MIT ICAT

MIT International Center for Air Transportation

# Airport Operations

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*16.72 Air Traffic Control*

*September 26th 2006*

# Outline

- **Airport Infrastructure**
  - Overview of the U.S. National Airport System and Foreign Airports
  - Airport configuration
  - Runways conditions & characteristics
  - Communication, Navigation, Surveillance Equipment
  - Multi Airport Systems

- **Airport Performance**
  - Capacity, Utilization & Delays

- **Operations**
  - General ATC structure and functions

  - Terminal Approach
  - Final Approach
  - Ground (arrivals)
  - Gate operations (arrivals)
  - Airport Surface
  - Gate operations (departures)
  - Ground (departures)
  - Take-Off / Transition to Terminal and Center

# World Airport System

- **Number of Airports World Wide: 49,024 (in 2006)***

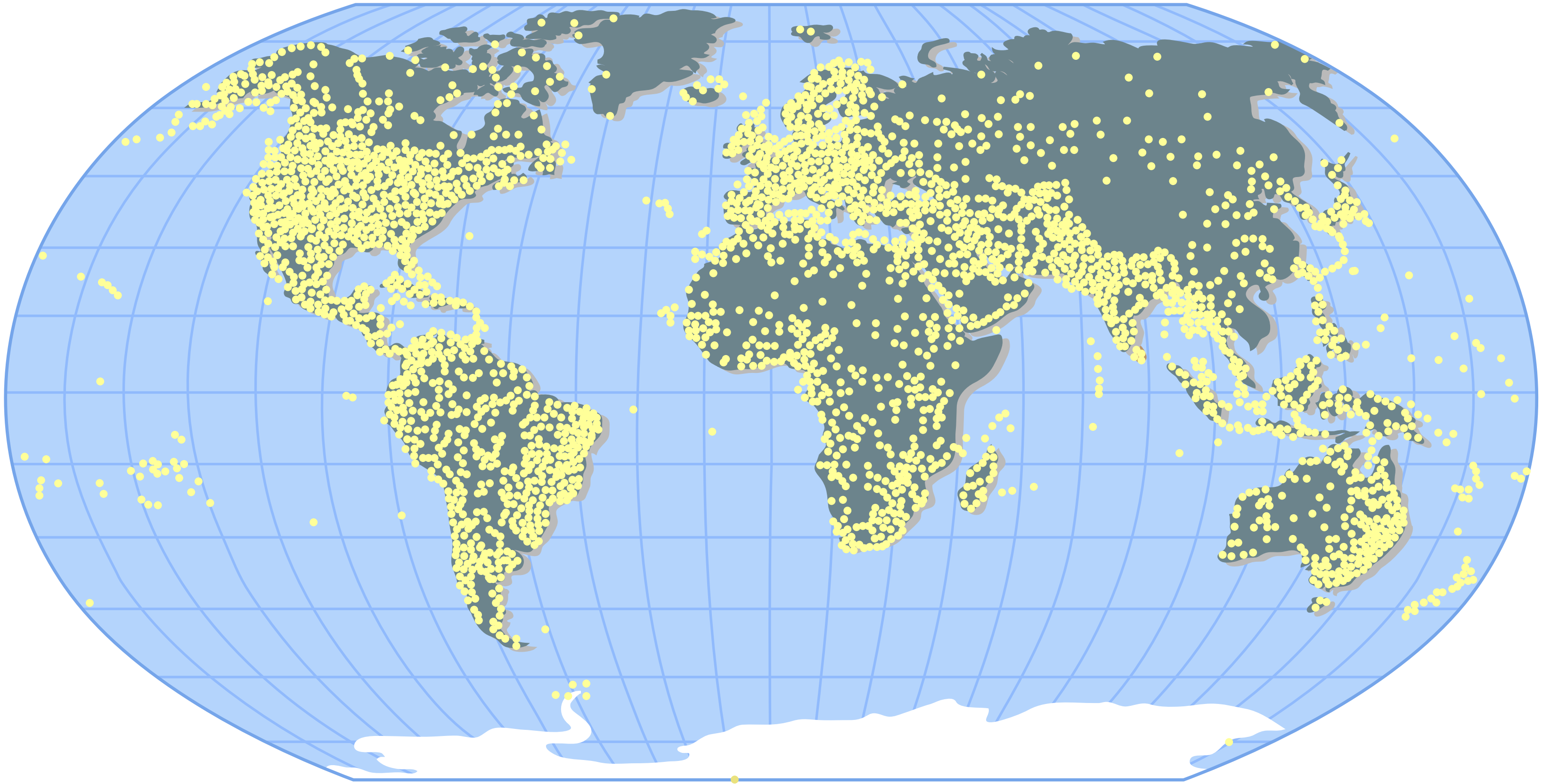

Figure by MIT OCW.

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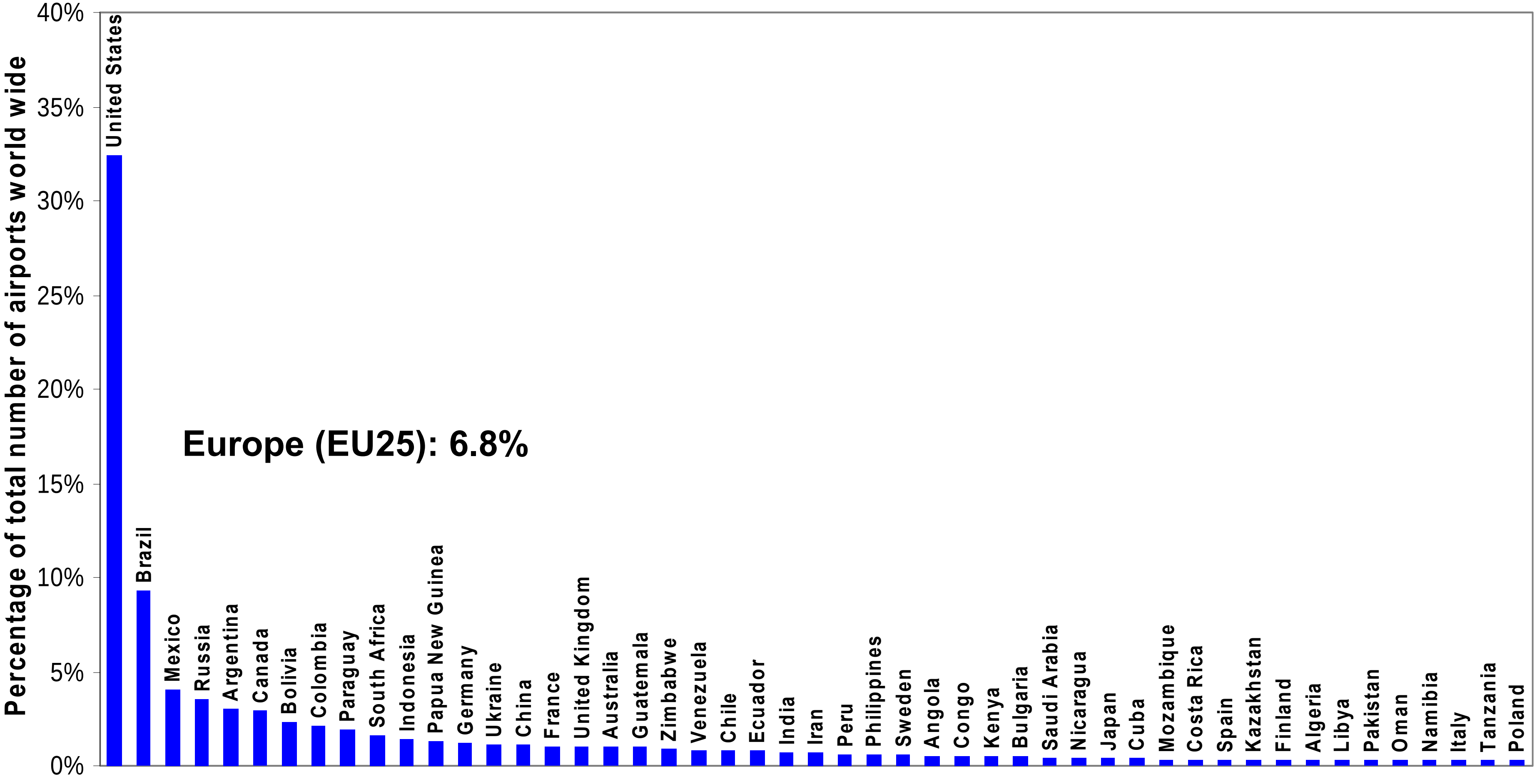
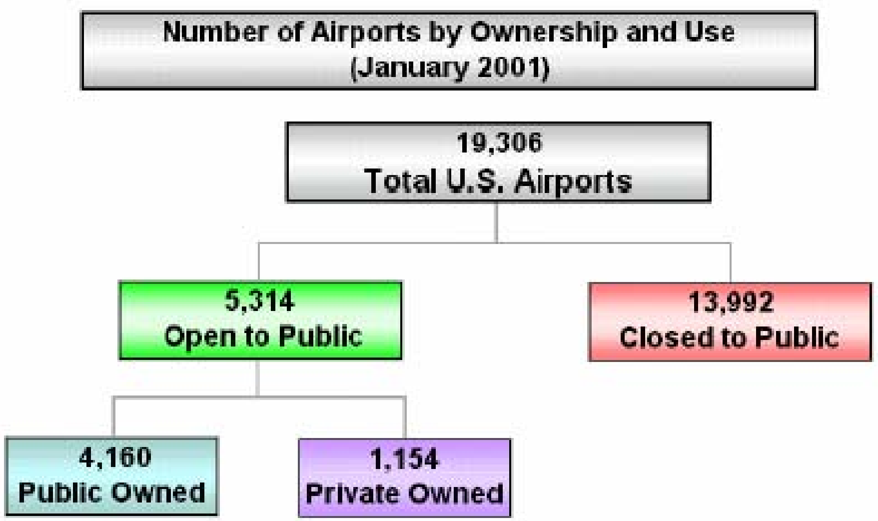
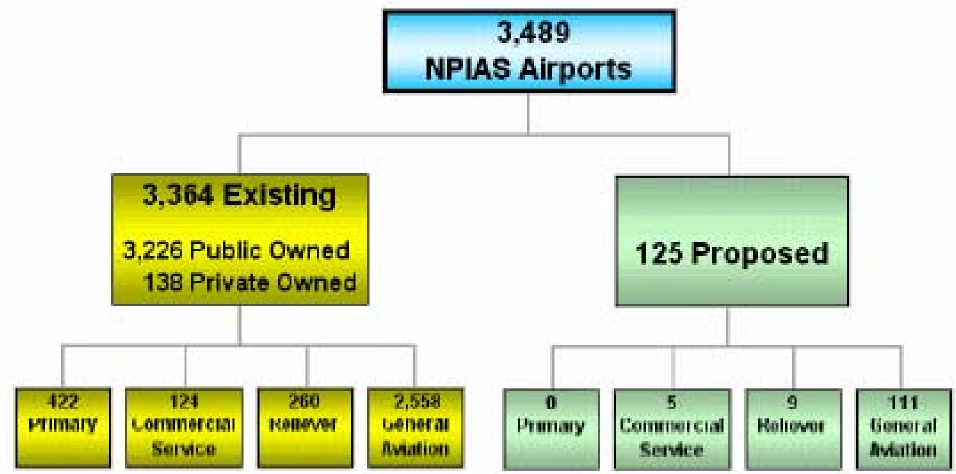



