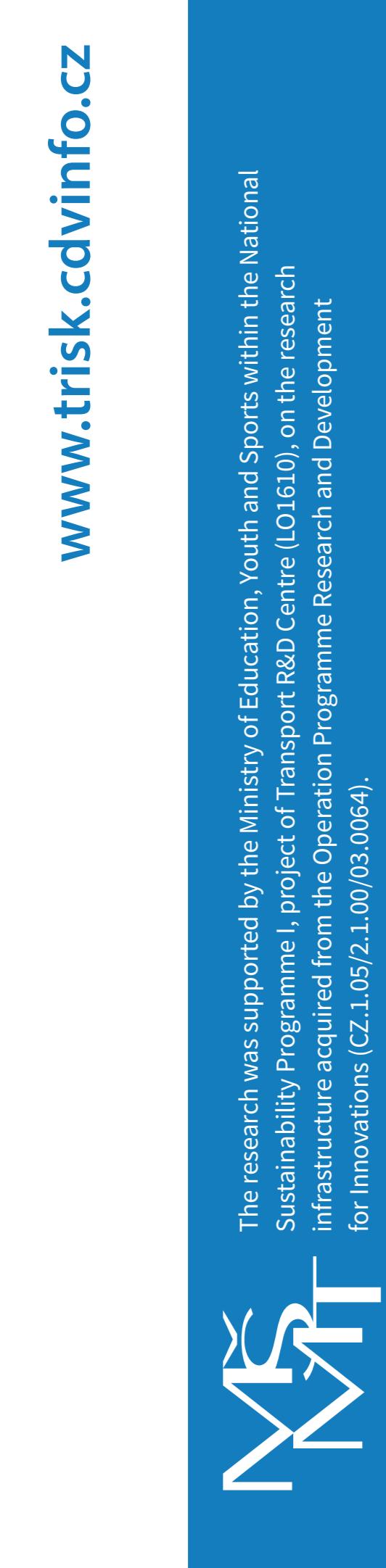


IMPROVING SOCIETAL RESILIENCE THROUGH ENHANCED RECONNECTION SPEED OF DAMAGED NETWORKS



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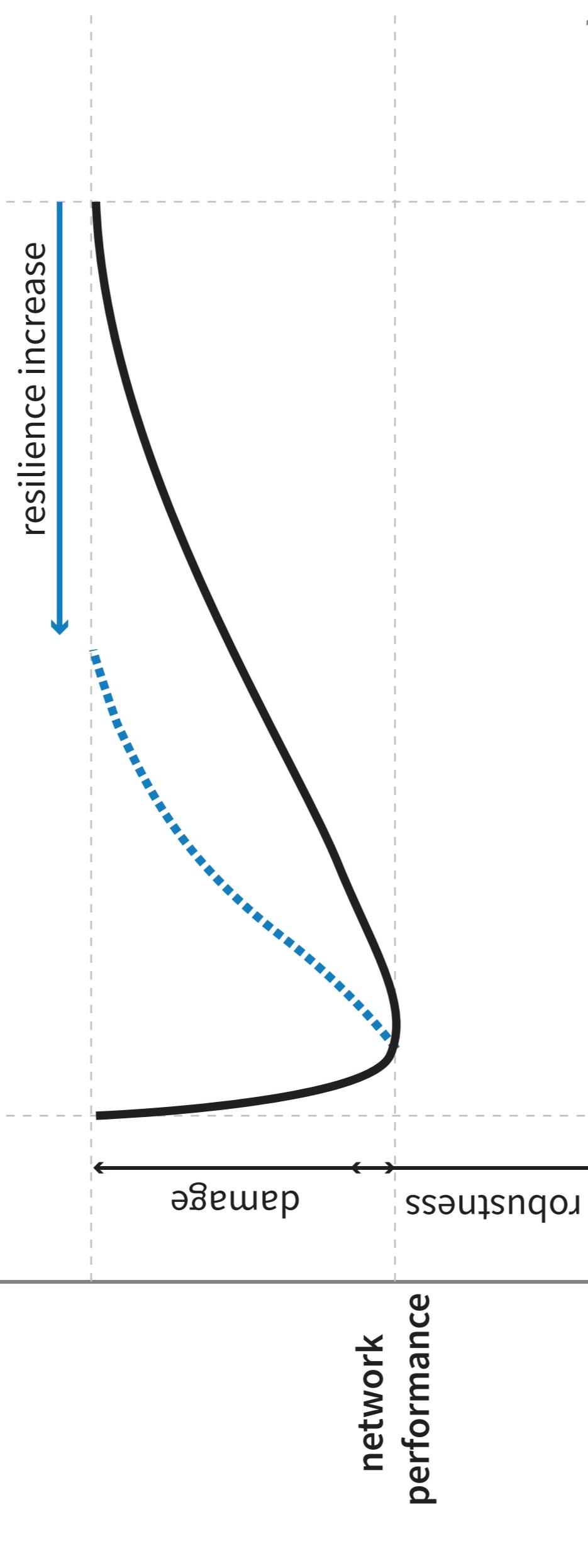
Introduction

