A pedestrian simulation model for airport performance analysis

Sofia Kalakou
WORKSHOP ON PEDESTRIAN MODELS 2014
Lausanne, 10th of April 2014
“A pedestrian simulation model for airport performance analysis”

- Transport systems evolve rapidly
- Passenger expectations are increasing
- Huge investments, long life cycle, financial shortages
- Pedestrian behavior is highly unpredictable
- Degrees of freedom increase when offering more options/opportunities to people
- Technological innovations
Outline

• Objective
• Airport components and users
• Airport performance and measures
• Passenger flow simulation methodology
• Case study
• Simulation results
• Uncertainties
• Next steps
General Objective

Develop a simulation model to evaluate airport performance by integrating pedestrian/pasenger behavior and space characteristics
Airport passenger building components, processes and users

- Passenger Arrival
- Check-in
- Non-aeronautical Services
- Security control
- Gate control

Inside or outside the terminal

- Airport/Airline Employee
- Passenger
- Businessman
- Security Emp.
- Leisure visitor
Passenger activities and movements
Performance measures

- **Perception Analysis**
  - Quality of Flight Information Displays
  - Audio information/information staff
  - Quality of guidance/signage/directions
  - Availability of drinking water
  - Courtesy/helpfulness of security staff
  - Architectural diversion
  - Level changes
  - Walking time
  - Orientation quality
  - Walking distance

- **Queueing Theory**
  - Availability of seats
  - Processing time
  - Waiting times
  - Occupancy rates

- **Simulation**
  - Average/maximum queue size in check-in counters
  - Total/average moving time in the airport
  - Space for the queues or the queues’ configuration
  - Route length
  - The expected number of passengers per year
  - Resource utilization rates
  - Average number of check-in counters and passport control stations
  - Expected daily revenue
  - Estimation of the capacity of that facility
  - Lighting and comfort of the counters
  - Wideness of building
Passenger Flow Simulation Methodology (1)

Combination of Discrete Event Simulation with Pedestrian Dynamics Simulation

Steps

• Determination of the characteristics of the entities to be simulated (flights and passengers)
• Modelling passenger events
  ❖ Passenger arrival
  ❖ Check-in
  ❖ Discretionary activities
  ❖ Security control
• Modelling passenger behavior
  ❖ Walking characteristics (group formations, speed, collision)
  ❖ Activity characteristics
Passenger Flow Simulation Methodology (2)

A) Walking characteristics (group patterns, speed, collision)

Moussaid et al. (2010): effect of group size on speed and U,V group patterns
Young (1999), speed in airport terminals

B) Activity characteristics

Activity choice might vary depending on the personal characteristics of the passenger and the characteristics of his trip.
Case study

Departures area of Portela Lisbon airport

- Check-in Zones
- Retail activities
- Offices
- Security

[Map of Departures area of Portela Lisbon airport]
Results(1) – Pedestrian simulation model with current activity patterns

Security process time

<table>
<thead>
<tr>
<th>Pax percentiles</th>
<th>Process time (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>25%</td>
<td>0</td>
</tr>
<tr>
<td>50%</td>
<td>10</td>
</tr>
<tr>
<td>75%</td>
<td>30</td>
</tr>
<tr>
<td>90%</td>
<td>40</td>
</tr>
<tr>
<td>100%</td>
<td>90</td>
</tr>
</tbody>
</table>

Legend:
- 2 pr and 3 max
- 2 pr and 4 max
- 1 pr and 3 max
Results(2) – Pedestrian simulation model with different activity patterns

Security process time

![Bar chart showing security process time for different Pax percentiles with three activity patterns: 2 pr and 3 max, 2 pr and 4 max, 1 pr and 3 max.](chart.png)
Results(3) – space / pax

Unused space

> 2
Results (4) – Future space requirements scenarios with varying check-in, security machines and probability of security risk

Requirements for the security area - queue areas

Paper under submission
Next steps

These are the results of the base model.

The performance of the aeronautical activities is **highly dependent on the discretionary activities** and behavioral issues of the passengers/pedestrians.

need to model more accurately behavioral aspects and passenger choices
Uncertainties to be studied

Need to evaluate and restrict the effect of uncertainties

- Arrival pattern
- Activity pattern
- Distribution of service times
- Number of check-in machines
- Security category probability

Perform factorial design and ANOVA tests
Pedestrian Planning

In the literature 5 categories have been identified as pillars in pedestrian planning:

- Wayfinding
- Pedestrian cognition
- Space configuration
- Safety
- Modeling
Pedestrian Modeling

• Explore any latent relationships between space characteristics, passenger choices and flows of passengers
• Indicate the value of each area as derived from the way the passengers perceive it and the value they add to it
• Pave the way for future in-terminal location choices
• Incorporate pedestrian choices in flexibility of terminal planning as inputs that have the potential to indicate areas that are often preferred
Pedestrian modeling

Issues

• How do the passengers perceive the airport environment and move in it?
• Which factors determine pedestrian choices?

Data collection through a survey:

• Passenger and flight characteristics
• Activity choices
• Wayfinding
• Trajectories
Space characteristics

Connectivity  Integration  Isovist area

Visual step depth
Model improvement

How do the passengers distribute their available time inside the airport

5 categories of explanatory variables

• What they feel (time availability, time to gate)
• What they are (SDC, trip purpose)
• What they do (activity choices, criterion selection)
• What they see (signage, space configuration)
• What they perceive (confusion, space configuration)
Questions ?

Discussion