Data Source: CIA World Wide Fact Book, 2006.

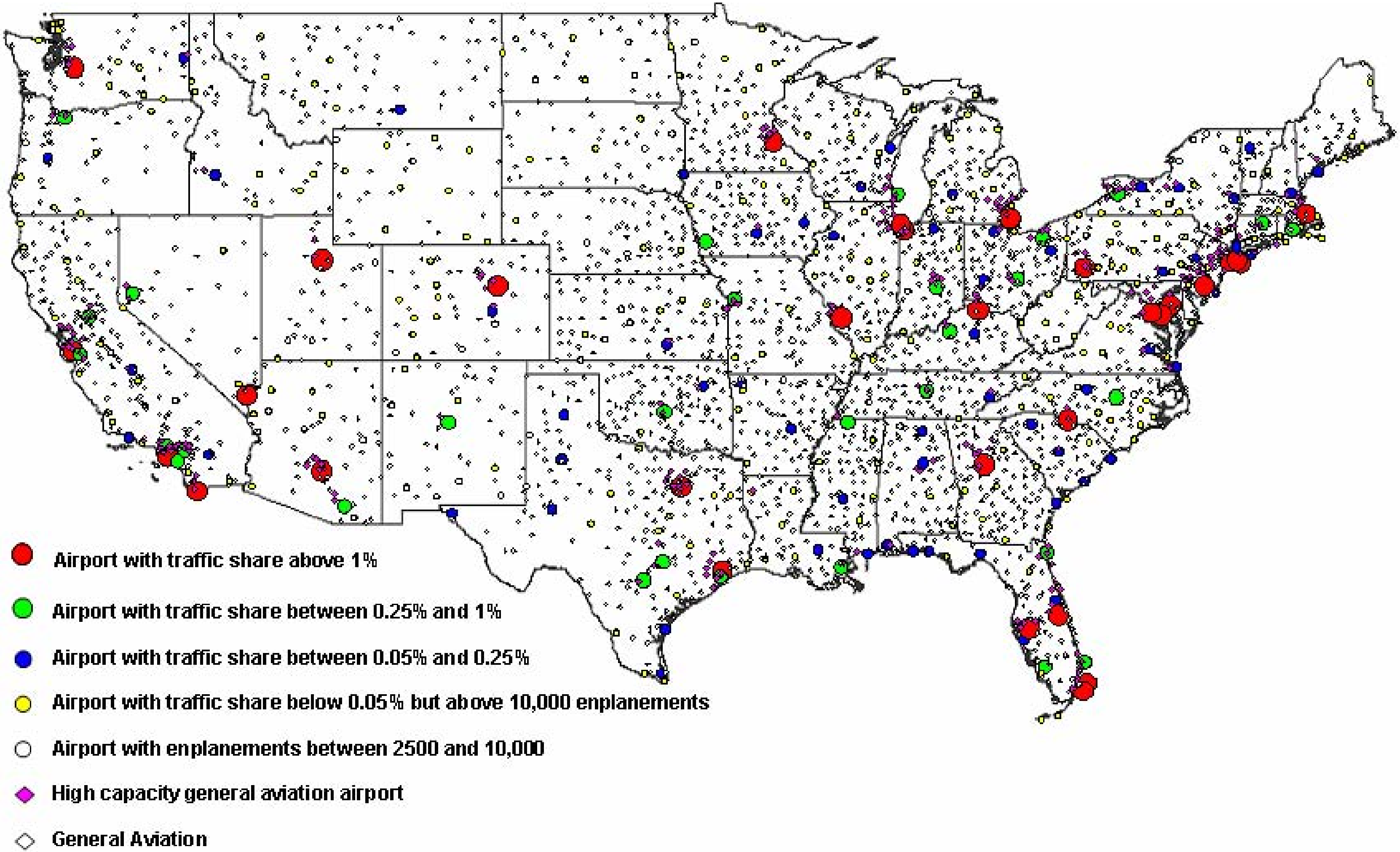
# U.S. National Airport System




Data source: National Plan for Integrated Airport System, FAA, 2005-2009.