- » Extreme events which result in road network break up will occur regardless of the process of hazard reduction.
- » We focus on the speed of the recovery process which can be optimized.
- » The result of the optimization procedure is a sequence of road links which represent the optimal routes of the repair units or distribution of relief.
- » The optimization process is, however, highly nontrivial because of the large number of possible routes.
- » We introduce an approach based on the Ant Colony Optimization algorithm which is able to suggest an almost optimal solution under various constraints
- » This approach can then be applied by, e.g. the administrator of the network / relief agency.

IMPROVING RESILIENCE for disconnected networks means shortening the time of connection

The main aims of the earliest phase of the reconstruction process are:

- » Rapid relief distribution
- » Rapid connection of the isolated parts of the network



Consequences

1. Road network disintegration into isolated parts
 2. Reduced network serviceability (due to prolonged travel times)
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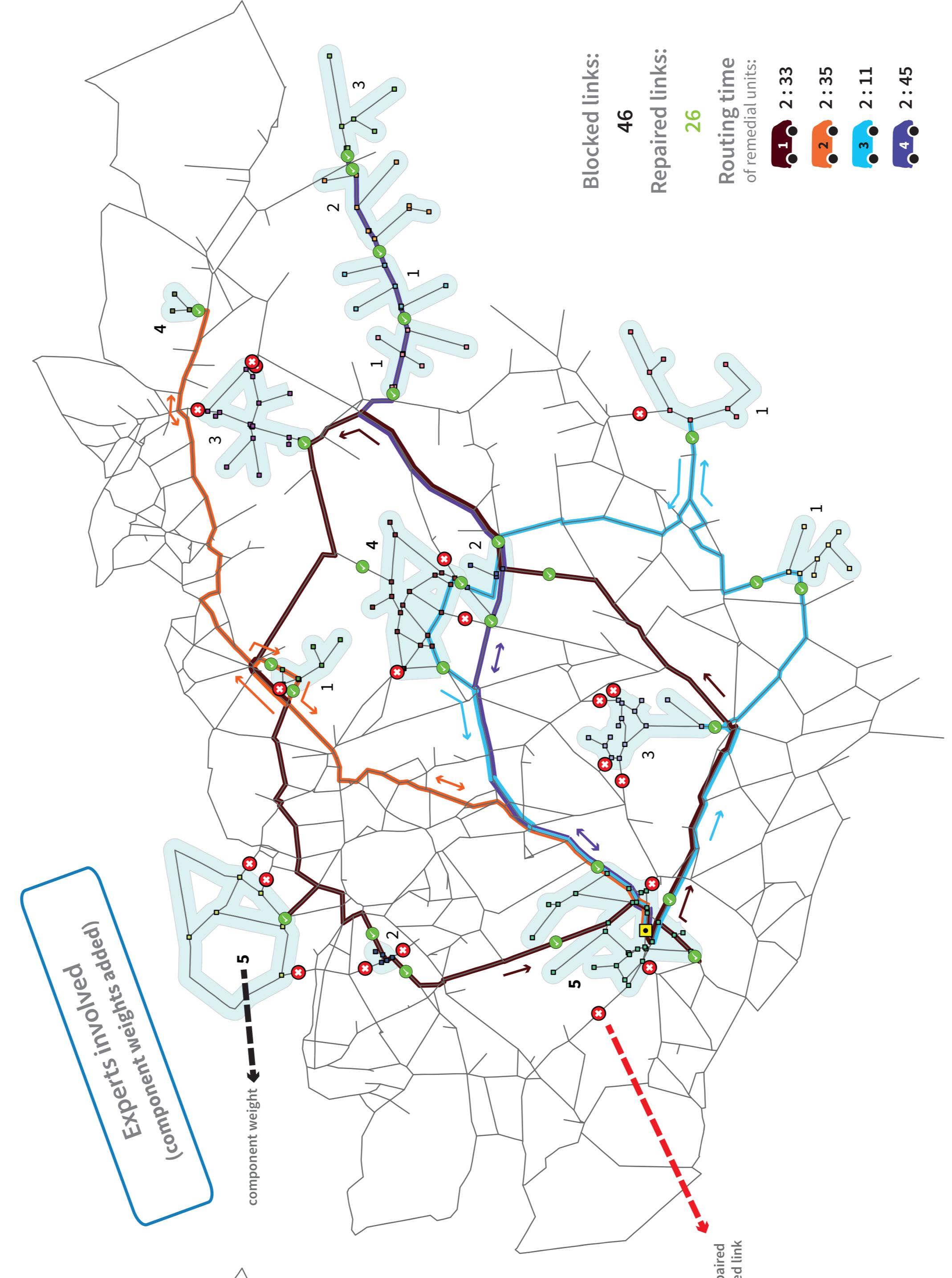
Solutions

