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Determination of Optimal Work Zones in a Transport Network with A Mixed-Integer Linear Programming Model

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A-PROBLEM / GOALS

Infrastructure managers are not only required to determine which deteriorated objects need to be upgraded but also the work zones in which construction activities are executed in the most efficient and beneficial way. To achieve this objective, an optimization model using mixed-integer linear programming is developed that allows managers to determine optimal workzones in a transportation network. The model includes the objective function that maximizes the long term benefit. Work zones are subject to several constraints; a maximum work zone length constraint, a minimum distance between work zones and a budget constraint.

B-MODEL

Objective function: $$Maximize\ \ Z = \sum_{n=1}^{N}\sum_{k=1}^{K}\delta_{n,k}\cdot(B_{n,k} - C_{n,k})$$

Constraints:

(1) Continuity $$\sum_{n=1}^{N}\sum_{k=1}^{K}\delta_{n,k} = 1$$

(2) Budget $$\sum_{n=1}^{N}\sum_{k=1}^{K}\delta_{n,k}\cdot C_{n,k} \le \Omega$$

(3) Max length of work zone and min distance betweet work zones $$\sum_{n=1}^{N}\sum_{k=1}^{K}\delta_{n,k}\cdot\gamma_{n,k,i} \le 1\ \ \forall i$$

n: object
k: intervention type
δ: decision variable
B : Benefit
C : Cost
Ω: Budget
γ: Combination parameter

C-VALAIS ROAD NETWORK

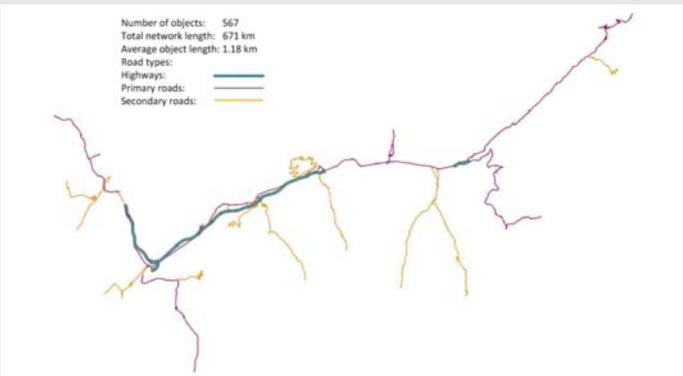

Figure 1: Road network - Canton of Valais, Switzerland

- The network is divided into 567 objects with a total length of 671 km.
- Three intervention types are avalable for each object:
  + Do-nothing (type 0) intervention,
  + Low benefit (type 1) intervention and
  + High benefit (type 2) intervention
- A routing algorithm is developed to form a matrix of continuity and a matrix of combination parameters.
- Three scenarios are formulated to see the changes in optimal results.
- A mixed-integer linear solver is used with branch and bound algorithm.

D-RESULS

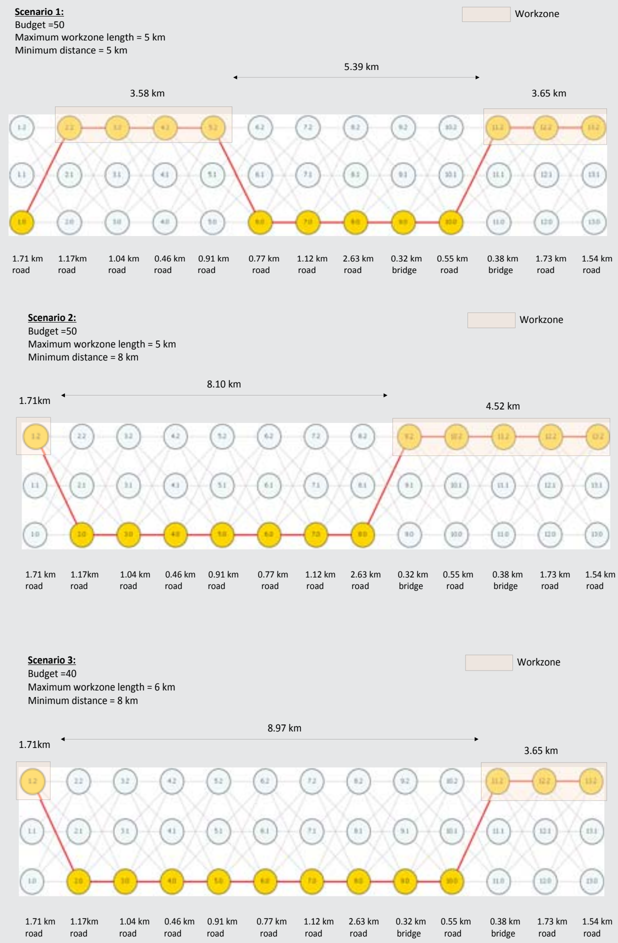

Figure 2: Graphical represetation of optimal solution for a part of the network

Table 1: Summary of optimal solutions

Scenarios	Budget (mus)	Max work zone length (km)	Min distance (km)	Benefit (mus)	Number of selected objects
1	50	5	5	483	23
2	50	5	8	456	29
3	40	6	8	386	17

E-CONCLUSIONS

- The routing algorithm is robust and enables a simulation of large networks.
- Optimal solution is obtained satisfying all constrainsts, especially the maximum length of work zones and minimum distance between adjadcent work zones that were not possible with previous researches.
- Inputs and outputs can be represented graphically using GIS softwares.
- The model can be extended to generate work programs for multiple planning periods.