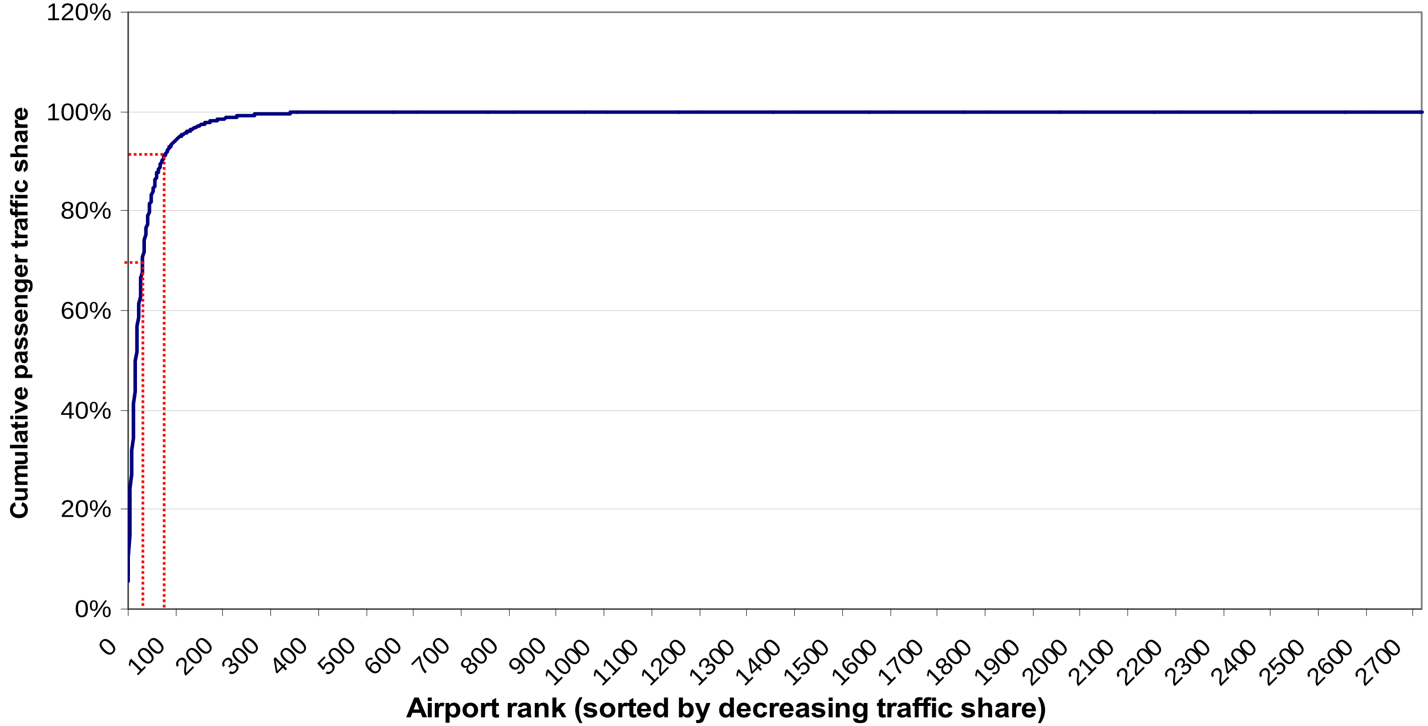
# US National Airport System




Data source: FAA National Plan for Integrated Airport System (existing airports: 3364)

# Concentration of Traffic at a Small Number of Airports

- **World Wide:**
  - Airports with more than 2 million passengers per year: ~300
  - Top 100 airports in the world: ~70% of annual passenger enplanements
  - Top 30 airports: ~35%
- **United States:**
  - Top 30 airports:  70% of U.S. passenger enplanements
  - Top 70 airports: 90% of U.S. passenger enplanements




**Data source: FAA Terminal Area Forecast Historical Data, 2004.**

# Airport Physical Layout

- **Airport physical characteristics**
  - number of runways, [ 1 to 7]
  - length of runways, [ ~ 500 ft to 16,000 ft]
  - geometric configuration of runways,
  - airfield layout,
  - location,
  - configuration of terminal facilities.

- **Range from very simple to complex geometries**

- **Area occupied is only mildly correlated with traffic volumes**

- **Layouts are influenced by historical and local factors**

# Land Area of Some Major Airports

## U.S. airports

| Airport | Acres | $m^2$ ($x10^6$) |
|---|---|---|
| Denver | 34,000 | 136 |
| Dallas/Ft. W. | 18,000 | 72 |
| Orlando | 10,000 | 40 |
| Kansas City | 8,200 | 33 |
| Chicago | 6,500 | 26 |
| Atlanta | 6,000 | 24 |
| JFK International | 4,950 | 20 |
| Los Angeles | 3,600 | 14 |
| Miami | 3,250 | 13 |
| Newark | 2,300 | 9 |
| Boston | 2,250 | 9 |
| Wash Reagan | 960 | 3.8 |
| LaGuardia | 650 | 2.6 |

## Foreign airports

| Airport | $m^2$ ($x10^6$) |
|---|---|
| Buenos Aires EZE | 34 |
| Paris CDG | 31 |
| Amsterdam | 22 |
| Frankfurt | 19 |
| Athens | 16 |
| Munich | 15 |
| Singapore | 13 |
| Brussels | 12 |
| Milan MXP | 12 |
| London LHR | 12 |
| Tokyo HND | 11 |
| Sydney | 9 |
| Zurich | 8 |
| London GTW | 8 |
| Tokyo NRT | 7 |
| Kansai | 5 |

Data source: de Neufville R., & Odoni A. R., "Airport Systems: Planning, Design and Management", 2003.

# Factors Affecting Airport Area &Number and Layout of Runways

- **Principal factors affecting airfield size:**
  - **Runways: Number and configuration**
  - **ILS Antenna Ground Planes and Lighting**
  - **Unused area:  noise “buffer” or for future expansion**
  - **Types of aircraft and operations:**
    **runway, taxiway, apron dimensions and separations**
  - **Location of passenger terminals and landside facilities relative to runways**

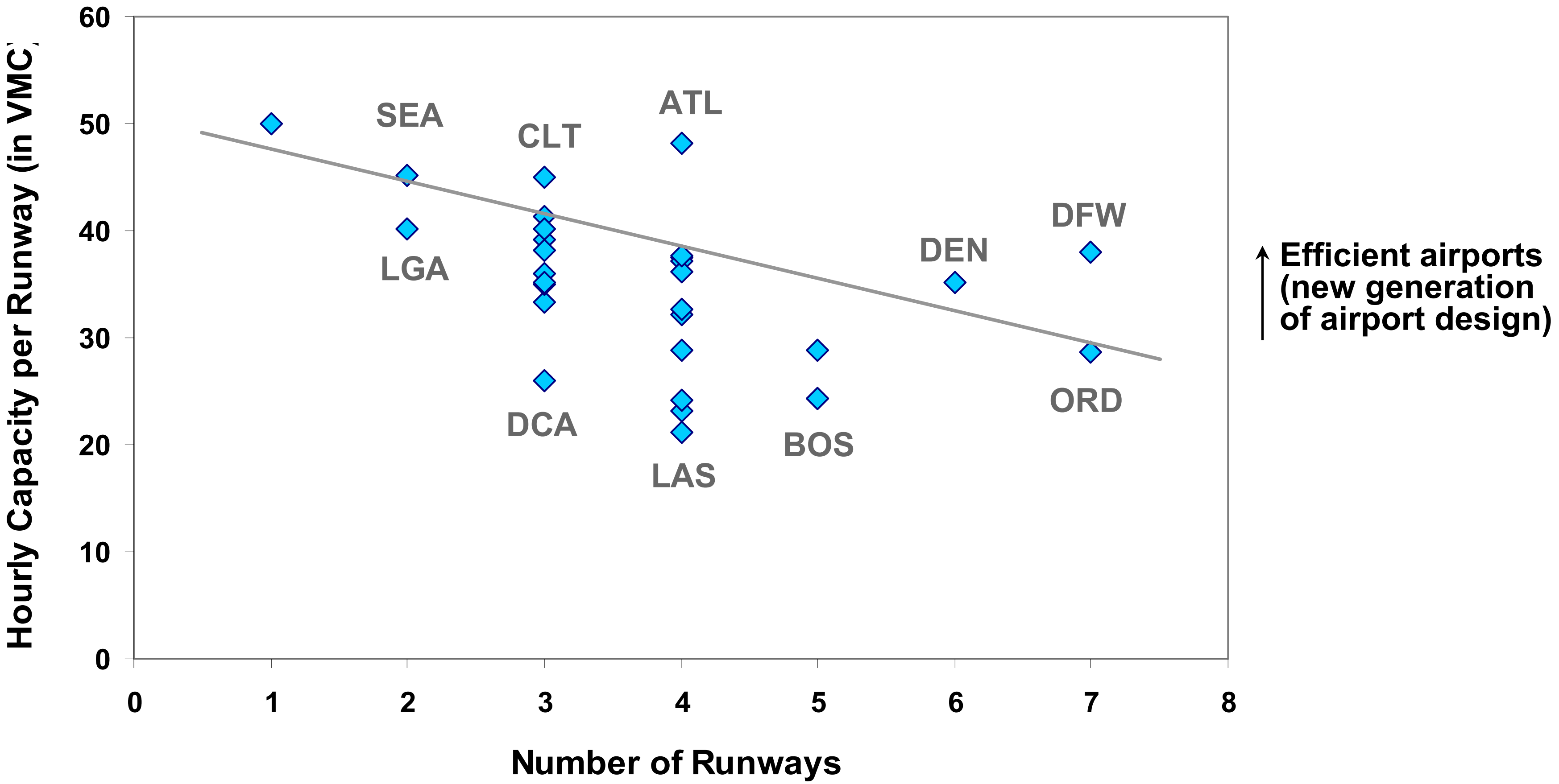
- **Factors affecting the number of runways:**
  - Desired capacity
  - Distribution of wind directions

