of the path (Google),
- do not cover the entire territory of Europe (OpenStreetMap),
- do not take into account different types of trucks (TomTom, Here Maps),
- do not consider the number of stops at traffic lights (TomTom, Here Maps).

The result is intended to be used as a quantitative basis for organizing goods transportation and decision-making regarding optimizing already existing logistics chains. For each company that orders the product, the software works based on an individual database that stores the required map (graph), vehicles in the company's fleet, and closures that dispatchers will enter during operation.

From the point of view of research activity, the essential contributions and know-how of the software and the related mathematical state of knowledge include:

• A special new graphical representation of map data that adds virtual nodes so that the edges can be evaluated according to additional parameters while preserving traffic information.

• Implementation of forbidden sequences, i.e., sequences of edges, each of which can be traversed individually but cannot be traversed as a precisely specified sequence of nodes.

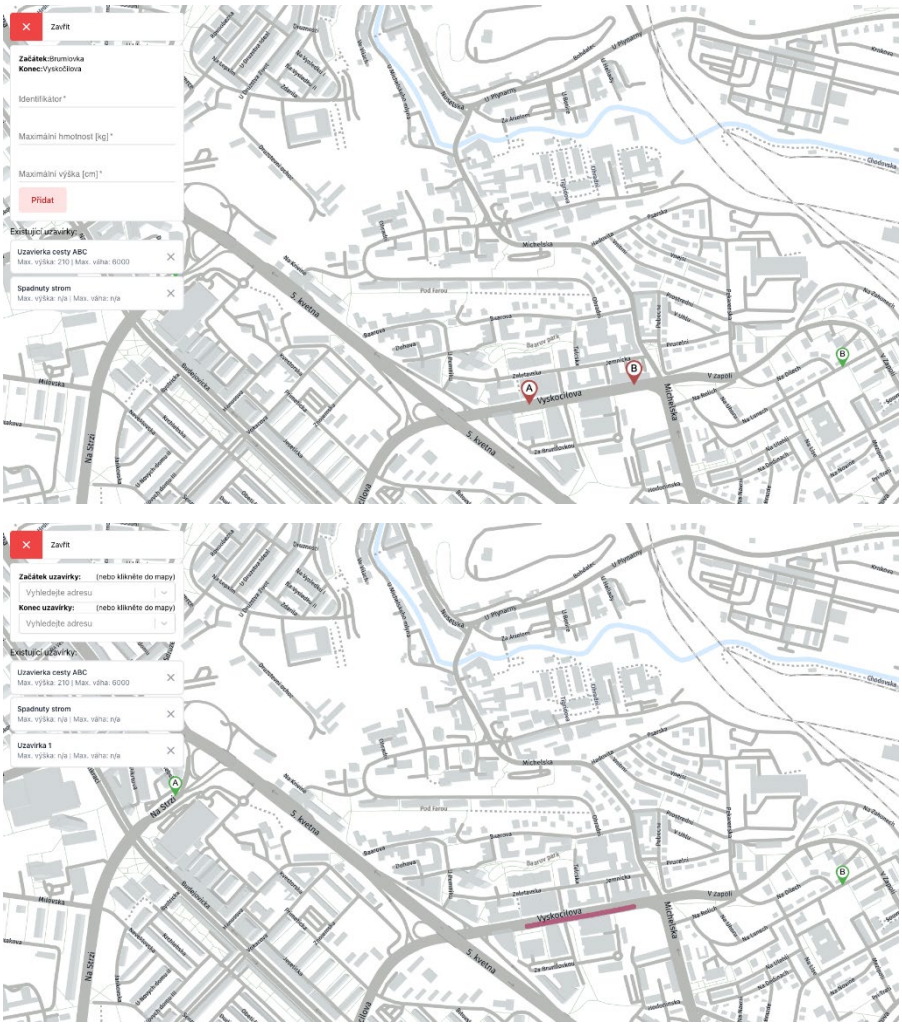
• The algorithm can process any change in the traffic situation (increase/decrease in cost of edge or its possible removal) without new preprocessing. Thus, the user can enter closures (including a time limit for the closure).

