Applications of Operations Research and Mathematical Programming

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Computational Aspects of Optimization

Contents

Operations Research and Mathematical Programming

Goal: improve/stabilize/set of ...

- Problem understanding
- Problem description – probabilistic, statistical and econometric models
- Optimization – mathematical programming (formulation and solution)
- Verification – backtesting, stresstesting
- Implementation (Decision Support System)
- Decisions

Operations Research/Management Science

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Operations Research/Management Science

Optimization of advertising campaigns

- **Goal** – maximization of the effectiveness of a advertising campaign given its costs or vice versa
- **Data** – "peoplemeters", public opinion poll, historical advertising campaigns
- **Target group** – (potential) customers (age, region, education level ...)
- **Effectiveness criteria**
  - GRP (TRP) – rating(s)
  - Effective frequency – relative number of persons in the target group hit k-times by the campaign
- Nonlinear (nonconvex) or integer programming

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Vehicle routing problems

- **Goal** – maximize *filling rate* of the ships (operation planning), fleet composition, i.e. capacity and number of ships (strategic planning)
- **Rich Vehicle Routing Problem**
  - time windows
  - heterogeneous fleet
  - several depots and inter-depot trips
  - several trips during the planning horizon
  - *non-Euclidean distances* (fjords)
- Integer programming :-(, constructive heuristics and tabu search

- **Downstream logistics optimization at EWOS Norway**. Research report, Molde University, submitted. With K. Haugen, J. Novotný, A. Olstad

Vehicle routing problems

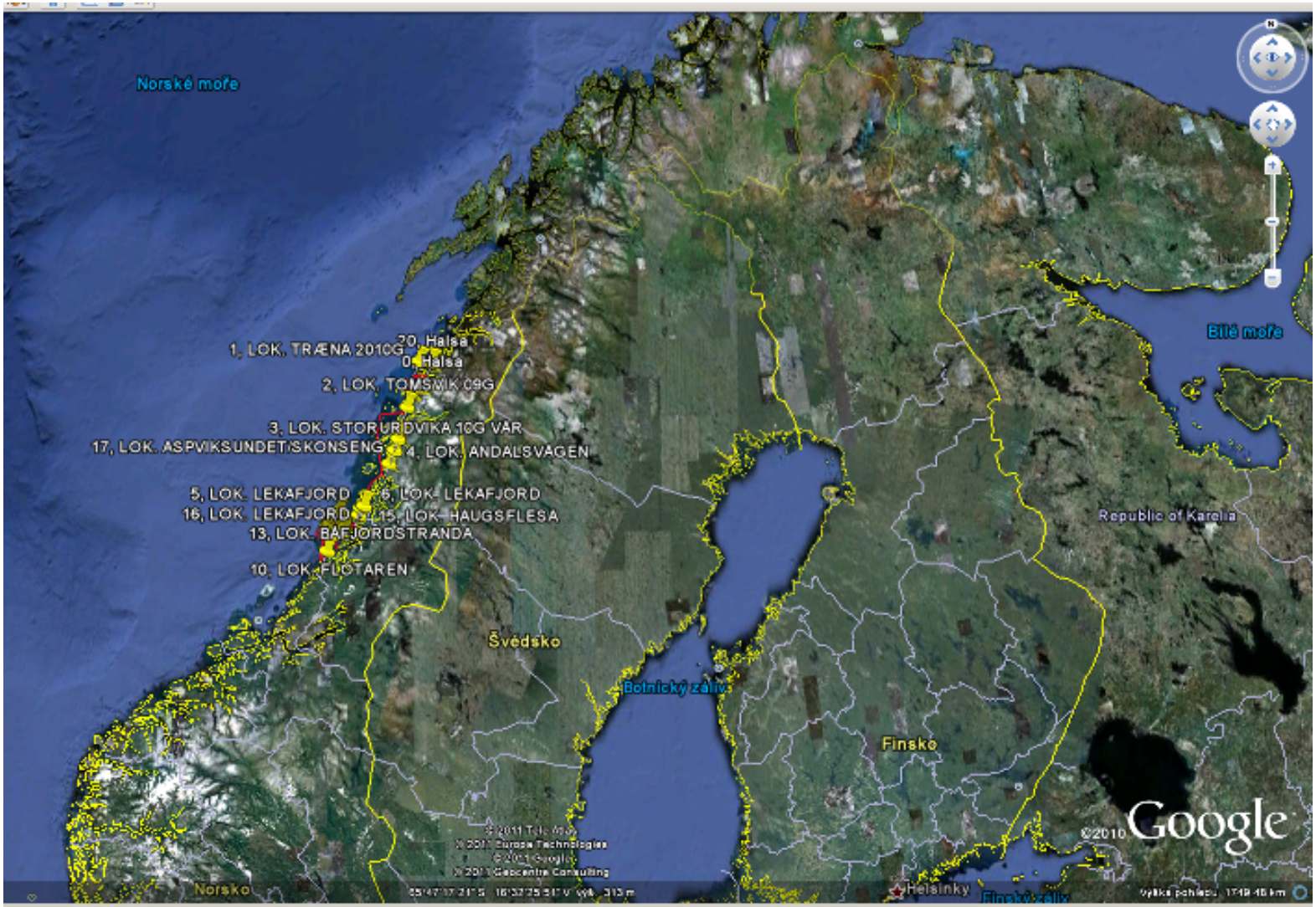
- Traveling Salesman Problem
- Uncapacitated Vehicle Routing Problem (VRP)
- Capacitated VRP
- VRP with Time Windows
- ...