- **Factors affecting runway configuration:**
  - Wind direction
  - Shape of the land area

**Source: Hansman R. J. & Odoni A. R., “Airport” Presentation  & National Climatic Data Center (NCDC), 2002.**

# Decreasing Marginal Capacity of Airports

- **Implication of configuration on overall throughput of the airport**



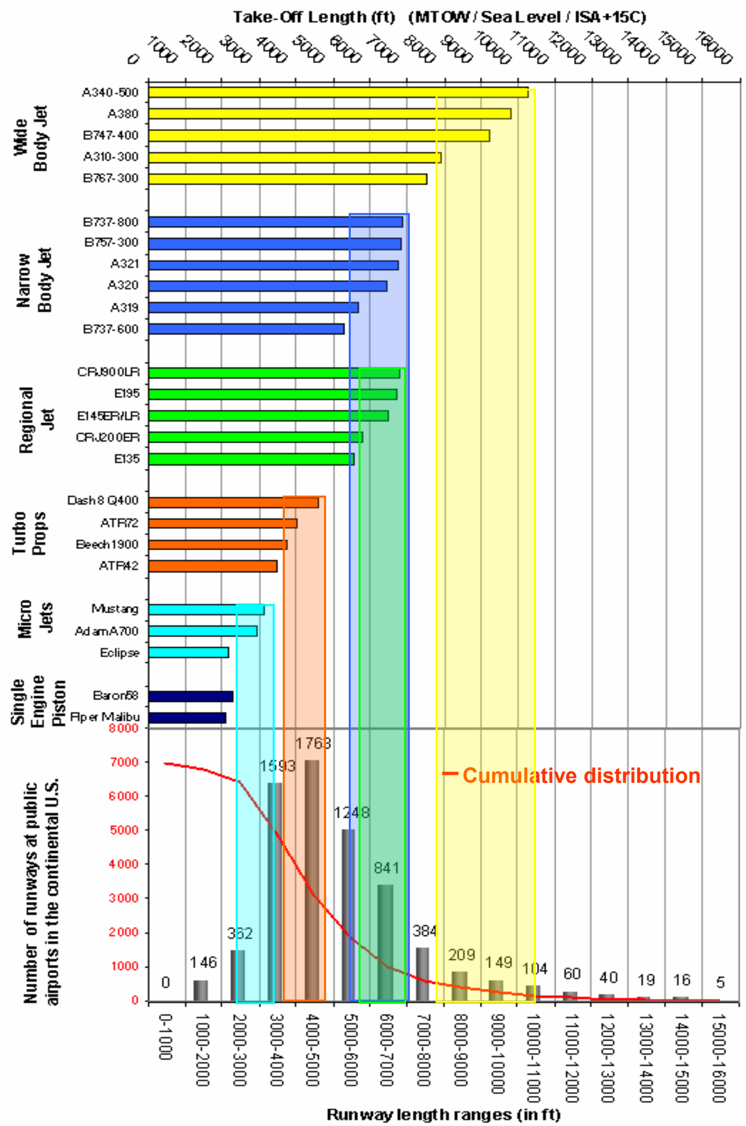

Data source: [Hourly Capacity: FAA Airport Benchmark Report 2001] and [Number of runways from Airport diagram: Airnav.com]

# Aircraft Take-Off Field Length Requirement vs. Runway Length

- **Factors affecting runway length requirements**
  - Weight of the aircraft
  - Stage length (required fuel onboard)
  - Weather
  - Airport location (elevation)
  - Runway slope
  - Runway surface type

- **Number of runway (by length) in the U.S.**

| Runway length greater than | Number of runway |
|---|---|
| 7000 ft | 986 |
| 5000 ft | 3075 |
| 3000 ft | 6431 |

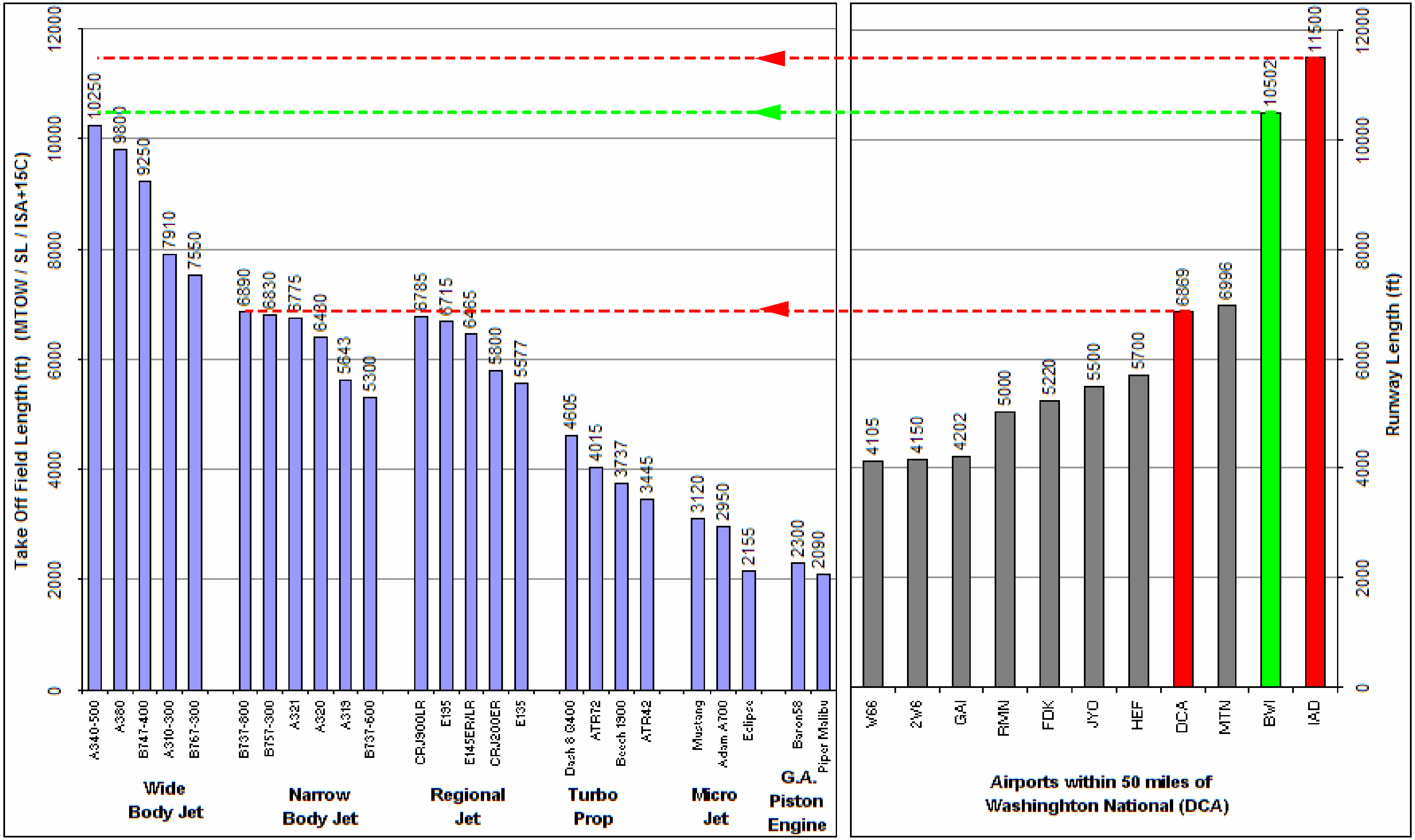



Data source: FAA Form 5010 & Jane's All the World Aircraft.

