A DISCRETE EVENT SIMULATION MODEL FOR INBOUND BAGGAGE HANDLING

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A Discrete Event Simulation Model for Inbound Baggage Handling

- Scientific framework of the research
  - Inbound baggage handling is the last activity of the flight trip, where passengers are less eager to accept delays and malfunctions

- Motivation for research
  - Optimization of activity performance from a variety of points of view
  - Niche topic within literature on airport performance evaluation

- Methodology
  - Discrete event simulation model for inbound flights

- Case study
  - Bologna G. Marconi International Airport in Italy

- Simulation
  - Arena

- Results and main findings

- Conclusions
Literature review

- **Outbound baggage handling optimization models**
  - Abdelghany et al. (2006) → scheduling at a US airline’s hub
  - Frey et al. (2010) → heuristic model for international airports
  - Savrasov et al. (2010) → discrete event simulation of baggage handling system for Riga airport
  - Barth and Pisinger (2012) → allocation of baggage piers to departing flights, tested at FRA airport

- **Transfer baggage handling simulation**
  - Barth (2012) → simulation model, tested at FRA airport
  - SITA (2017) → estimation of baggage mishandling costs incurred and potential savings due to RFID and tracking systems

- **Inbound baggage handling simulation**
  - Horonjeff (1969) and Brwone et al (1970) → queue theory to model baggage & passenger arrival at baggage claim area
  - McKenzie (2003); Delonge (2012); Frey et al. (2017) → pier allocation

- **Simulation of the whole airport activities**
  - Cavada et al (2017) → arrival + transit + departure BHS simulation
Facts and figures

- Bad baggage handling may cause dissatisfaction to pax, monetary cost to airlines and damage airport’s image.
- Delays are negatively perceived at all stages (LOS, turnaround, travel time)
- Tracking is the basis for analysing mishandling reasons, understanding the problem and its reasons and solving it.

- Pax +52.1% (2.48 → 3.77 bln)
- Bags mishandled -54% (46.9 → 21.6 mln)
- Bags mishandled x 1k pax -69.7% (18.88 → 5.73)
Outbound, transfer and inbound baggage handling activities have been scrutinized.

Inbound process has been split into 6 sub-activities from aircraft block-time to last bag delivery time.

In addition to passengers and handling personnel, also people in charge of performing security screening control (international and non-EU flights mainly) and airport management play a role in optimization thanks to data collection and process engineering.
The following time instants are set, simulated by the model and compared with those collected during the Winter peak campaign at BLQ airport → 23/12/2016 – 7/01/2018 between 10.00 – 12.00 am and 7.00 - 12.00 pm.

BT = aircraft on-block time
T1 = the loader reaches the aircraft hold
T2 = the first bag is unloaded from the aircraft
T3 = the last bag is unloaded from the aircraft
T4 = first bag delivered at the baggage claim area
T5 = last bag delivered at the baggage claim area

BT to T3 → n° of agents and ramp team efficiency
T3 to T4 → driver + distance from the terminal
T4 to T5 → driver + belt typology

BT, T4, T5 are automatically stored in the Business Intelligence database of the airport.
Annual traffic (FY 2016)

- Almost 70,000 movements
- More than 7.6 million pax
- 3 aprons, 34 aircraft stands
- 6 EU + 5 non-EU belts
The layout of EU and non-EU delivery area is introduced within the model for the case study of Bologna airport

- 6 EU and 5 non-EU belts
- The EU area is equipped with a remote monitor, therefore an additional time interval is added
- One flight/belt
- Belts n° 3-4 (EU) 8-9-10 (non-EU) are suitable for LA & VLA equipped with ULD
- 57 scheduled network carrier flights have been taken into account (47% Schengen; 32% with ULD)
- No charter and LCC have been included in the analysis due to the heavy uncertainty of baggage figures
Simulation

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IN AIR 2018

LITERATURE REVIEW

OUTLINE

METHODOLOGY

RESULTS

CONCLUSIONS

1. Creation of crew bags
2. Creation of priority bags
3. Creation of other bags
4. Baggage typology (loose/ULD)
5. Aircraft arrival
6. Wait for the loader
7. First bag disembarked
8. Last bag disembarked
9. Displacement to the terminal
10. Start baggage delivery
11. End baggage delivery
Simulation

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OUTLINE  LITERATURE REVIEW  METHODOLOGY  SIMULATION  RESULTS  CONCLUSIONS

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INAIR 2018
Results

All the relevant $\Delta t_{ij}$ intervals have been directly recorded and then simulated for each flight inspected.

