1.224J/ ESD.204J

Outline

– Sign-up Sheet
  • Introductions
– Carrier Systems Overview
– Course Overview
  • Syllabus
Course Objective #1

Provide an understanding of carrier systems
Carrier Systems

• Transportation service networks
  – Warehouses/ Consolidation centers/ Hubs/Yards
  – Dock doors, gates

• Assets
  – Vehicles
  – Personnel/ Crews
  – Handling equipment

• Movement requirements
  – Freight
  – Passengers
Carrier Problems: Core Components

• Time and Space Considerations
  ➢ Large-Scale Problems

• Discrete Conveyances and Personnel
  ➢ Integrality Requirements

• Networked operations
  ➢ Inter-related decisions

• Non-linear and Flow-dependent Costs
  ➢ Non-linear, complex interdependencies
Some Examples
Less-Than-Truckload Operational Load Planning

• Given:
  – Tractor, trailer, load, driver routes and schedules
  – Real-time information describing status of the system

• Find:
  – New tractor, trailer, load, and driver routes and schedules to minimize costs and satisfy service requirements given current system status and limited knowledge of future status
Rail Yard Modeling

• Given:
  – Operations at an inter-modal rail yard
  – Available resources

• Develop:
  – Simulation of yard activities
    • Describe/evaluate yard performance and resource utilization
  – Optimization-based strategies to improve yard performance
Airline Fleet Assignments

• Given:
  – Flight schedule
    • Flight legs
    • Departure times
  – Fleets (aircraft types)
    • Operating and carrying costs per flight leg
    • Number of aircraft
    • Operating characteristics
  – Passenger itinerary demand
    • Itinerary fares

• Develop:
  – Minimum cost assignment of aircraft types to flight legs
    • Each flight is assigned exactly one fleet type
    • Only available aircraft of each type are assigned
    • Aircraft balance is achieved, by location
The Overall Planning Process
Service Planning Hierarchy

**Input**
- Demand characteristics
  - Infrastructure
  - Resources
  - Policies (e.g. coverage)
- Demand characteristics
  - Resources
  - Policies (e.g. headways and pass loads)
- Route travel times
  - Demand characteristics
  - Resources
  - Policies (e.g. reliability)
- Route travel times
  - Resources
  - Policies (e.g. reliability)
- Work rules and pay provisions
  - Resources
  - Policies

**Function**
- Network and Route Design
- Frequency Setting
- Timetable Development
- Vehicle Scheduling
- Crew Scheduling

**Output**
- Set of Routes
- Service Frequency by Route, day, and time period
- Departure/Arrival times for individual trips on each route
- Revenue and Non-revenue Activities by Vehicle
- Crew Duties
Service Planning Hierarchy

Network Design
Frequency Setting
Timetable Development
Vehicle Scheduling
Crew Scheduling

Infrequent Decisions
Service Considerations Dominate
Judgment & Manual Analysis Dominate

Frequent Decisions
Cost Considerations Dominate
Computer-Based Analysis Dominates
Airline Planning

Fleet Planning

Schedule Planning
- Route Development
- Schedule Development
  - Frequency Planning
  - Timetable Development
  - Fleet Assignment
  - Aircraft Rotations

Pricing

Crew Scheduling

Revenue Management

Airport Resource Management

Sales and Distribution

Operations Control

Types of Decision:
- Strategic
  - Long Term
- Tactical
  - Short Term

Time Horizon:
- Long Term
- Short Term
Railroad Planning

Strategic Plans
- Network Design and Improvement
- Terminal Location and Capacity
- Service Planning and Differentiation
- Merger and Acquisition

Tactical Plans
- Blocking Plan
- Maintenance of Way Plan
- Train Schedule Plan
- Crew Schedule Plan
- Power Schedule Plan

Operational Plans
- Train Timetables
- Empty Car Distribution
Course Objective #2

Demonstrate how to develop, solve and interpret the results of optimization models and algorithms applied to carrier systems

- Decision and policy making aids for large-scale, complex transportation systems
Why Mathematical Modeling and Automated Solutions?

• Carrier problems are large scale, complex problems
• Intuition fails to produce “optimal,” or possibly “feasible” solutions
• Generating feasible solutions manually can be very time consuming
• Without decision support technology, scenario analysis is limited or impossible
Approach

• Overview of optimization modeling

• Case studies/ applications
  – Provide representative examples of the types of carrier problems, and their complexity
  – Allows development of the “art” of problem formulation and modeling
    • Exactness vs. tractability trade-offs
  – Provide hands-on opportunities to apply the “science” of optimization
Case Studies

• **Context:**
  - Transportation procurement/ direct transportation in logistics
  - Transit vehicle and crew scheduling
  - Airline crew and aircraft maintenance routing

• **Models:**
  - Network representations
  - Linear programs
  - (Mixed) integer programs
Methods

• Problem classification as “easy” or “hard”
• Use of LP and IP solvers
  • Simplex method
  • Branch-and-bound
• Decomposition techniques
• Heuristic strategies
• Sensitivity analysis
  • Shadow prices, reduced costs and complementary slackness
Syllabus & Academic Honesty Policy