Design of Components of Airport Passenger Buildings

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Design of Components of Airport Passenger Building

- **Objective: To show how standards for sizing can be integrated into design**
- **Topics**
  - ✈ 1. Procedure
  - ✈ 2. Practical Example : Paris/de Gaulle, Air France Passenger Building

Procedure

- 1. Estimate Critical Loads ;
  Identify “hot spots”
- 2. Calculate Requirements
  - ✈ Storage Areas
    - Lines
    - Hold Spaces
  - ✈ Flows
    - Corridors
    - Passageways
- 3. Integrate into Design

Critical Loads (1)

The essential problem is:
CONCENTRATION OF TRAFFIC
in time and space

- People do not spread out evenly
- People cluster in attractive places
- Examples?
  - ✈ around check-in desks, gate areas
  - ✈ at mouth of baggage claim
  - ✈ at nearest of many facilities

Critical Loads (2)

- **Concentration phenomenon**
  - ✈ Creates bottlenecks
  - ✈ These define capacity
- **Concentration phenomenon means:**
  - ✈ Capacity of a large facility cannot be found simply by applying standards to whole area
- **Failure to grasp this fact often causes significant design failures**

Example Hot Spot Dallas/Fort Worth Airtrans

Estimation of Loads

Three important ideas:

- 1. Cumulative Arrival Diagram
- 2. Empirical Measurements needed for each situation, site
- 3 . Modulation by secondary activities

Calculation of Requirements

Recall from discussion of capacity:

- Storage Facilities
  - ✈ queues, hold rooms, ...
  - ✈ Require tradeoff: Cost vs. LOS
  - ✈ This is the issue – How big are queues?
- Flow Facilities
  - ✈ corridors, stairs, …
  - ✈ Capacity larger than most designers think

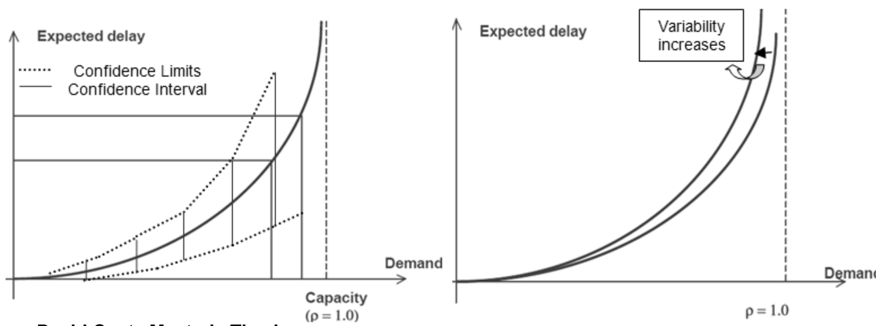
Behavior of Queues as ρ => 1

ρ = arrival rate /service rate. Equation is for steady state

$$W_q = \frac{\lambda\,[(\frac{1}{\mu})^2 + \sigma_t^2]}{2(1-\rho)} = \frac{\lambda\,[E^2(t) + \sigma_t^2]}{2(1-\rho)}$$

σ_t – standard deviation of service times

E(t) = expected value for service times



Source: David Costa Master's Thesis

Instituto Superior Tecnico, Lisboa, 2009

What happens in practice Steady Flows

- **Theory tells us that**
  - **queues build up infinitely as ρ=>1**
  - **Also system becomes increasingly unreliable**
- **Thus, managers often operate continuous system at ρ ~ 0.4**
  - **Example: Denver Bag system**
    - **At higher rates, delivery => unreliable and transfer operations => chaotic**

What happens in practice
Transient flows

- It often happens that arrivals are – for a time – faster than service
- Then queues build up rapidly
- This is a typical situation to analyse
- Cannot be done by formula
- Solution by
  - ✈ simulation – OK, but complex, unavailable
  - ✈ Graphically – “quick and easy”, flexible

Calculating Storage Facilities I

Two Phases:

- Exploration of Tradeoffs
  - ✈ Using cumulative arrival diagram
- Sizing of Space

Calculating Storage Facilities II

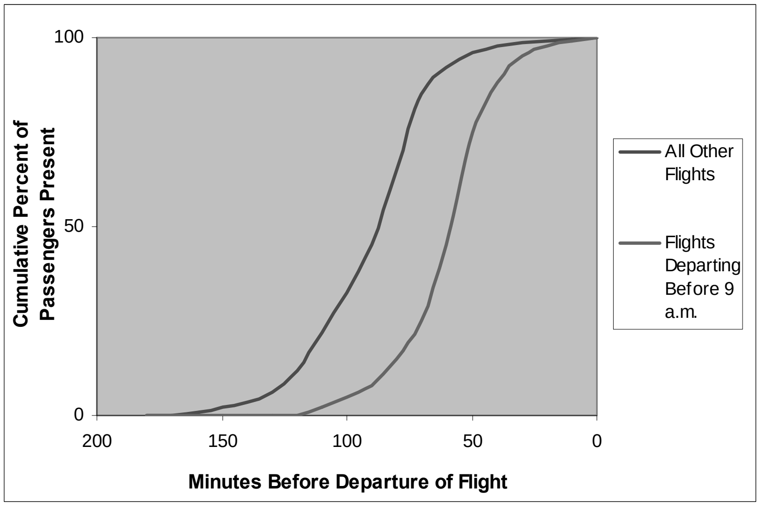
- Use of Cumulative Arrival Diagram
  - ✈ 1. Estimate, plot arrivals of Customers based on local measurements
  - ✈ 2. Superimpose departures of Customers generated by service rate of check-in, aerobridge, gate, ...
  - ✈ 3. Establish Maximum Customers Waiting Queue = arrivals - departures
  - ✈ 4. Explore Effect of Alternatives