# Airport/Runway Infrastructure

# Washington Regional Area

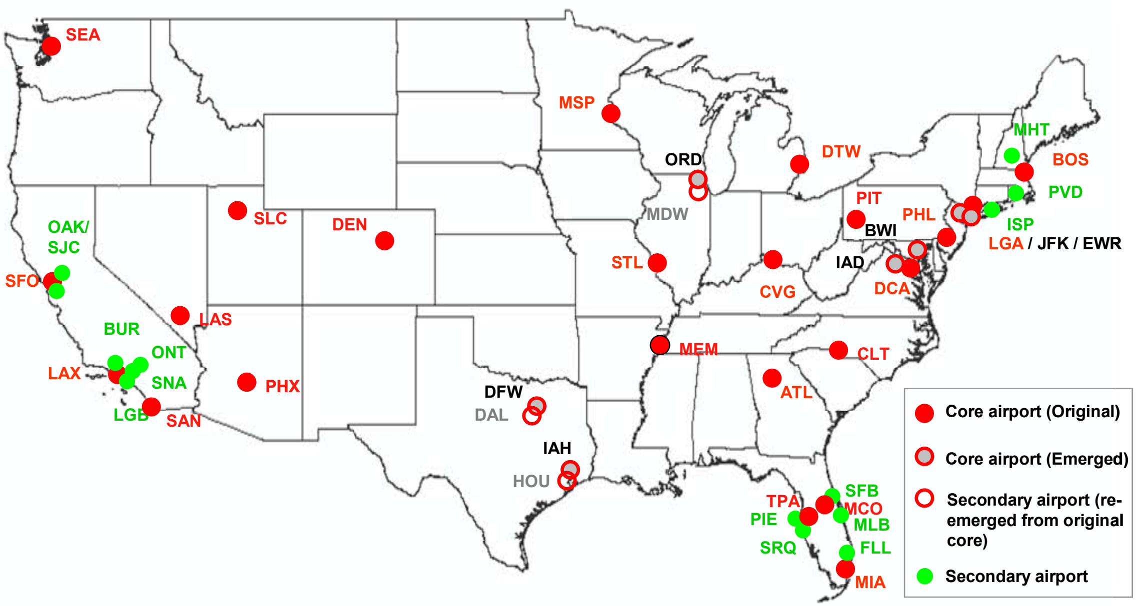
- **Runway length constraints at key airports also set aircraft design and performance (i.e. DCA)**

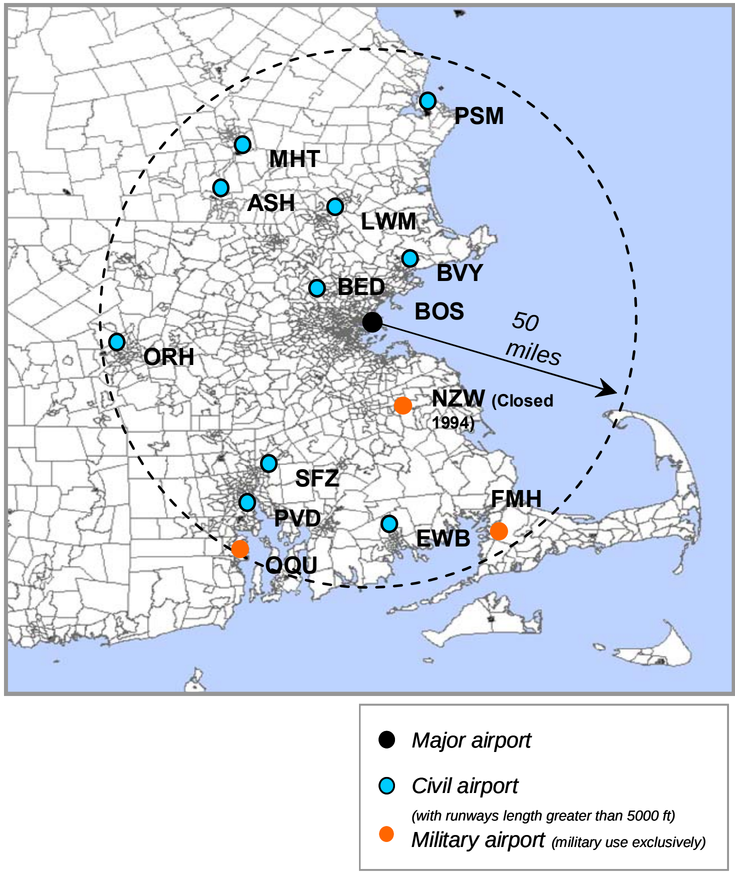



Data source: FAA Form 5010.

# Operations of Multi-Airports Systems

- **Emergence of Secondary Airports and new Core Airports**
- **Transition from single Regional Airport System to Multi Airport Systems**