The following are screenshots showing the functionality of the application:

***Closure***

1. Original route


2. Entering the closure







3. New route

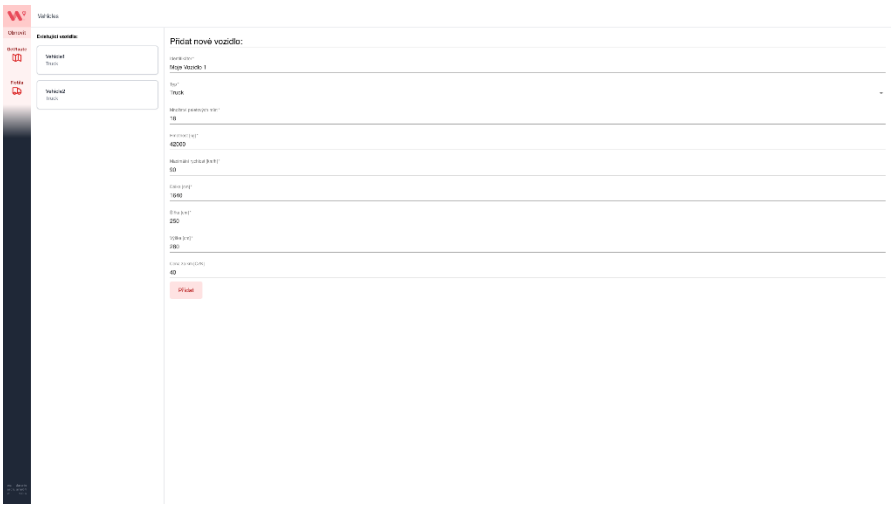

4. Deleting the closure



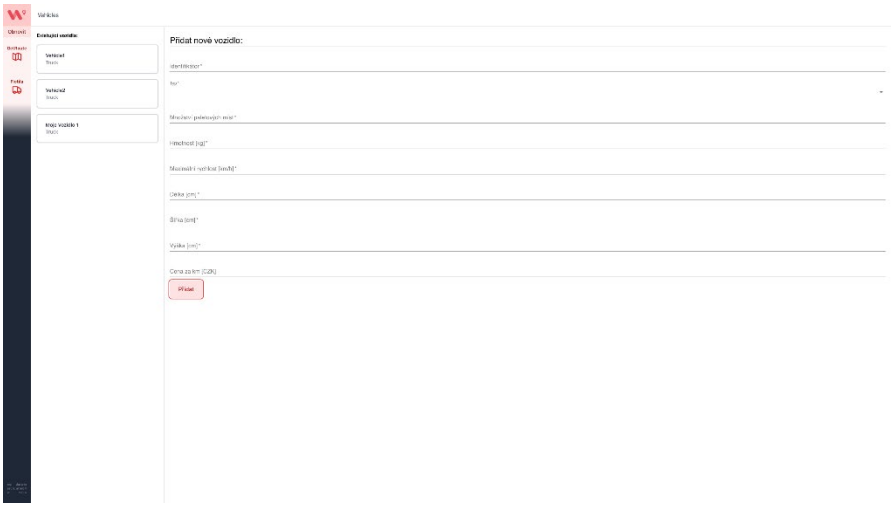
5. Return to the original route

### *Adding a vehicle*

1. Entering vehicle parameters

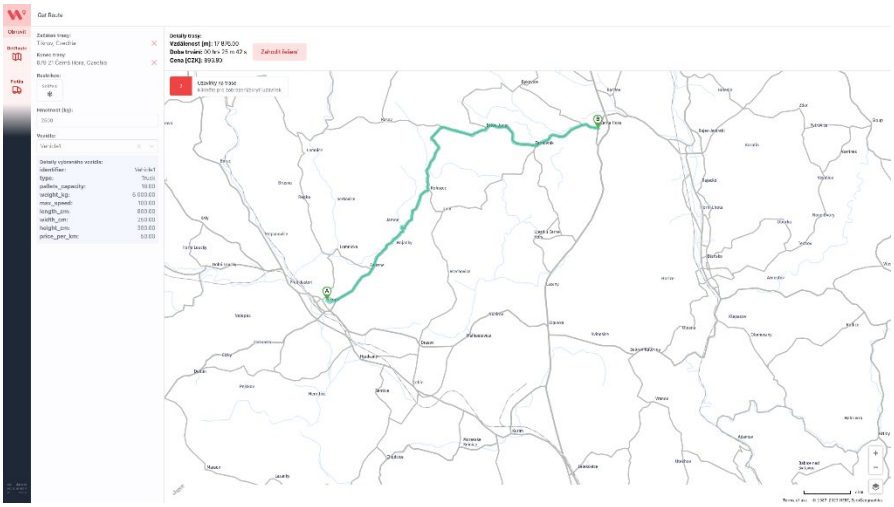


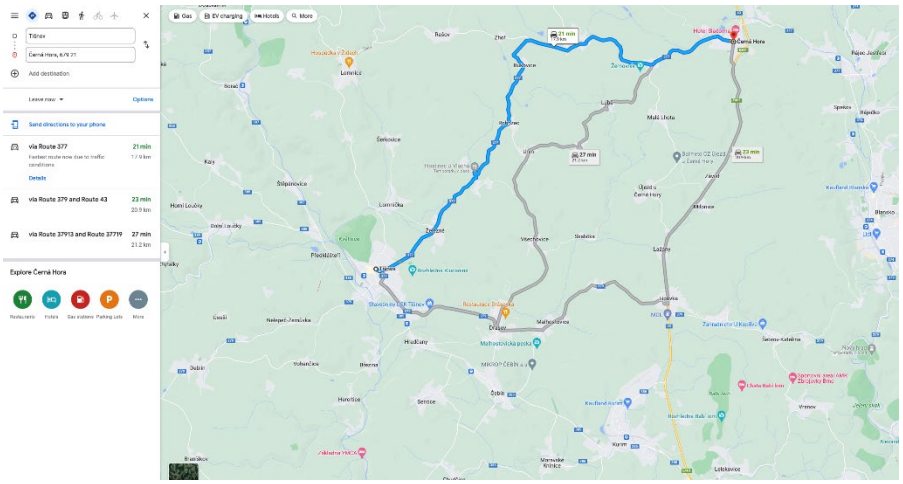

2. The new vehicle will appear in the list