Geosciences		Structural solutions		Network solutions	
Natural hazards identification and spatial occurrence mapping	What natural processes could take place here?	Increasing physical resistance of vulnerable objects	Identify nodes whose connection will improve network robustness the most	Build new roads to increase resilience with effective network redundancy	Network links prioritization in order to restore connection
		Robust objects will withstand natural hazards longer			

THE TOPIC OF THIS POST

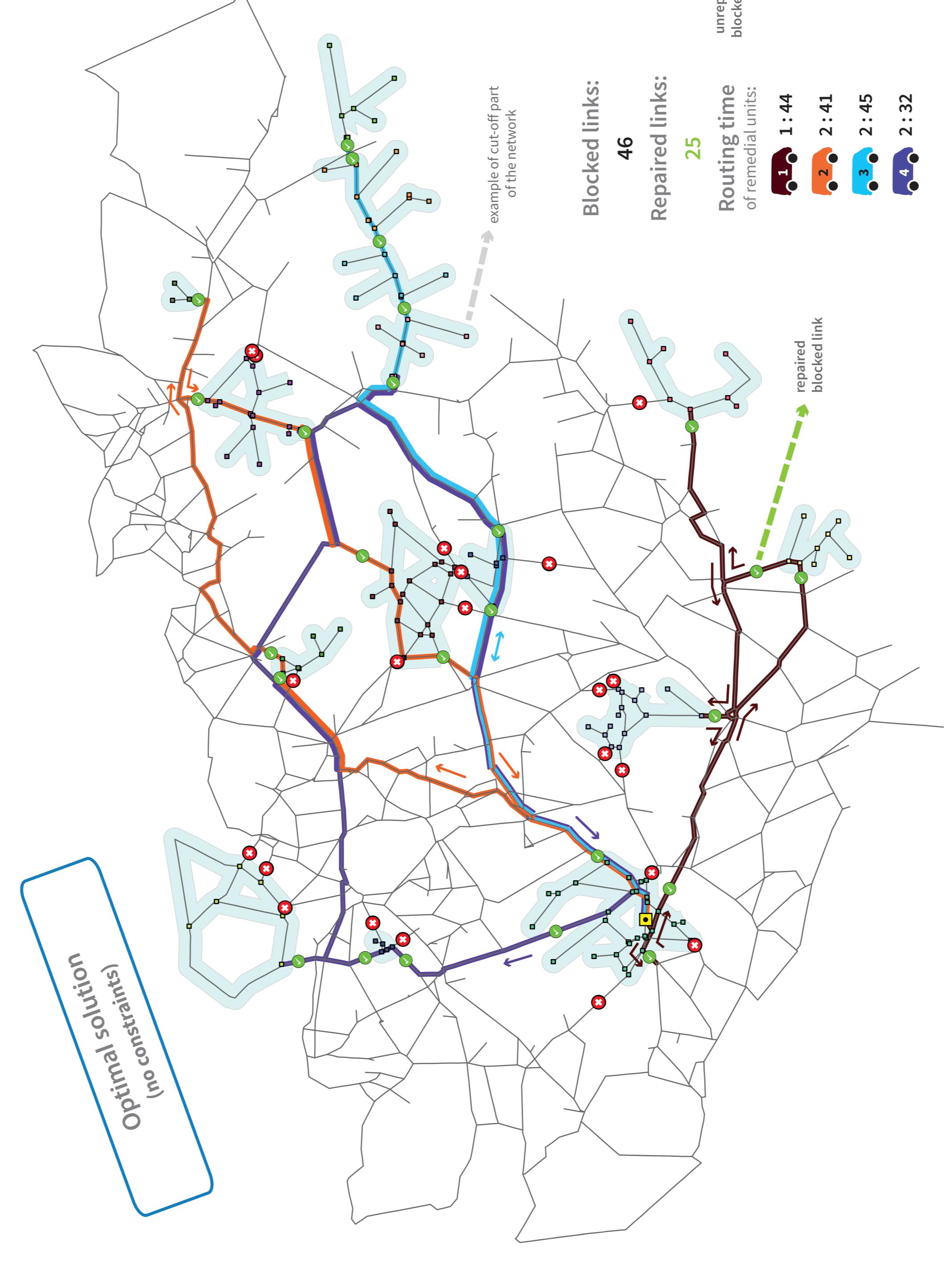
Known issues

1. How to find an optimal combination of links to be repaired?
 2. What does optimal mean? What are the criteria of optimality?
