Connecting people with the world’s greatest travel possibilities.

OR Applications in the Airline Industry

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Who is Sabre Holdings?

A world leader in travel commerce, retailing travel products, and providing distribution and technology solutions for the travel industry.
Connecting people with the world’s greatest travel possibilities.

Operations Research @ Sabre
Sabre Airline Solutions

• Helps Airlines Plan, Market and Execute their Businesses
  Over 100 software products to help Airlines run their business efficiently
  Extensive use of Operations Research models to generate “Optimal” solutions to Business Problems
  Solutions deployed at over 100 major airlines worldwide
Operations Research in Airlines

- **Planning**
  Schedule Planning, Crew Planning and Rostering, Fleet and Slot Optimization, Resource Optimization

- **Marketing**
  Revenue and Price Optimization

- **Execution**
  Flight Path Optimization, Aircraft and Crew Recovery, Gate Optimization, Aircraft Loading
## Airline Planning

<table>
<thead>
<tr>
<th>Timeframe</th>
<th>Long-Term Planning</th>
<th>Medium-Term Planning</th>
<th>Operate</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 Years – 18 Months</td>
<td>• Market/Customers to Serve</td>
<td>• IATA Slot Optimization</td>
<td>• Short-Term Re-fleeting</td>
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<tr>
<td></td>
<td>• Basic Schedule Structure</td>
<td>• Crew Assignment and Rostering</td>
<td>• Upgrade/Downgrade Equipment</td>
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<tr>
<td></td>
<td>• Partnerships</td>
<td>• Revenue and Price Optimization</td>
<td>• Cancel Low-Demand Flights</td>
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<tr>
<td></td>
<td>• Long-term Facilities/Fleet Plan</td>
<td></td>
<td>• Recover Aircraft and Crew from Disruptions</td>
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<td></td>
<td>• Routes and Frequencies</td>
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<td>• Initial A/C Assignments</td>
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### Revenue vs. Constraints Over Time

- **Revenue** increases over time.
- **Constraints** increase over time.

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**Note:** This diagram illustrates the planning process from long-term to medium-term to short-term, with key activities highlighted at each stage.
Long-term Planning

- **Identify Markets to Serve**
  Select the appropriate mix of markets and service type

- **Routes / Frequencies**
  Decide the best routes and frequencies
  Optimize the timing of flights to provide best connectivity

- **Evaluate Partnerships and Alliances**
  Optimize the choice of partners and flights to partner on

- **Determine Fleet type and count required**
  Assign Aircraft (Fleet) to Flights to match supply and Demand
  Minimize the number of Aircraft needed to fly the planned schedule
Schedule Optimization

- **Design and Develop a new schedule given**
  Hub Structure (departure and arrival banks)
  Slot restrictions
  Frequency restrictions
  Station curfew
  Minimum ground times

![Diagram showing schedule optimization with Served Departure Complexes, Empty Complexes, and Served Arrival Complexes.](image)
Fleet Optimization

• Assign aircraft type to specific flights to maximize profit
  Range constraints
  Airport constraints
  Regulatory constraints
  Maintenance constraints
  Crew considerations
    Use Homogenous fleet types for a given market
  Match supply and demand
Fleet Optimization – Fleet Count
Current Evaluations estimate the value of such processes as:

<table>
<thead>
<tr>
<th>Improvement</th>
<th>Incremental Profit (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improved Productivity Through Automation</td>
<td>0.5%-1%</td>
</tr>
<tr>
<td>Better Schedule Planning</td>
<td>1%-3%</td>
</tr>
<tr>
<td>Better Fleet Optimization</td>
<td>0.5%-3%</td>
</tr>
<tr>
<td><strong>Total Incremental Profit</strong></td>
<td><strong>1%-9%</strong></td>
</tr>
</tbody>
</table>
Medium Term Planning

• **Crew Optimization / Rostering**
  Assign Crew to Flights
  Crew duty constraints
  Qualifications
  Union contracts
  Current fleet assignment
  Generate Rosters for the Crew
  Union contracts
  Govt. regulations

• **Revenue and Price optimization**
  Determine optimal price points and available inventory
  Demand patterns
  Type of market (Business / Leisure)
  Available capacity
Revenue Management Primer

Given a Price-Demand curve - 
Revenue and Consumer Surplus for a given price point can be established
Revenue Management is all about increasing revenue and decreasing the Consumer Surplus!

The Revenue Management Solution
Differentiate the product and set multiple price points
Essentially convert consumer surplus to Revenue!
Airline Revenue Management

• Differentiate products by applying “Restrictions”
  Advance Purchase, Online Fare only etc.

• Set “Optimal” allocations for the different products based on forecasted demand for each product
  Forecast using time-series models
    Exponential smoothing, Kalman Filtering etc.
Revenue Management - Illustrated

[Graph showing revenue management over days to departure with different booking and revenue trends.]
Short – Term Operations

• Close in Re-Fleeting
  Upgrade / Downgrade equipment to match observed demand
  Cancel low-demand flights

• Irregular operations
  Re-assign aircraft for unscheduled maintenance
  Rub-off delays on aircraft availability
  Crew recovery
  Overtime allocation

• Flight Operations
  Determine optimal flight path
  Optimal fuel level
    Burn rate
    Cost of fuel
    Range
  Optimal loading of Aircraft for balance
Close-in Re-fleeting

- Reassign (Swap) aircraft to match supply and demand
  Swap only “crew-compatible” aircraft
  Minimizes denied boardings and empty seats!
  Works with Revenue Management systems to determine demand
  Demonstrated Revenue gain of 2-5 million Euro / month!
Recovery from irregular operations

- Operations are constantly disrupted due to:
  - Weather delays
  - Weather delays at out-stations (delay of inbound aircraft)
  - Crew rub-off delays
  - En-route / ATC delays

- Real-Time optimization to get the schedule back on track
  Select suitable flights to delay/cancel to enable recovery
Current Focus

• **All about integration**
  Integrated Crew and Fleet assignment
  Integrated Schedule planning and Revenue Management
  Integrated Crew and Aircraft recovery
  Robust schedule planning to minimize recovery

• **Real time optimization**
  Revenue management controls re-optimized dynamically after every booking!

• **Problems complexity increases geometrically**
  Exact solutions are not possible at the moment
  Use techniques like Branch and Price, Branch and Cut to get close to optimality
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