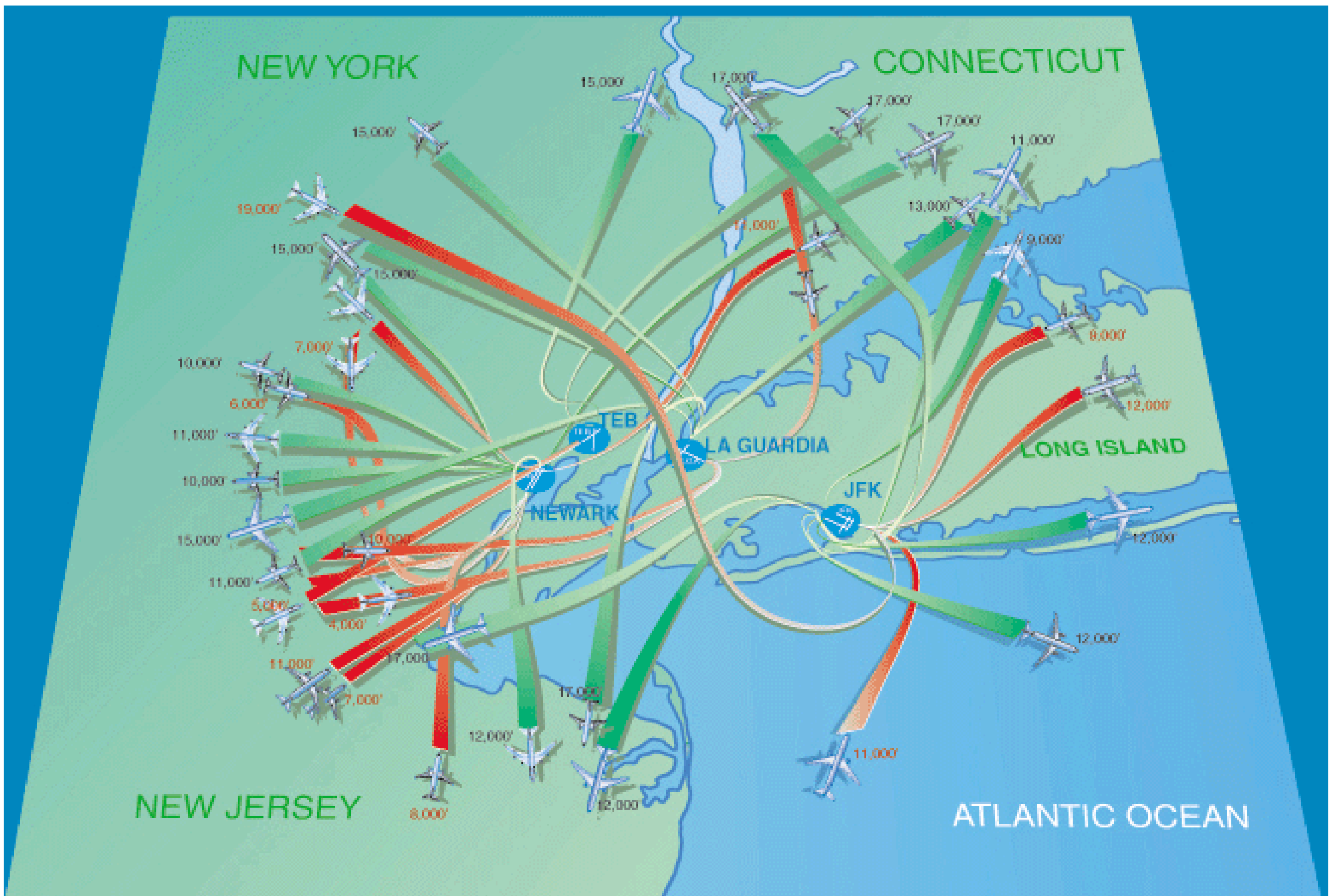



**Data source: FAA Terminal Area Forecast Historical Data, 2004.**

# Operations of Multi-Airports Systems

- **Interactions between airports within the regional airport system**




**Source: FAA, NY/NJ/PHL Airspace Redesign.**

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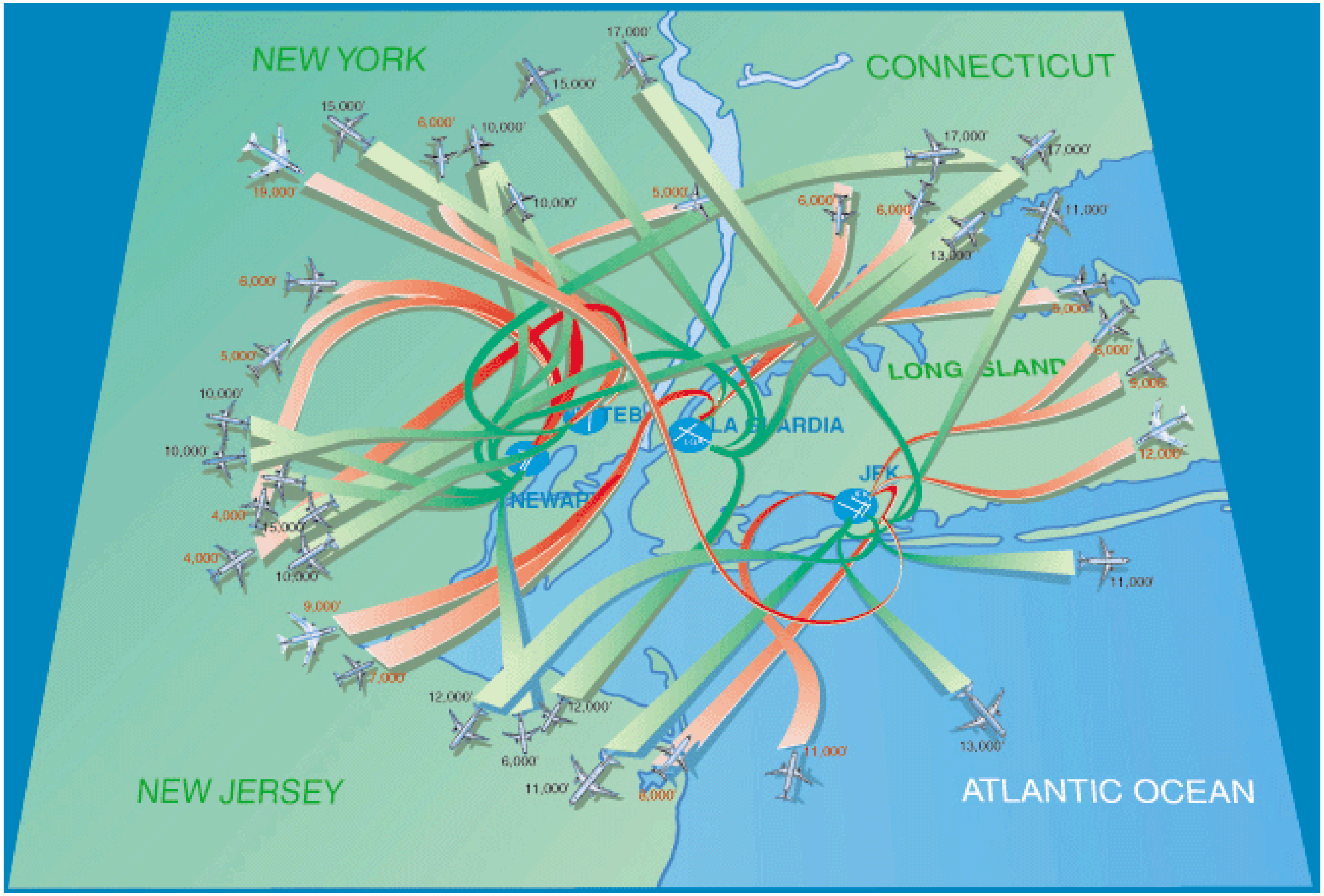


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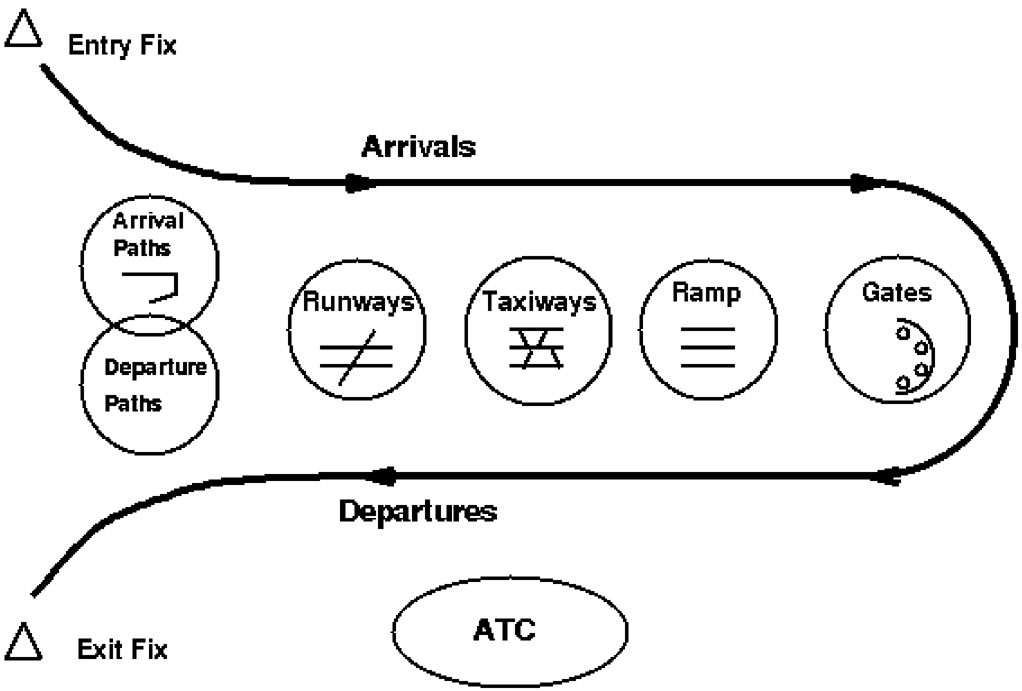
  - Capacity, Utilization & Delays

# Airport as a Multi Server (Queue) System

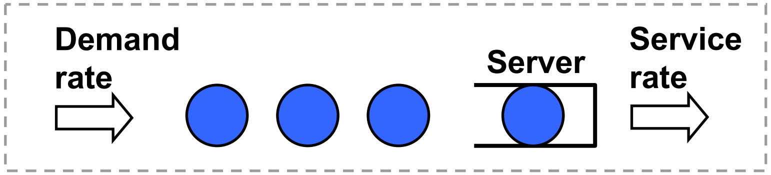
- **Servers:**
  - Upstream airspace
  - Approach/Entry fix
  - Runway
  - Taxiway holding points
  - Gate (arrivals)

  - Gate (departure)
  - Taxiway holding points
  - Runway
  - Downstream airspace



# Basics of Queuing Theory

- **Queuing System**




- **The "utilization ratio", $\rho$ , measures the intensity of use of a queuing system**

