

# Applications of Operations Research and Mathematical Programming

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COMPUTATIONAL ASPECTS OF OPTIMIZATION

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**Goal:** improve/stabilize/set of ...

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

Operations Research/Management Science

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# Optimization of advertising campaigns

- **Goal** – maximization of the effectiveness of a advertising campaign given its costs or vice versa
- **Data** – “peplemeters”, 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 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

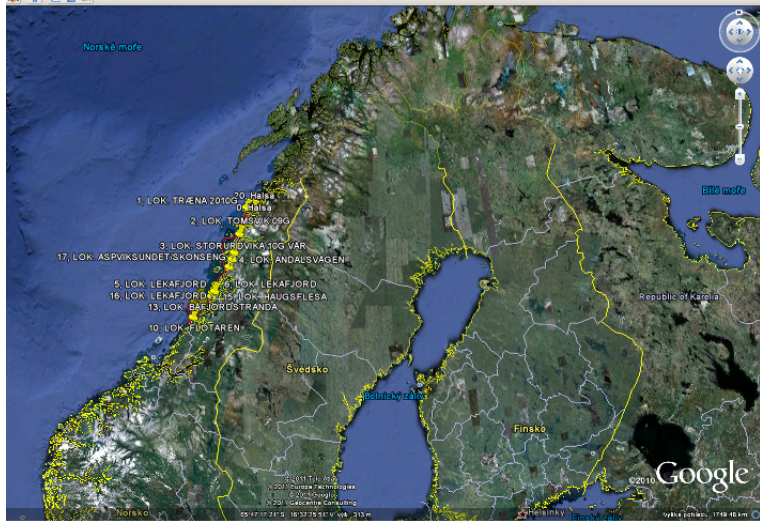
- Traveling Salesman Problem
- Uncapacitated Vehicle Routing Problem (VRP)
- Capacitated VRP
- VRP with Time Windows
- ...

# 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* ...



# Optimization of reparations of oil platforms

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

# Pricing in nonlife insurance

- **Goal** – optimization of prices in MTPL/CASCO insurance taking into account riskiness of contracts and competitiveness of prices
- **Risk** – compound distribution of random 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/multi-period)

# Inverse modelling in atmosphere

- **Goal** – identification of the source and of the amount released into the atmosphere
- **Standard approach** – Bayesian models
- **New approach** – Sparse optimization – Nonlinear/quadratic integer programming
- **Application:** (nuclear) power plants accidents, volcano accidents, nuclear tests, ...
- 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/>