Calculating Storage Facilities III

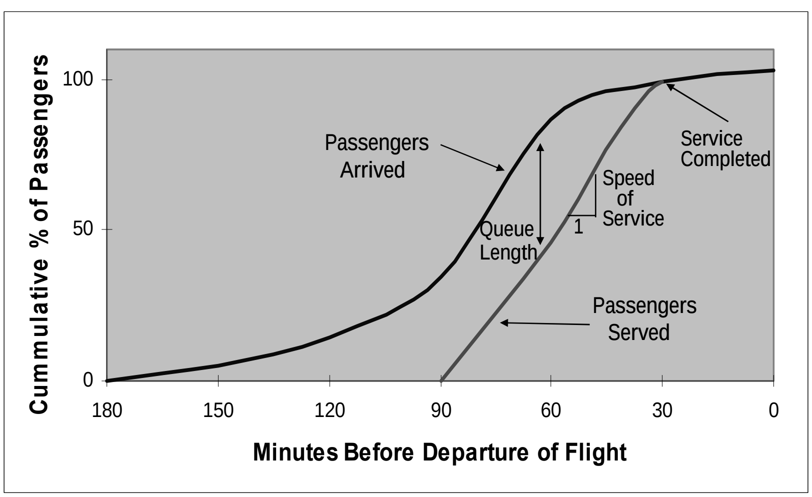
- Two kinds of calculations:
  1. Area = (Customers) (sq. m. per person)
     using appropriate space standards
  2. Queue Length ~ (Customers) (0.6 m. per person)

- Note: Queues generally project awkwardly
  - ✈ Often block passage for other customers

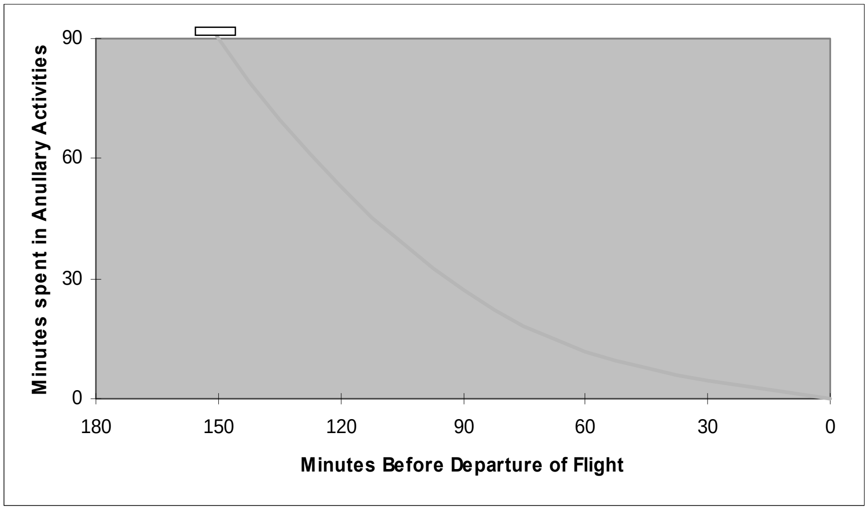
Typical Cumulative Load Diagram (Paris 1980)



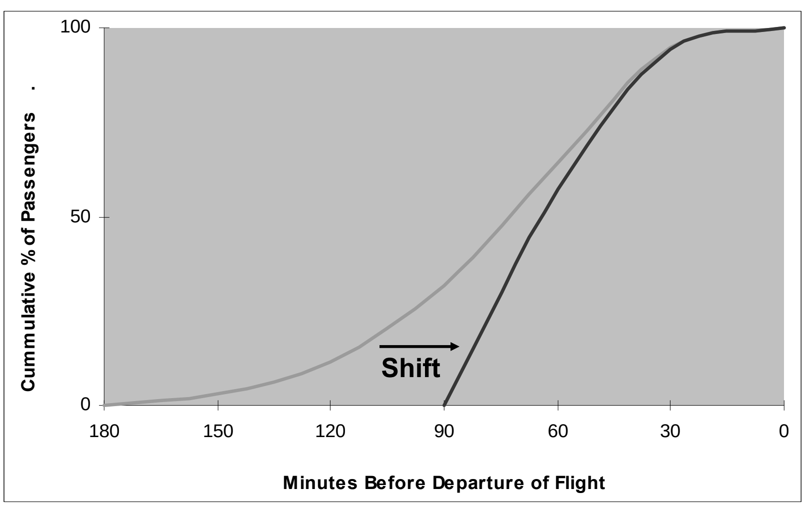
Typical Design Tradeoff for "Storage" Facilities