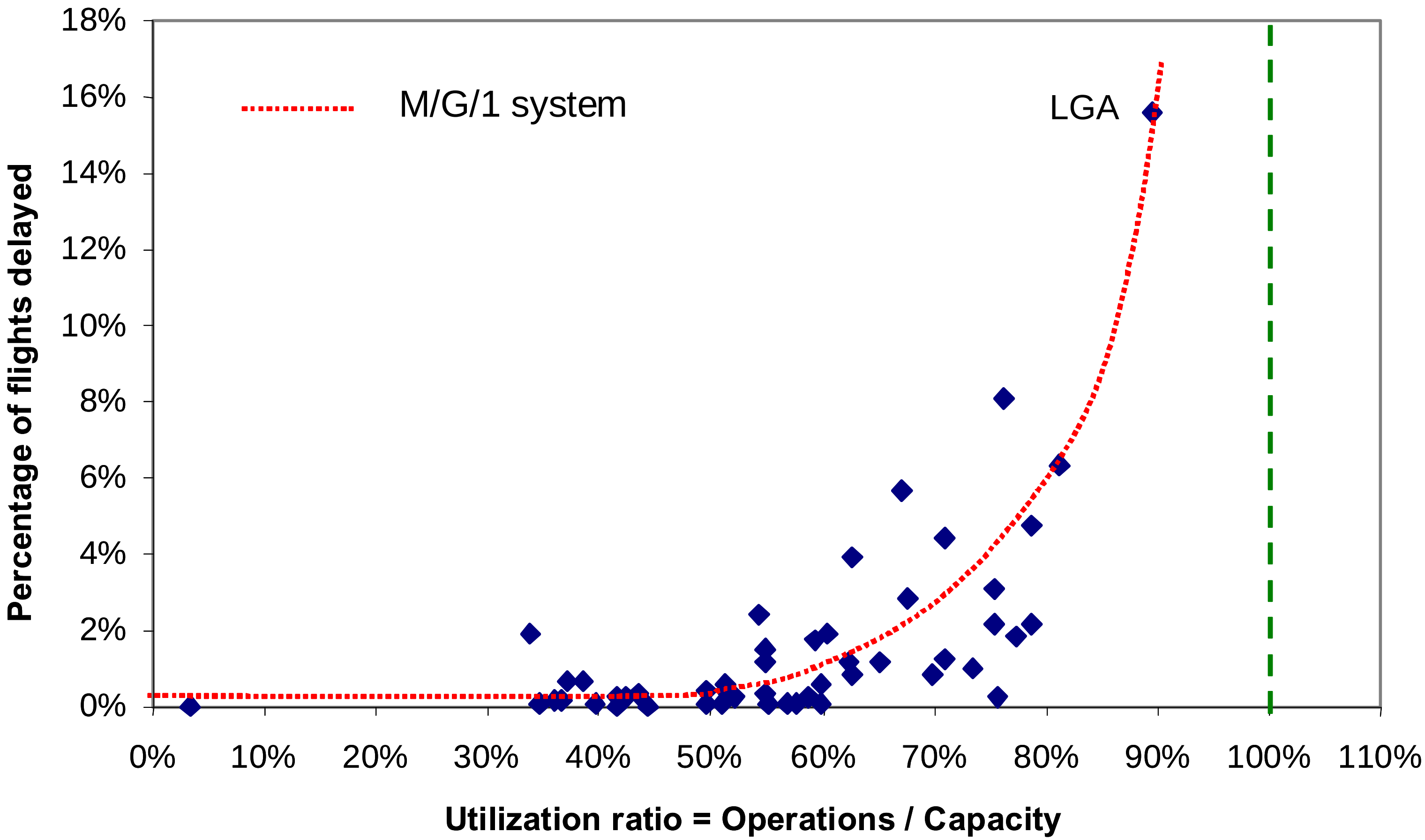
$$\rho = \frac{\text{demand rate}}{\text{service rate}} = \frac{\text{"demand"}}{\text{"capacity"}} = \frac{\lambda}{\mu}$$

- **A queuing system cannot be operated in the long run with a utilization ratio which exceeds 1, since the longer the system is operated, the longer the queue length and waiting time will become.**

- **A queuing system will be able to reach a long-term equilibrium ("steady state") in its operation, only if $\rho < 1$, in the long run.**

# Delays vs. Utilization Ratio

- **As the demand rate approaches the service rate (or as $\rho \rightarrow 1$, or as "demand approaches capacity") the average queue length and average delay increase rapidly**




**Author computation of annual capacity, utilization ratio**

**Data source: FAA Benchmark report 2001.**

# Airport as a Multi Server (Queue) System

- **Airport is a system of servers**
  - Upstream airspace
  - Approach/Entry fix
  - Runway
  - Taxiway holding points
  - Gate (arrivals)

  - Gate (departure)
  - Taxiway holding points
  - Runway
  - Downstream airspace

- **Aircraft and passengers are:**
  - input flows that enter queues
    (taxiways, aprons, waiting lines for
    boarding and ticketing, etc.)
  - waiting to be served by a service facility
    (runways for take-off and landing, gates, ticket counters, boarding gates, etc.)
  - and ultimately leave the system.

- **Each server has a finite capacity to serve its incoming flow**

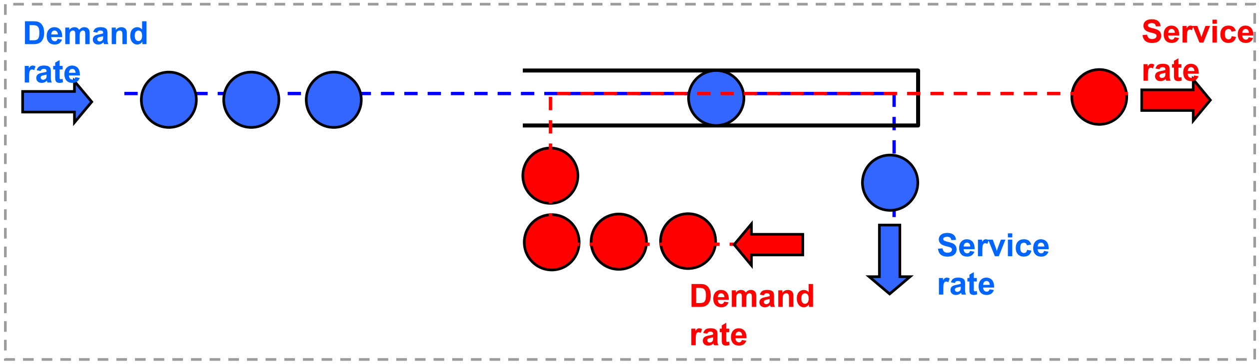
- **Overall airport has a finite capacity**

- **Dominant constraint in the system:**
  - runways (Average Arrival Rate (AAR), Average Departure Rate (ADR)