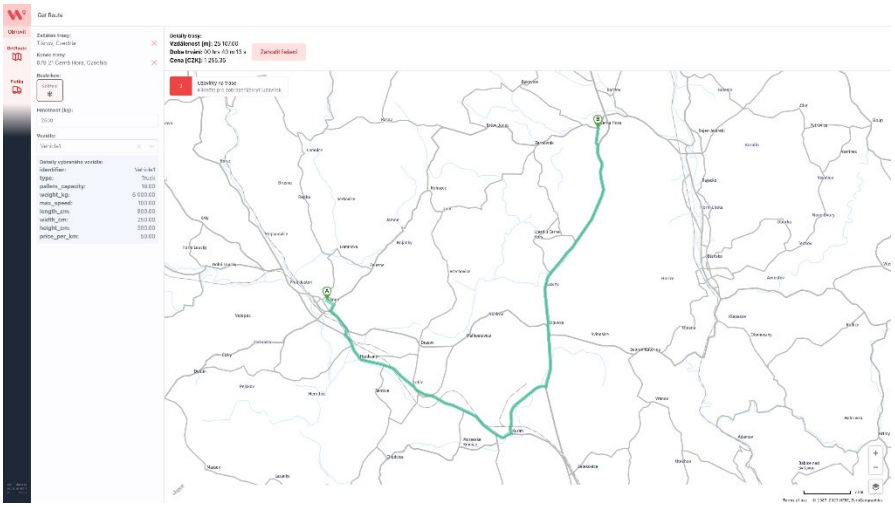

### *Effect of the weather conditions*

1. Route for a truck in summer (corresponds to results from Google)



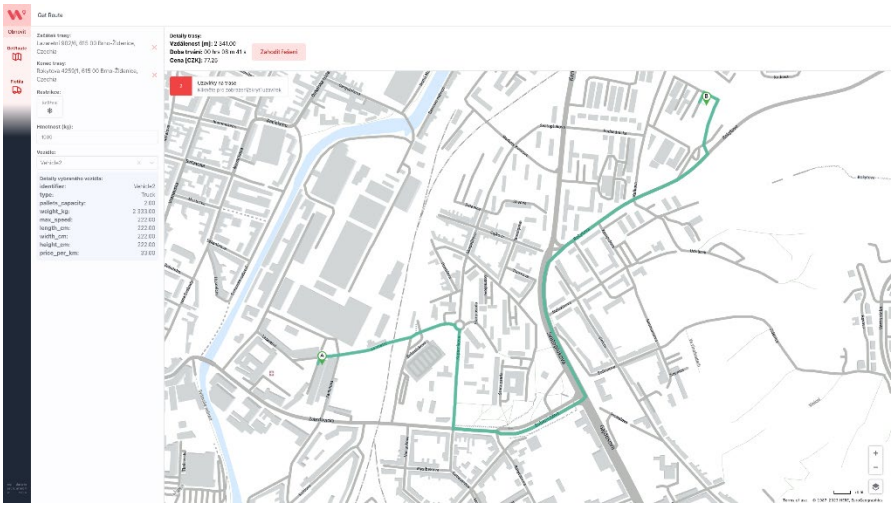


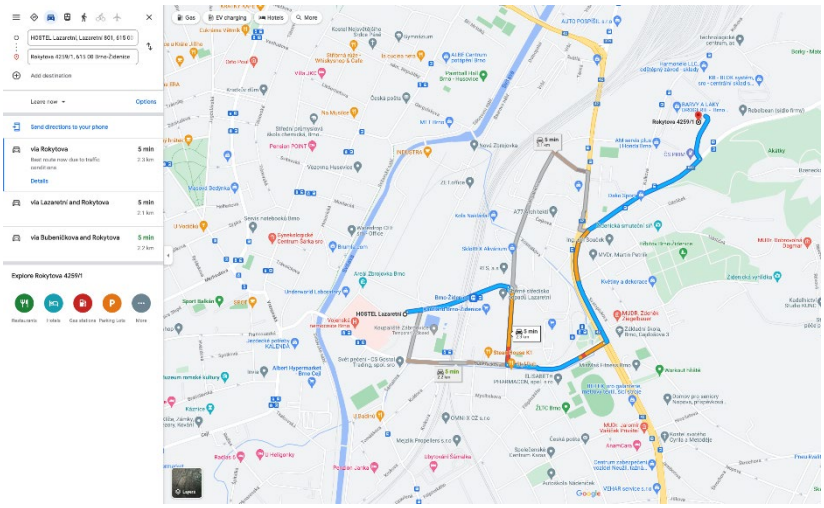
2. Adding snow (finds an alternative route due to the dangerous elevation gain on the original route)



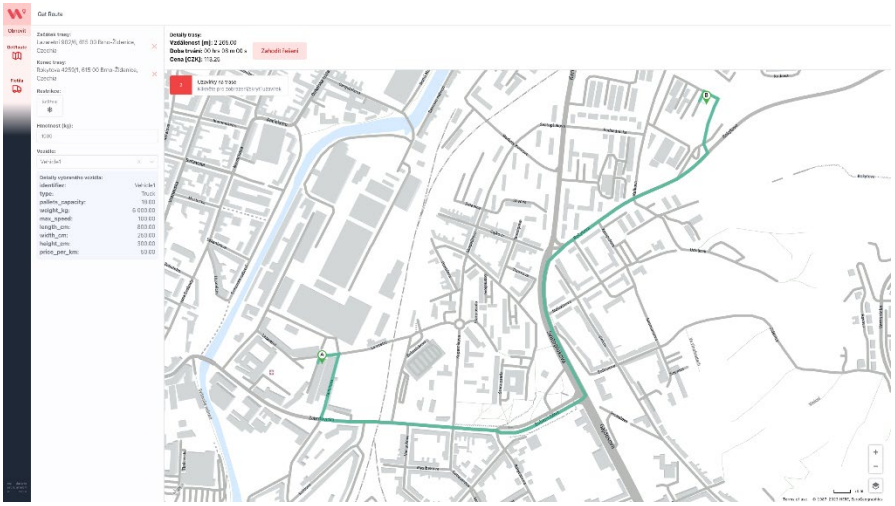
***Working with restrictions for different types of cars***

1. Route for an ordinary vehicle up to 3.5 t (corresponds to results from Google)





2. Alternative route for the truck due to height restrictions (passing under the bridge on the original route)



REFERENCES

1. Geisberger, Robert; Sanders, Peter; Schultes, Dominik; Delling, Daniel (2008). McGeoch, Catherine C. (ed.). "Contraction Hierarchies: Faster and Simpler Hierarchical Routing in Road Networks". Experimental Algorithms. Lecture Notes in Computer Science. Springer Berlin Heidelberg. 5038: 319–333