Optimization and Operations Research Motivation

Michel Bierlaire

Introduction to optimization and operations research



Operations Research: a short history

17th-18th centuries

Decision problems involving uncertainty



D. Bernoulli



C. Huygens



B. Pascal

19th century

- ▶ Invented the first mechanical computer.
- ▶ Worked on transportation problems.

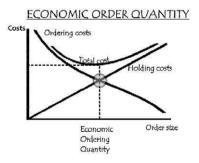


Ch. Babbage

Operations Research: a short history

Harris (1913)

Inventory management, optimization.



Operations Research: a short history

Patrick Blackett (1897–1974)

- Military operations.
- Organization of convoys.



George Dantzig (1914–2005)

Simplex algorithm (1945)



Key concepts

Modeling

Translation of real problems into mathematical formulation.

Optimization

Identification of the best possible configuration of a system.

Simulation

Imitation of the operations of a complex system in a computer.

Concrete research in our laboratory Airlines



- Crew assignment.
- Re-optimization after a major disruption.

Port operations

- Port of Gioia Tauro, Italy.
- ▶ Port of Ras-Al-Khaima, UAE.



Urban traffic

- ► Traffic light optimization.
- ► Mitigation of congestion.



Vehicle routing

- ► School bus.
- Parcel delivery.
- ► Collection of recycled waste.



Train timetable

- Passenger-centric timetable.
- Disposition timetable in case of major disruption.



Electric bus

- ► TOSA: catenary-free electric bus
- Fast charging at bus stop.
- ▶ Which bus stops must be equipped?



Accelerated moving walkways

- ▶ Post-car world: car-free cities.
- Promotion of walking.



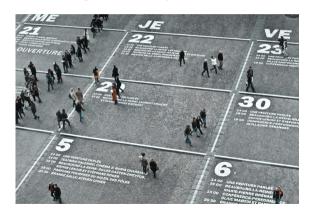
Clip-Air: a modular aircraft

- ► Capsules can be transferred on road or rail.
- For passengers, freight, or fuel.



Activity-based models: an optimization approach

- ► In collaboration with SBB/CFF/FFS
- ▶ Reproduce the scheduling of a full day.



Course structure

Seven topics

- 1. Linear optimization: from geometry to algebra.
- 2. Linear optimization: the simplex algorithm.
- 3. Duality.
- 4. Networks and transhipment.
- 5. Shortest paths
- Integer optimization Branch and bound.
- 7. Unconstrained nonlinear optimization Newton's method and line search.

Textbook