Typical Basis for Modulating Cumulative Load Diagram



Typical Final Cumulative Load Diagram



Calculating Flow Facilities I

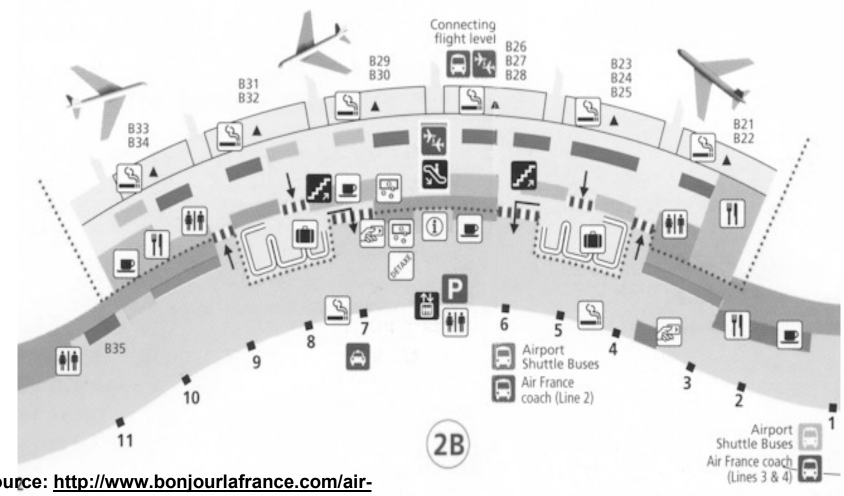
- **Note Carefully:**
  - 1. Implication of Flow crucial
  - 2. Flow = > more apparent space
  - 3. Big difference between Storage and Flow capacity
- **Example of Difference**
  - Storage Capacity
    - Space 3m wide, 30 m long ==> 90 sq.m area
    - Assume LOS = C ==> 1.9 sq. m per person
    - Storage capacity = 90 / 1.9 = 47 persons
  - Flow Capacity
    - Walking at 66m / minute
    - Apparent area = 3m (66 m/min) = 198 sq m / min
    - Flow Capacity = 198/1.9 = 94 persons / min = 5460 /hour!!!

Calculating Flow Facilities II

- **Procedure**
  - 1. Choose LOS, Level of Service
    => PMM, Persons per Meter width per Minute
  - 2. Calculate Effective Width Needed
    = Flow per minute / PMM
  - 3. Calculate Minimum Design Width
    = Effective Width + 1.5m.

Extra 1.5m for edge effects due to walls, counter flows, …

Example: Paris/de Gaulle Layout of Terminal 2B



Source: http://www.bonjourlafrance.com/air-france/paris_charles_de_gaulle_airport/cdg-terminal-2a-2b.htm

Example: Paris / de Gaulle Typical features

- Typical features before revision:
  - 1 hour flight turnaround at gate
  - 300 passengers per flight
  - 6 check-in counters per flight
  - 8 m. between counters and wall
  - 1.5 minute check-in time per passenger
  - 0.6 m. per passenger in line

Example Difficulties

- **Counters insufficient**

  Passengers per minute = 300 / 50 = 6
  Counters required = 6 (1.5 min) = 9 > 6

- **Queue Space insufficient**

  Assume half, 150 passengers wait
  Average queue = 150 / 6 = 25
  ==> 25 (0.6 m.) = 15 > 8 m.

Revision of Air France Passenger Buildings

Two main steps:

- ✈ 1. To create queue space ==> eliminate obstructions (telephones, ...) ; add counters
- ✈ 2. To guarantee service ==> Reduce Gate Use, using up to 2 hour turnaround

- **Capacity loss: from 10 to ~ 6 flights/day**
- **50% more space needed to service load**

- **Very Expensive problem!!!**

Example: Paris / de Gaulle Features after revision

- European (2B) after revision:
  - 0.45-1 hour flight turnaround at gate
  - 100 passengers per flight
  - 3 check-in counters per flight
  - 12 m. between counters and wall
  - 1.5 minute check-in time per passenger
  - 0.6 m. per passenger in line
- 8 Flights/gate per day

Example: Paris / de Gaulle Features after revision

- Intercontinental (2A) after revision:
  - 1.30-2hr flight turnaround at gate
  - 300 passengers per flight
  - 6 check-in counters per flight
  - 12 m. between counters and wall
  - 2 minute check-in time per passenger
  - 0.6 m. per passenger in line
- 4 Flights/gate per day

Take-aways

- **Key issue: focus on areas of concentration in time and space**
- **Key technical concept: queues build up as transient phenomena**
  - **Arrivals faster than service rate, sometimes before service starts**
  - **This builds up queues**
  - **Analysis graphically or by simulation. Formal analysis not practical**