Vehicle routing problems

Our approach:

1. Mathematical formulation
2. Solving using GAMS based on historical data
3. Heuristic(s) implementation
4. Implementation to a Decision Support System

In the future, *Inventory Routing* ...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15, LOK. HAUGSFLESA
13, LOK. BAFJORDSTRANDA
10, LOK. FLOTAREN
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Scheduling – Reparations of oil platforms

- **Goal** – send the right workers to the oil platforms taking into account uncertainty (bad weather – helicopter(s) cannot fly – jobs are delayed)
- **Scheduling** – jobs = reparations, machines = workers (highly educated, skilled and costly)
- Integer and stochastic programming

- M.B., J. Novotný, A. Olstad: **Fixed interval scheduling under uncertainty - a tabu search algorithm for an extended robust coloring formulation**. Computers & Industrial Engineering 93, 45–54, 2016.
- M.B., Š. Hájek: **Flow-based formulations for operational fixed interval scheduling problems with random delays**. Computational Management Science 14(1), 161–177, 2017.

Pricing in nonlife insurance

- **Goal** – optimization of prices in MTPL/CASCO insurance taking into account riskiness of contracts and competitiveness of the prices on the market
- **Risk** – compound distribution of random losses over 1y (Data-mining & GLM)
- Nonlinear stochastic optimization (probabilistic or expectation constraints)

- M.B. **Optimization approaches to multiplicative tariff of rates estimation in non-life insurance**. Asia-Pacific Journal of Operational Research 31(5), 1450032, 17 pages, 2014.
- M.B. **Underwriting risk control in non-life insurance via generalized linear models and stochastic programming**. Proceedings of the 30th International Conference on MME 2012, 61–66.

Multiplicative tariff of rates

		GLM	SP model (ind.)	SP model (col.)
TG	up to 1000 ccm	3 805	9 318	5 305
TG	1000–1349 ccm	4 104	9 979	5 563
TG	1350–1849 ccm	4 918	11 704	6 296
TG	1850–2499 ccm	5 748	13 380	7 125
TG	over 2500 ccm	7 792	17 453	9 169
Region	Capital city	1.61	1.41	1.41
Region	Large towns	1.16	1.18	1.19
Region	Small towns	1.00	1.00	1.00
Region	Others	1.00	1.00	1.00
Age	18–30y	1.28	1.26	1.27
Age	31–65y	1.06	1.11	1.11
Age	over 66y	1.00	1.00	1.00
DL less that 5y	YES	1.00	1.00	1.00
DL more that 5y	NO	1.19	1.13	1.12

Optimization in power industry

Energy markets

- **Goal** – profit maximization and risk minimization
- **Day-ahead bidding** from wind (power) farm
- Nonlinear stochastic programming

