Promising Aircraft Modifications for Low Handling Costs

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Overview

Review of ground handling services
Reference Data

- DOC Methods
- Ground Handling Charges
- Ground Handling Procedures

Detailed Cost Prediction
Optimal Procedure Identification

New Aircraft Proposals
Modifications evaluation
Overview

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Ground Handling Activities - Classification

- Cabin service
- Ramp services
- Passenger services
- Field Operation Services
Ground Handling Activities - Classification

- Cabin services

- Ramp services

- Passenger services

- Field Operation Services
Ground Handling Activities – Ramp Services

- Cargo and Luggage Handling
- Catering
- GPU
- Refuelling
- Transport Passengers
- Pushback
Ground Handling Activities – GSE

**Ground Support Equipment:** Equipment that involve ground power operations, aircraft mobility, and loading operations.

- Refuelers
- Tractors
- Ground power units
- Buses
- Container loader
- Transporters
- Potable water trucks
- Belt loader
- Passenger stairs
- Pushback tugs
- Container loader
- De-icing vehicles
- Air starter
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Reference Data: Aircraft

- The Airbus A320 has been chosen, as it is the most commonly used Airbus aircraft at Low Cost Carriers.
Reference Data: Mission

- A research have been carried out in order to find the low cost airline’s average route length.

Average Length Distance of Low Cost Airlines (km)
Reference Data: Mission

- Low cost airline’s average route length.

<table>
<thead>
<tr>
<th>Category</th>
<th>Average Route length (km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regional</td>
<td>560.08</td>
</tr>
<tr>
<td>Charter</td>
<td>1835.89</td>
</tr>
<tr>
<td>Original</td>
<td>911.05</td>
</tr>
<tr>
<td>Full Service</td>
<td>1034</td>
</tr>
<tr>
<td>All Airlines</td>
<td>1028.53</td>
</tr>
<tr>
<td>3 Main Airlines</td>
<td>1066.33</td>
</tr>
</tbody>
</table>

Average Length Distance of Low Cost Airlines

1028 km
Reference Data: Ground Handling Procedure

A320 manual
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DOC Methods

Available DOC methods:

- AEA - \( C_{FEE,GND} = K_1 \cdot m_{PL} \)
- Boeing - \( C_{FEE,GND} = (K_1 + K_2 \cdot K_3 \cdot \text{Seats}) \cdot 5.05 + FHC \)
- AEA-Boeing - \( C_{FEE,GND} = (K_3 + \text{Total Seats} \cdot K_4 \cdot K_5) \cdot K_6 + K_7 \cdot \frac{\text{Block Fuel}}{6.75} \)
- Airbus - No Method
- American Airlines - No Method
- Lufthansa - Tables
- Fokker - \( C_{FEE,GND} = K_1 + K_2 \cdot \text{seats} \)

Those constants depend on number of seats, range, type of airline and country.
DOC Methods

In general:

\[ C_{GH} = K \cdot m_{PL} \]
\[ C_{GH} = K \cdot n_{Pax} \]

- DOC methods for handling cost do not take into account detailed aircraft parameters
- Available DOC method cannot accurately predict the handling cost for all scenarios
- Influence of the A/C configuration on the GH costs cannot be studied with DOC methods
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Ground Handling Charges

- Airport schedules of charges have been investigated.
- The charges can be divided in three categories:
  - Airport Infrastructure Charges
  - Baseline service
  - Additional services

$$C_{HC} = \sum C_{AI}(\text{operation}) + C_{BL}(MTOW, n_{pax}) + \sum C_{AD}(\text{operation})$$
Ground Handling Costs: Airport Charges

These costs have been listed and a ground handling cost breakdown tool has been produced.

<table>
<thead>
<tr>
<th>Service</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use of AI charge</td>
<td>100.3225</td>
</tr>
<tr>
<td>Baseline</td>
<td>1612.41</td>
</tr>
<tr>
<td>Fuel AI charge</td>
<td>42.97797</td>
</tr>
<tr>
<td>Airbridge</td>
<td>116.19</td>
</tr>
<tr>
<td>GPU</td>
<td>42.51</td>
</tr>
<tr>
<td>Pushback</td>
<td>114.43</td>
</tr>
<tr>
<td>Transport at ramp</td>
<td>86.235</td>
</tr>
<tr>
<td>Stairs</td>
<td>17.18</td>
</tr>
</tbody>
</table>

Ramp standard Service Cost for an A320

<table>
<thead>
<tr>
<th>Airport</th>
<th>Ramp standard Service Cost (euros)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Madrid MAD (AENA 2008)</td>
<td>1756.27</td>
</tr>
<tr>
<td>Salzburg SZG (Salzburg 2007)</td>
<td>1280.00</td>
</tr>
<tr>
<td>Aarhus AAR (Aarhus 2007)</td>
<td>1620.86</td>
</tr>
</tbody>
</table>
Ground Handling Costs: Airport Charges

• These costs only depend on operational aspects (services and time)

• Aircraft parameters are also not taken into account.

<table>
<thead>
<tr>
<th>Aircraft class</th>
<th>Airplane type</th>
<th>Aircraft class</th>
<th>Airplane type</th>
</tr>
</thead>
<tbody>
<tr>
<td>4A</td>
<td>AEROSPATIALE A5300 Ecourel CESSNA TWIN PISTON</td>
<td>71</td>
<td>AIRBUS 320</td>
</tr>
<tr>
<td>4B</td>
<td>AEROSPATIALE SN385 Dauphin AVIOCAR CN212-200</td>
<td>72</td>
<td>BOEING 727-200</td>
</tr>
<tr>
<td>4C</td>
<td>EMBRAER 120 BRASILIA AVIOCAR CN235</td>
<td>81</td>
<td>BOEING 757-300 AIRBUS A310</td>
</tr>
<tr>
<td>31</td>
<td>AEROSPATIALE ATR 42 DE HAVILLAND DHC-6</td>
<td>82</td>
<td>AIRBUS A300 B4/C4/F4 BOEING 767-300</td>
</tr>
<tr>
<td>41</td>
<td>AEROSPATIALE ATR 72 CANADAIR REGIONAL JET 9000</td>
<td>83</td>
<td>AIRBUS 340-200 BOEING 777-200</td>
</tr>
<tr>
<td>51</td>
<td>BRITISH AEROSPACE 146-300 McDONNELL DOUGLAS DC-9</td>
<td>91</td>
<td>McDONNELL DOUGLAS MD-11 BOEING 777-300</td>
</tr>
<tr>
<td>61</td>
<td>BOEING 737 McDONNELL DOUGLAS MD 83</td>
<td>93</td>
<td>BOEING 747-200/400 AIRBUS A340-600</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>MTOW</th>
<th>Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aircraft between 0 and less than 16 Tons</td>
<td>13.16%</td>
</tr>
<tr>
<td>Aircraft between 16 and less than 22 Tons</td>
<td>17.51%</td>
</tr>
<tr>
<td>Aircraft between 22 and less than 38 Tons</td>
<td>28.04%</td>
</tr>
<tr>
<td>Aircraft between 38 and less than 56 Tons</td>
<td>77.88%</td>
</tr>
<tr>
<td>Aircraft between 56 and less than 72 Tons</td>
<td>100.00%</td>
</tr>
<tr>
<td>Aircraft between 72 and less than 86 Tons</td>
<td>120.33%</td>
</tr>
<tr>
<td>Aircraft between 86 and less than 121 Tons</td>
<td>135.30%</td>
</tr>
<tr>
<td>Aircraft between 121 and less than 164 Tons</td>
<td>150.28%</td>
</tr>
<tr>
<td>Aircraft between 164 and less than 191 Tons</td>
<td>179.37%</td>
</tr>
<tr>
<td>Aircraft between 191 and less than 231 Tons</td>
<td>202.50%</td>
</tr>
<tr>
<td>Aircraft between 231 and less than 300 Tons</td>
<td>264.81%</td>
</tr>
<tr>
<td>Aircraft over 300 Tons</td>
<td>314.64%</td>
</tr>
</tbody>
</table>
Ground Handling Costs: Airport Charges

However, different handling procedures can be compared with this tool.

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A - Standard</td>
<td>Standard procedure</td>
</tr>
<tr>
<td>B - External Apron</td>
<td>External Apron, transport, stairs, pushback.</td>
</tr>
<tr>
<td>C - External ramp</td>
<td>External ramp, transport of passengers, pushback</td>
</tr>
<tr>
<td>D - Terminal</td>
<td>Terminal ramp, airbridge</td>
</tr>
<tr>
<td>E - External ramp</td>
<td>External ramp, transport of passengers, stairs</td>
</tr>
<tr>
<td>F - External ramp</td>
<td>External ramp, transport of passengers</td>
</tr>
<tr>
<td>G - Terminal</td>
<td>Terminal ramp, no airbridge, pushback</td>
</tr>
<tr>
<td>H - Terminal</td>
<td>Terminal ramp, no airbridge</td>
</tr>
</tbody>
</table>
Ground Handling: Optimal GH procedure

- Handling is carried out at a terminal ramp without need of pushback or transporting passengers.
- This cost-efficient procedure is the most used by the LCA.
- Examples:
Ground Handling : Conclusions

• To decrease the ground handling costs, LCA avoid as much ground handling services as possible.