The statistical distribution of service times has been derived from probability density functions for each $\Delta t_{ij}$ interval and $\chi^2$ test.

As for $\Delta t_3$ loose baggage, two different distributions fit, depending on the amount of bags.

Additional input info for the model such as composition of ramp team, airline policies on crew - priority baggage - use of ULD have been derived by a questionnaire issued to the three ground handler operators.

<table>
<thead>
<tr>
<th>Time interval</th>
<th>Probability density function</th>
<th>Average (min)</th>
<th>Standard deviation (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\Delta t_1$</td>
<td>Gauss</td>
<td>3,167</td>
<td>2,1</td>
</tr>
<tr>
<td>$\Delta t_2$</td>
<td>LogNormale</td>
<td>0,29 (Log)</td>
<td>0,4242 (Log)</td>
</tr>
<tr>
<td>$\Delta t_3$ ULD</td>
<td>Gauss</td>
<td>8,517</td>
<td>3,667</td>
</tr>
<tr>
<td>$\Delta t_3$ NT &lt; 80 bag</td>
<td>Gauss</td>
<td>4,75</td>
<td>1,383</td>
</tr>
<tr>
<td>$\Delta t_3$ NT &gt; 80 bag</td>
<td>Gauss</td>
<td>11,2627</td>
<td>2,9833</td>
</tr>
<tr>
<td>$\Delta t_4$ non-Schengen</td>
<td>Gauss</td>
<td>2,2</td>
<td>1,5</td>
</tr>
<tr>
<td>$\Delta t_4$ Schengen</td>
<td>Laplace</td>
<td>1,583</td>
<td>\</td>
</tr>
<tr>
<td>$\Delta t_5$</td>
<td>Gauss</td>
<td>0,91667</td>
<td>0,4</td>
</tr>
</tbody>
</table>
Results

A relevant amount of replication (n=200) has been set in order to:
• minimize the model’s fluctuation ascribable to discrete event simulation
• to have returned realistic Last Bag time values
• to have returned low values of confidence interval

<table>
<thead>
<tr>
<th>Number of replications</th>
<th>1</th>
<th>5</th>
<th>10</th>
<th>15</th>
<th>30</th>
<th>50</th>
<th>70</th>
<th>100</th>
<th>200</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard deviation</td>
<td>\</td>
<td>4.53</td>
<td>2.3</td>
<td>1.95</td>
<td>1.82</td>
<td>2.18</td>
<td>1.66</td>
<td>1.42</td>
<td>0.93</td>
</tr>
<tr>
<td>%</td>
<td>-21.23</td>
<td>-4.22</td>
<td>-3.68</td>
<td>+0.36</td>
<td>+1.5</td>
<td>-2.33</td>
<td>-0.92</td>
<td>+2.6</td>
<td>-1.32</td>
</tr>
</tbody>
</table>

On average, the difference between observed and simulated values is lower than 10%. Higher discrepancies might be due to:
• Position of the flight and apron layout
• Relevant traffic within the winter peak
• Variability of baggage figures
• Management of rota and breaks from the handlers
• Random nature of incoming baggage security control for non-Schengen flights
• LH simulated figure does not take into account the presence of a relevant number of LCC flights within the same morning peak
This contribution is quite unique of its kind within scientific literature, due to the aspect involved and the amount of data collected and disclosed from handling agencies and airport manager.

The identification of statistical distribution for each interval has allowed to model the process adherently to real-time operation; transferability is possible due to the high degree of standardization of operations.

BHS’s performance is important both for inbound and outbound process as long as the traffic increases.

The model allows the identification of notable traffic peaks and of its effect on airport operation & aircraft turnaround.

The model highlights scopes for cooperation between manager and handlers to limit negative effects on LOS.

The model is useful to simulate and test alternative scenarios such as the evolution of traffic over time and the introduction of new technologies and procedures within the process.


THANK YOU!

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