 3. Are all the criteria necessary or should they only be included as a recommendation?
 4. Can there be only one algorithm for all the applications?
- (the reconstruction process, relief distribution, utilization of heavy machinery during repairs)



Where to begin?

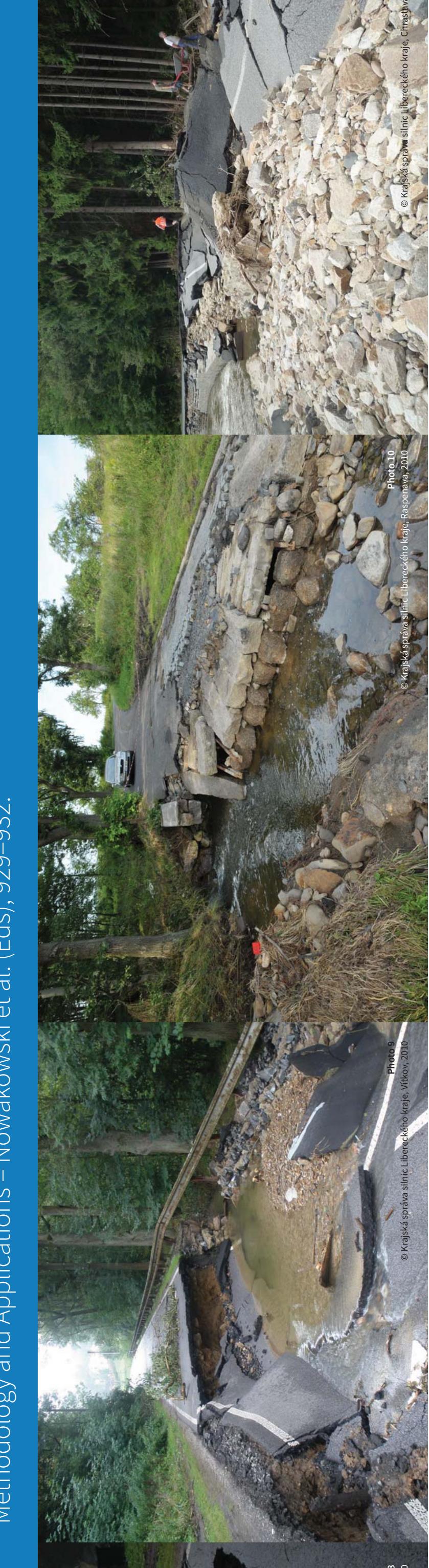
1. Monitor the situation (identify the blocked road links, network components, people and important facilities without connection)
2. Activate remedial units
3. Ask experts to assess importance of each isolated part (optional, if there is an expert)
4. Plan routes for remedial units (run the algorithm presented here)
5. Start security actions and reconstructions (repair immediately only the most important road links in order to secure connectivity)