• In order to achieve this, a more autonomous aircraft are required.

• For example
  • Pushback can be avoided by Autonomous Pushback Systems
  • Airbridge use can be switched by stairs.
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Optimal Procedure Identification

Modifications evaluation
New aircraft proposals

<table>
<thead>
<tr>
<th>Model</th>
<th>Developer</th>
<th>Criteria</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>A2007</td>
<td>Delt University</td>
<td>Minimize turnaround</td>
<td>High wing, APS, Integrated stairs</td>
</tr>
<tr>
<td>StartXpress</td>
<td>Stuttgart University</td>
<td>More Electrical A/C.</td>
<td>High wing, New Engine</td>
</tr>
<tr>
<td>Orca</td>
<td>Stuttgart University</td>
<td>Minimize turnaround</td>
<td>New configuration. Double stairs at tail.</td>
</tr>
<tr>
<td>Larus</td>
<td>Stuttgart University</td>
<td>GH optimization</td>
<td>New configuration.</td>
</tr>
<tr>
<td>Globalspirit</td>
<td>Stuttgart University</td>
<td>DOC</td>
<td>High wing</td>
</tr>
<tr>
<td>Gastomis</td>
<td>Stuttgart University</td>
<td>GH and turnaround</td>
<td>New systems. Fuel cell APU</td>
</tr>
</tbody>
</table>

There is no studies about Ground Handling Costs
Overview

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Modifications evaluation
Integrated Stairs

- Weight Penalty of about 65kg.
- Increase of DOC 0.06% (8 USD/Trip)

- Avoid Delays and Utilization of Airport Equipment.
- Stairs -> 20 USD
- Airbridge -> 110 USD

- Possibility of boarding using two doors

- Compatibility with airbridges.

- A clear decrease on costs
Autonomous Pushback System

Weight Penalty of about 100kg.
Increase of DOC 0.1% (15USD/Trip)

Small maintenance and depreciation cost (5USD/trip)

Avoid Delays and Utilization of Airport Equipment.
Pushback -> 172USD/trip

It saves around 2 minutes in the turnaround time.

Potential to use fuel cells.

A clear decrease on costs
Kneeling system

- Lower sill height leads to lower loading costs.
- Very high weight penalty.
- Difficult to assess loading activity improvement
  - Belt and container loaders can be adapted to different geometries already.
  - Containers and pallets have standard sizes.

- Do not save costs.
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Modifications evaluation
Summary and future steps

- Despite these findings, aircraft configuration and geometry cannot be evaluated regarding GH costs yet.
- A new tool has to be developed for this purpose.
  - Ground Handling studies in detail.
  - Identification of Ground Handling parameters. $P_i$
  - Assign cost values to each element. $C_i = C(P_1, P_2, ..., P_i)$
  - Connection between GH costs and Aircraft parameters
  - Evaluation of different configurations
Summary and future steps

• A modelization of the ground handling costs is being carried out.
• Delays, geometrical compatibilities, staff, service precision parameters are taken into account.

\[ C_{GH} = C_1 \cdot C_2 \cdot C_3 \ldots C_i \]
Summary and future steps

• Software Simba 2D from ARC is able to perform ground handling simulations and calculate costs.

• Once the ground handling cost breakdown is totally defined, it is possible to calculate turn-around times and costs in parallel.

<table>
<thead>
<tr>
<th>Service</th>
<th>Time (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boarding</td>
<td>6 / 10</td>
</tr>
<tr>
<td>Cleaning</td>
<td>5</td>
</tr>
<tr>
<td>Lavatory</td>
<td>6</td>
</tr>
<tr>
<td>Refuel</td>
<td>2</td>
</tr>
<tr>
<td><strong>Total Servicing Time</strong></td>
<td><strong>&lt; 12 min</strong></td>
</tr>
</tbody>
</table>

**Notes:**
- Door L1: 150 Passengers at a rate of 150 passengers.
- Door L2: 150 Passengers at a rate of 100 passengers.
- Refuel: 2000 l fuel at a rate of 100 l/min.
- Lavatory: 2000 l water at a rate of 200 l/min.
Thank you for your attention

Further information can be found on:

- http://ALOHA.ProfScholz.de
- http://Aero.ProfScholz.de