## Defining Capacity of Airport Passenger Buildings

**Dr. Richard de Neufville**

Professor of Engineering Systems and Civil and Environmental Engineering
Massachusetts Institute of Technology

<table>
<thead>
<tr>
<th>Objective: To Present and Explain Standards for Sizing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Topics</td>
</tr>
<tr>
<td>- Concepts of Capacity</td>
</tr>
<tr>
<td>- Design Concept</td>
</tr>
<tr>
<td>- Levels of Service</td>
</tr>
<tr>
<td>- IATA Space Standards (New Version in 2004!)</td>
</tr>
<tr>
<td>- Dwell Time</td>
</tr>
<tr>
<td>- Flow Standards</td>
</tr>
<tr>
<td>- Summary</td>
</tr>
</tbody>
</table>
Concepts of Capacity I

1. Static: Storage Potential of Facility

2. Dynamic: Ability of Facility to Process Flows
   - The Central Concept for the Design of Airport Passenger Buildings
   - Passengers, bags, cargo always Queue for and Move through Services (e.g.: Check-in, inspections, waiting for departures, etc.)

Concepts of Capacity II

- Dynamic Capacity can be:
  1. Sustained: Maximum flow over a significant period
     i.e., a morning arrival period
  2. Maximum: Maximum flow for a brief period

- Dynamic Capacity is a Variable!!!
  Unlike Static Capacity, of a bottle
Design Concept

- From Queuing Theory recall:
  More Space, Service => Less Delays

- Design for Dynamic Flows is:
  Tradeoff between Delays ...
  and Cost of Service, Space

- Dynamic Capacity depends on:
  → 1. Acceptable level of Delays and thus:
  → 2. Length of Period over which delays build up

- For Short Periods, More Delays OK

Level of Service (LOS)

- A verbal description of Quality of Service in terms of Ease of Flow and Delays

- 6 categories (IATA Airport Development Man.):

<table>
<thead>
<tr>
<th>LOS</th>
<th>Flows</th>
<th>Delays</th>
<th>Comfort</th>
</tr>
</thead>
<tbody>
<tr>
<td>A - Excellent</td>
<td>Free</td>
<td>None</td>
<td>Excellent</td>
</tr>
<tr>
<td>B - High</td>
<td>Stable</td>
<td>Very Few</td>
<td>High</td>
</tr>
<tr>
<td>C - Good</td>
<td>Stable</td>
<td>Acceptable</td>
<td>Good</td>
</tr>
<tr>
<td>D - Adequate</td>
<td>Unstable</td>
<td>Passable</td>
<td>Adequate</td>
</tr>
<tr>
<td>E - Inadequate</td>
<td>Unstable</td>
<td>Unacceptable</td>
<td>Inadequate</td>
</tr>
<tr>
<td>F - Unacceptable</td>
<td>--- System Breakdown ---</td>
<td>---</td>
<td>Unacceptable</td>
</tr>
</tbody>
</table>

- System Managers should Specify LOS, e.g:
  → Level C = standard minimum ; Level D = for crush periods
## IATA LOS Space Standards


- Useful intro to more sophisticated new version
- In square meters per person

<table>
<thead>
<tr>
<th>Area</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wait/circulate</td>
<td>2.7</td>
<td>2.3</td>
<td>1.9</td>
<td>1.5</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td>Bag Claim</td>
<td>2.0</td>
<td>1.8</td>
<td>1.6</td>
<td>1.4</td>
<td>1.2</td>
<td></td>
</tr>
<tr>
<td>Check-in Queue</td>
<td>1.8</td>
<td>1.6</td>
<td>1.4</td>
<td>1.2</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td>Hold-room Inspect</td>
<td>1.4</td>
<td>1.2</td>
<td>1.0</td>
<td>0.8</td>
<td>0.6</td>
<td></td>
</tr>
</tbody>
</table>

- More space needed for movement, with bags

## IATA Stds: Wait / Circulate


- Old:  
  | Square meters / Passenger for Level of Service |
  | A   | B   | C   | D   | E   |
  | 2.7 | 2.3 | 1.9 | 1.5 | 1.0 |

- New:  
  - Distinguishes locations, likelihood of carts  
  - References speed

<table>
<thead>
<tr>
<th>Location</th>
<th>Carts</th>
<th>Space M²/pax</th>
<th>Speed m / sec</th>
</tr>
</thead>
<tbody>
<tr>
<td>Airside</td>
<td>None</td>
<td>1.5</td>
<td>1.3</td>
</tr>
<tr>
<td>After check-in</td>
<td>Few</td>
<td>1.8</td>
<td>1.1</td>
</tr>
<tr>
<td>Departure area</td>
<td>many</td>
<td>2.3</td>
<td>0.9</td>
</tr>
</tbody>
</table>
### IATA Stds: Passport / Hold

- **Old:**
  
<table>
<thead>
<tr>
<th>Level of Service</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Square meters / Passenger</td>
<td>1.4</td>
<td>1.2</td>
<td>1.0</td>
<td>0.8</td>
<td>0.6</td>
</tr>
</tbody>
</table>

- **New (for hold rooms only):**
  - Assumes 1.7 m²/pax sitting, 1.2 m²/ standee
  - LOS defined in terms of % of space used

<table>
<thead>
<tr>
<th>Maximum Occupancy Rate (% of Capacity)</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>40</td>
<td>50</td>
<td>65</td>
<td>80</td>
<td>95</td>
</tr>
</tbody>
</table>