Future works

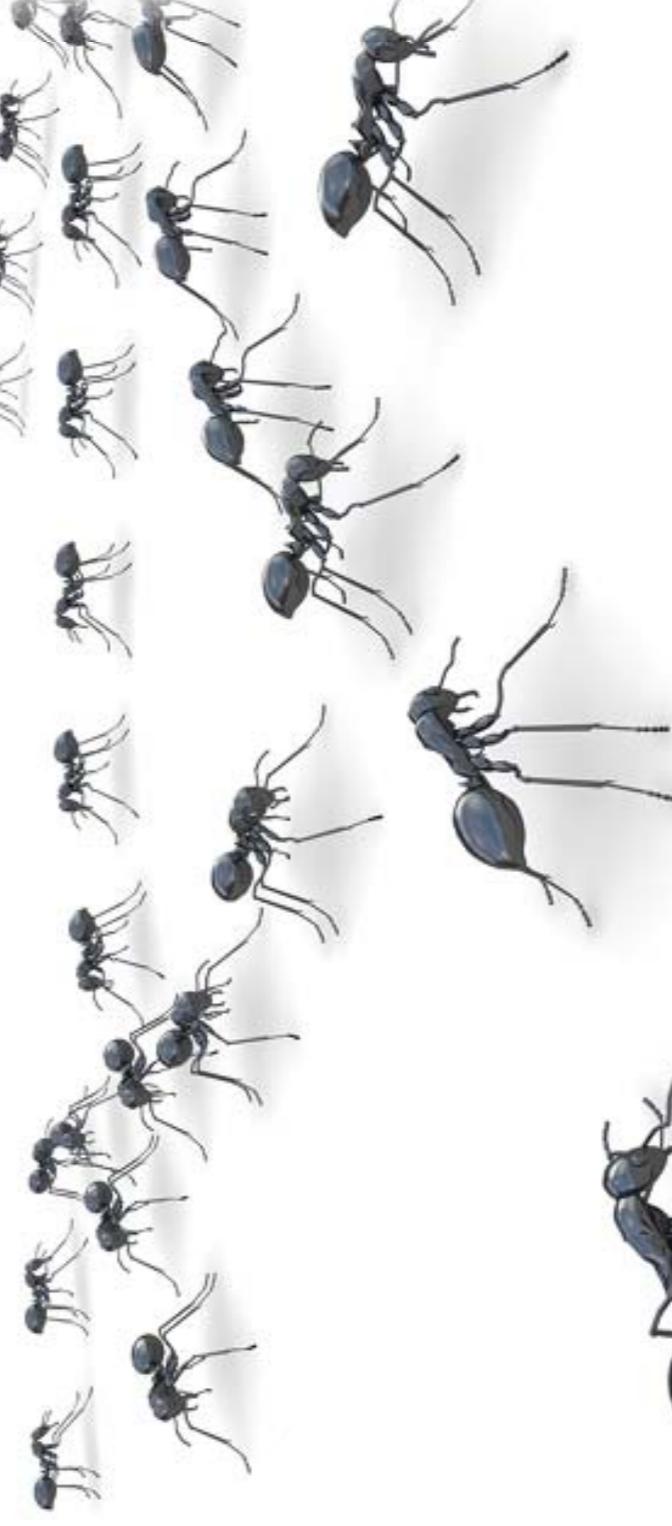
1. Analyzing dependencies among reconstruction works of remedial units.
2. Modification of the loss function and the algorithm to cover further optimization criteria (e.g., the relative importance of certain nodes for the entire network etc.)

Bil, M., Vodák, R. (2014): *The stochastic approach in road network vulnerability analysis: Safety and Reliability*. Methodology and Applications – Nowakowski et al. (Eds.), 929–932.



Where can this approach be applied?

1. (Humanitarian) relief distribution
2. Effective utilization of heavy machinery during repairs
3. Planning road repairs including further criteria influencing the roads of remedial units (number of cut-off people, an expert's estimate of importance of components, etc.)



Vodák, R., Bil, M., Kubecák, J., Andrášik, R. (2015): *Evaluating road network damage caused by natural disasters in the Czech Republic between 1997 and 2010*. Transportation Research Part A: Policy and Practice 80, 90–103.



The presented solution of road link prioritization

We used a modification of the ant colony algorithm which is based on pheromone trails and a heuristic. This algorithm ranks among the swarm intelligence methods and it constitutes certain metaheuristic optimizations.

Publications:

