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Comparative Study of Polish and Czech Cross Country Movement Models

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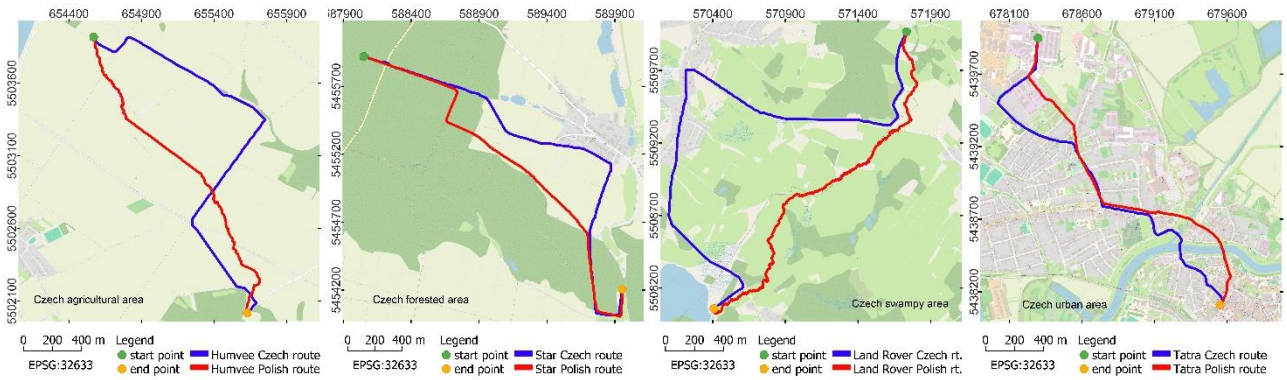
Abstract:

Terrain analysis is crucial in the operational planning process, aiming to guide planning units in decision-making regarding operation configuration. One key outcome of terrain analysis is the production of cross-country movement (CCM) maps, which delineate impassable areas for specific vehicles and outline optimal routes from start to destination. CCM maps find extensive utility in crisis management cells and military units, augmenting their planning capabilities. Numerous solutions and methodologies exist globally for crafting CCM models, as evidenced by publications such as Pokonieczny (2017), Rybanský (2022), and Bradbury (2018). This study undertakes a comparative analysis of methods developed by the Military University of Technology in Warsaw and the University of Defence in Brno, shedding light on their respective approaches.

The Czech CCM model, developed by Hubáček et al. (2018), integrates field measurements with GNSS tracking to calculate vehicle speeds. Regression analysis establishes correlations between speed and terrain features like slope. This statistical model, along with a digital elevation model and terrain representation, underpins a geoinformation model. It generates a raster of potential vehicle speeds for route optimization via least-cost analysis. Microrelief shapes' impact on passability, outlined by Dohnal et al. (2019), aids in identifying impassable obstacles for route determination. The Polish cross-country movement model meticulously evaluates terrain passability using a high-resolution digital elevation model and vehicle tractive parameters to find the optimal route. This process involves several stages, sequentially processing the elevation model to identify impassable regions and chart a route that avoids obstacles. Dawid et al. (2023) provide a detailed overview, including key stages such as generalizing the elevation model, excluding impassable zones, and iteratively determining the route while analysing microrelief.

The comparative case study utilized Polish and Czech geographical databases to assess both CCM models. Optimal route calculations were conducted across five typical land use categories found in Middle Europe: agricultural, forested, hilly, swampy, and urban (five in Poland, five in the Czech Republic), for four distinct vehicle types: Humvee, Star, Land Rover 110, and Tatra T815 8×8. A total of 40 routes were determined and compared, with route length serving as the primary parameter for comparison. Figure 1 includes a visualization of the selected routes as part of the analysis.



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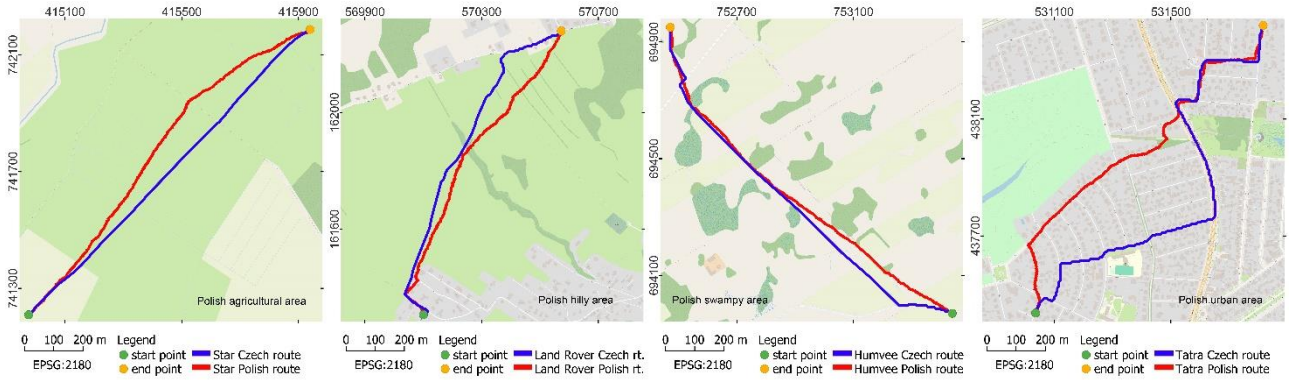

Figure 1. Determined routes with use of Polish and Czech models for selected areas and vehicles.

The comparative analysis reveals that, on average, the Czech model tends to produce longer route lengths, as demonstrated by the positive values depicted in Table 1. However, minor discrepancies in route lengths are observed in regions characterized by sparse road networks and local pathways, where the differences may be less pronounced. These outcomes align with initial expectations, which were formulated based on the distinct methodological frameworks of the respective CCM models.

Veh.	A. PL	F. PL	H. PL	S. PL	U. PL	A. CZ	F. CZ	H. CZ	S. CZ	U. CZ
Hmv	96	138	133	47	106	542	309	−71	1166	328
LR.	107	53	74	44	310	304	312	−197	919	198
Star	−46	139	190	30	168	586	292	174	1150	270
Tatra	−30	52	289	29	332	569	278	241	1189	274

Table 1. Disparity between the lengths of routes from Polish and Czech model [m]: A – agricultural; F – forested; H – hilly; S – swampy; U – urban; PL – Polish; CZ – Czech; Hmv – Humvee; LR – Land Rover. Negative value means that the Polish route is longer.

The case study reveals significant disparities between the two approaches of the CCM models. The Czech model relies on experimental field measurements, which were then validated in the field. Conversely, the Polish model is based on a thorough analysis of the interaction between vehicle chassis and terrain relief. Currently, definitively determining which model is more accurate or reliable proves challenging. Further assessment, including a comparison of additional route parameters like cost calculation, is being considered to provide clarity.

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