### IATA Stds: Bag Claim Area

- **Old:**
  
<table>
<thead>
<tr>
<th>Level of Service</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Square meters / Passenger</td>
<td>2.0</td>
<td>1.8</td>
<td>1.6</td>
<td>1.4</td>
<td>1.4</td>
</tr>
</tbody>
</table>

- **New:**
  - Assumes 40% of Passengers use carts
  - Has a wider range: more for A, less for E

<table>
<thead>
<tr>
<th>Level of Service</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Square meters / Passenger</td>
<td>2.6</td>
<td>2.0</td>
<td>1.7</td>
<td>1.3</td>
<td>1.0</td>
</tr>
</tbody>
</table>
IATA Stds: Check-in Area

- Old:
<table>
<thead>
<tr>
<th>Row width</th>
<th>Carts bags</th>
<th>Square meters / Passenger for Level of Service</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.2m</td>
<td>few</td>
<td>A: 1.7, B: 1.4, C: 1.2, D: 1.1, E: 0.9</td>
</tr>
<tr>
<td></td>
<td>more</td>
<td>A: 1.8, B: 1.5, C: 1.3, D: 1.2, E: 1.1</td>
</tr>
<tr>
<td>1.4 m</td>
<td>high</td>
<td>A: 2.3, B: 1.9, C: 1.7, D: 1.6, E: 1.5</td>
</tr>
<tr>
<td></td>
<td>heavy</td>
<td>A: 2.6, B: 2.3, C: 2.0, D: 1.9, E: 1.8</td>
</tr>
</tbody>
</table>

- New:
  → Reflects impact of number of bags, carts

Snake Line at LOS = C
Snake line at LOS = E

Note: Kiosks change process

- Kiosks = automated check-in machines => CUSS (Common Use Self Service) if common
- Speeds up check-in
  - Automated data entry (try to enter “de Neufville”)
- Less Staff, Less counter Space
  - Old layouts obsolete: e.g., Boston Internatl. Bldg
- Disperses Queues
  - Latest standards do not apply easily...
- CUSS at Las Vegas, Tokyo, in Canada
Dwell Time

- Determines Capacity of any space or process
- A Central Concept: Source of Major Problems

- Is Average Time a body is in a space or process
- When a person leaves a space, Replacement can use it
- As people move faster
  → Dwell time is shorter
  → More replacements can use space in any period

Formula for Space Required

- Space Required, sq. meters =
  (Load, pers./hour) (Std, sq.m./person) (Dwell time, hours)
  = (Persons/Time) (Area/Person) (Time) = Area

- Example:

  *What space is required for passport inspection of 2000 passengers per hour when maximum wait is 20 minutes?*

  Space Needed = 2000 (1) (1/3) = 667 sq. m.
### Formula for Capacity of a Space

- **Load, persons per hour =**
  \[
  \text{Load, persons per hour} = \frac{(\text{Space, sq. m.)}}{(\text{Std, sq. m. per pers})(\text{Dwell time, hrs})}
  \]

- **Examples:**
  - What is the recommended load (LOS = C) for a waiting room 30x50m, in which transit passengers average 90 minutes?
    
    \[
    \text{Recommended load} = \frac{(30)(50)}{(1.9)(1.5)} = \frac{1500}{2.85} = 527
    \]
  - What is the crush capacity of the same space?
    
    \[
    \text{Crush load} = \frac{(30)(50)}{(1.5)(1.5)} = 667 \text{ pers. per hr.}
    \]

### Flow Standards

**In terms of PMM = Persons/Minute/Meter**

<table>
<thead>
<tr>
<th>Type of Passageway</th>
<th>Level of Service Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
</tr>
<tr>
<td>Corridor</td>
<td>10</td>
</tr>
<tr>
<td>Stairs</td>
<td>8</td>
</tr>
</tbody>
</table>
Level of Service Diagram for Passenger Flows

Assumptions of Flow Standards

- **Two Factors**
  - 1. Space per Person
    - e.g.: 1.9 sq. m. per person for LOS = C
  - 2. Walking Speed
    - e.g.: 66 meters/min = 4 km/hour
    - => Low Dwell Time => High Capacity

- **Example:**
  - Capacity of Corridor, 5m. wide, 40m. long
  - Dwell time = 40 / 4000 = 0.01 hour
  - Recommended Load, persons per hour
  - = (5) (20) / (1.9) (0.01) = 5,000
Formula for Flow Areas

- Total Corridor Width Needed, meters = Effective Width + 1.5m. for edge effects
- Eff. width = (Persons /Minute) / (PMM)
- Example: What is recommended width of corridor to handle 600 persons per quarter hour, in both directions?
  Effective width = 80 / 20 = 4.0m
  Required width = 4.0 + 1.5 = 5.5m

- Note: Corridor capacity is very great!
  → Most corridors > need;
  Architectural considerations dominate

LOS varies over day, year!

- Example Distribution from Toronto
Summary

- **Key concepts about capacity:**
  - 1. Not purely technical issue
  - 2. Management decision about tradeoffs
    - Cost vs. LOS
  - 3. Financial and Service Objectives are critical

- **Key technical details:**
  - 1. Dwell time critical factor
  - 2. Through flows slash dwell time
  - 3. Capacity of corridors enormous