Power plant operations

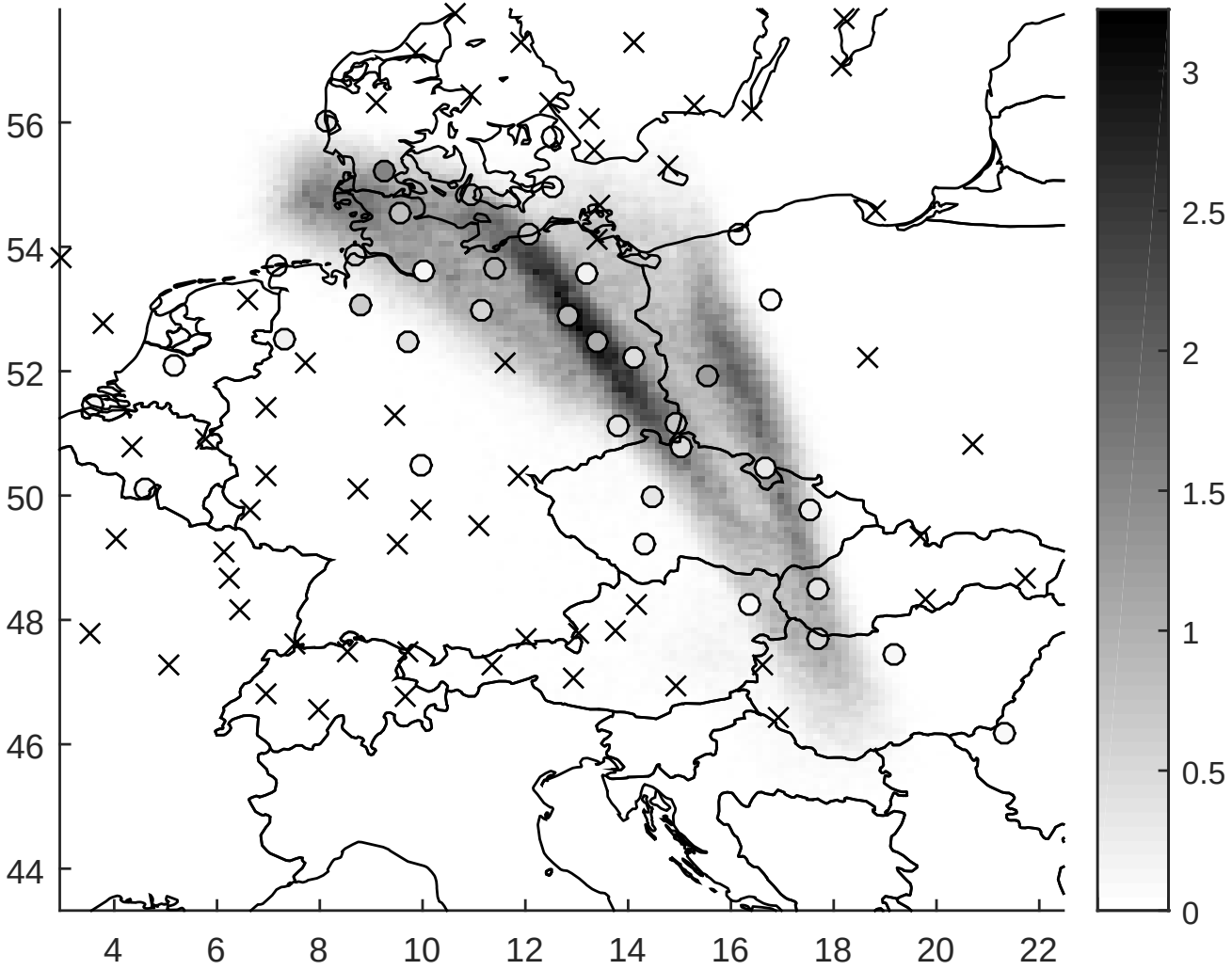
- **Goal** – profit maximization and risk minimization
- **Coal power plants** – demand seasonality, ...
- Stochastic linear programming (multistage/multiperiod)

Inverse modelling in atmosphere

- **Goal** – identification of the source and the amount released into the atmosphere
- **Standard approach** – dynamic Bayesian models
- **New approach** – Sparse optimization – Nonlinear/quadratic integer programming (weighted least squares with nonnegativity and sparsity constraints)
- **Applications**: nuclear power plants accidents, volcano accidents, nuclear tests, emission of pollutants ...

- L. Adam, M.B.: **Sparse optimization for inverse problems in atmospheric modelling.** Environmental Modelling & Software 79, 256–266, 2016. (free Matlab codes available)

- **Project:** http://stradi.utia.cas.cz/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