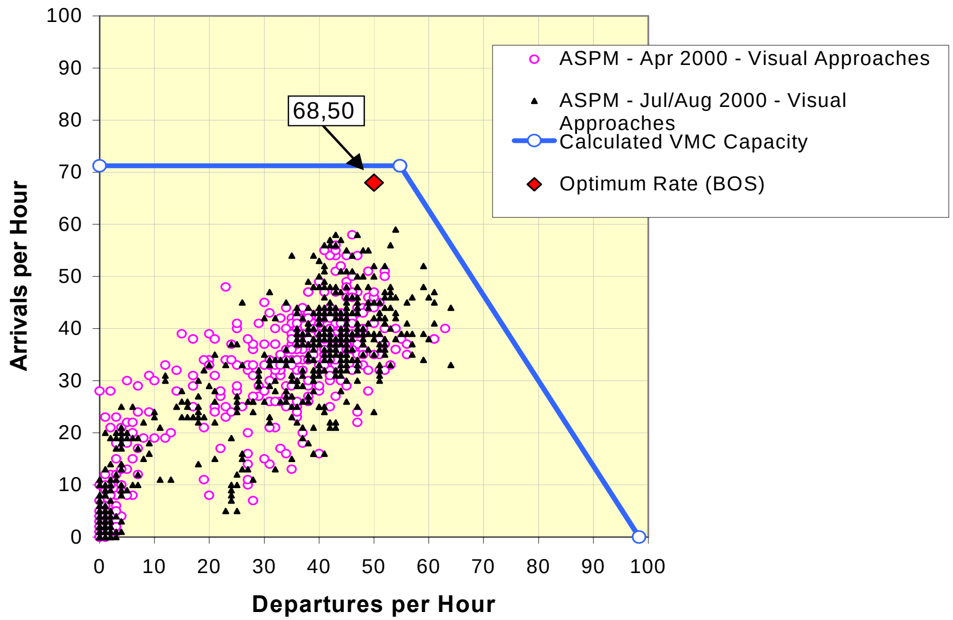
# Runway Capacity

## Two server system (arrival and departures)

- **Conceptual representation of a runway as a server with two queues**

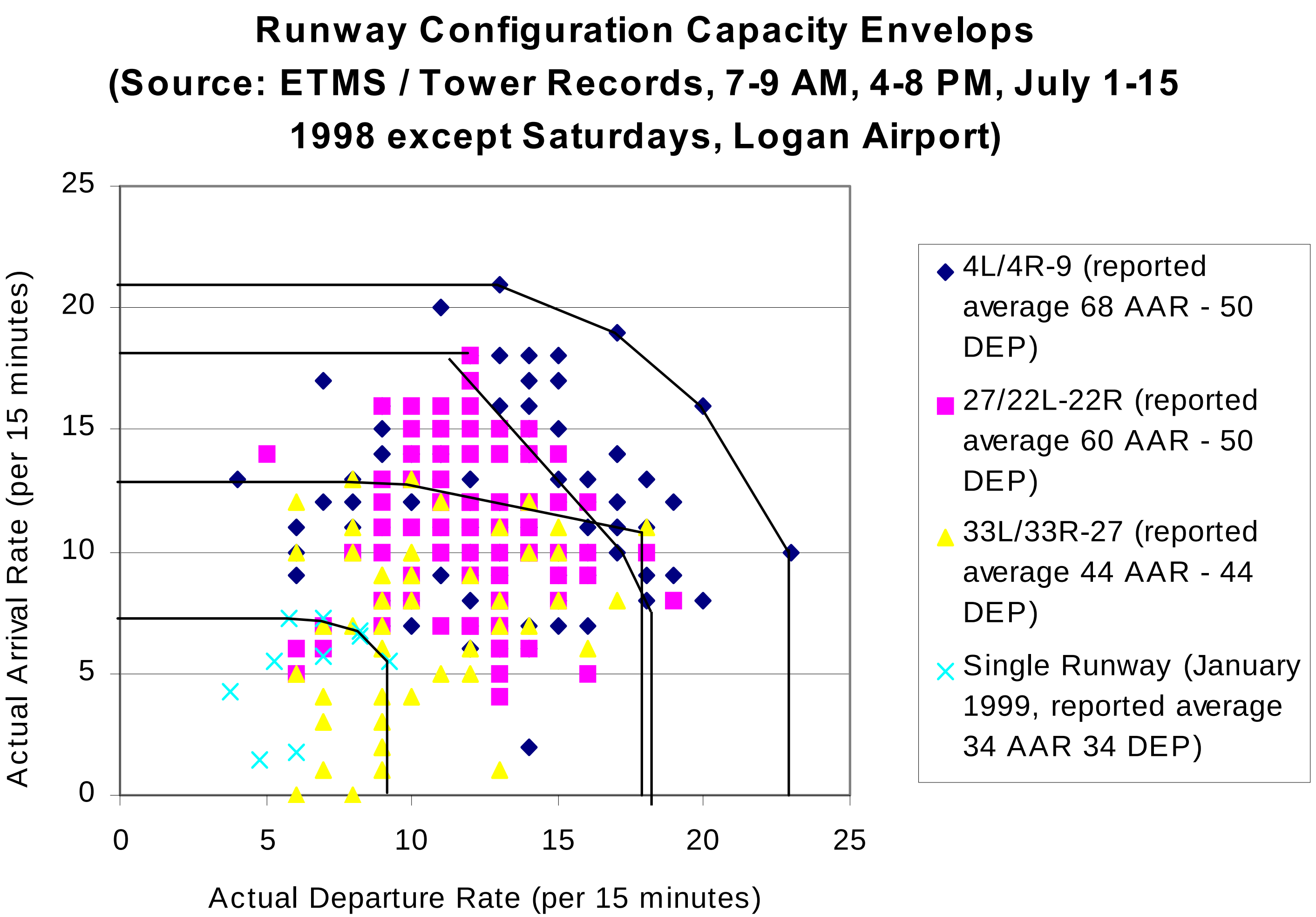



- **Illustration of trade between departure and arrival rates**




Data source: FAA Benchmark report, 2001.

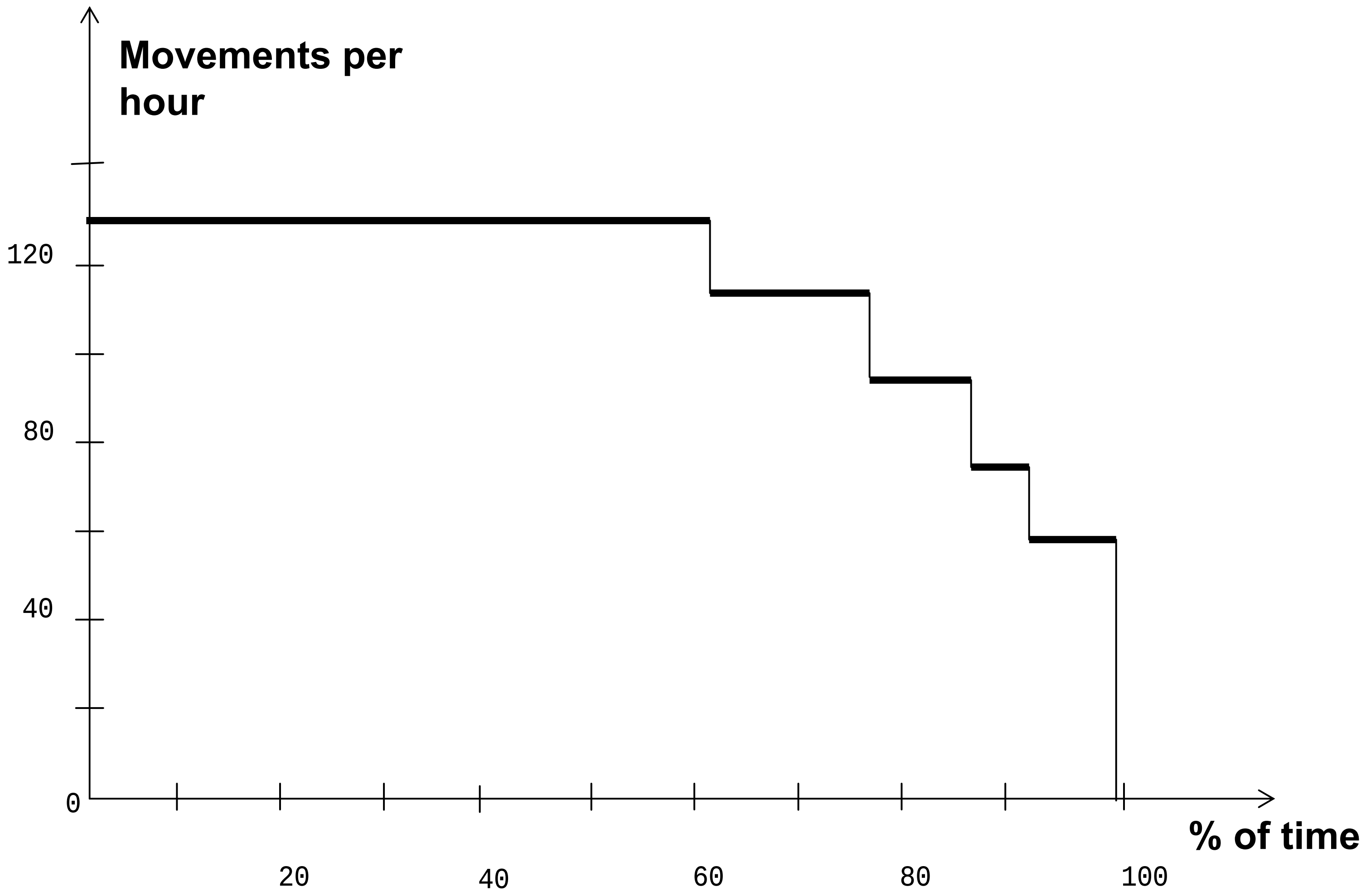
# Runway Configuration Capacity Envelopes




Source: Hansman R. J. & Odoni A. R., "Airport" Presentation.

# Capacity Coverage Chart:

# Boston/Logan BOS




Source: Hansman R. J. & Odoni A. R., “Airport” Presentation.

# Runway Capacity & Scheduling Behavior

- **Airport Capacity**
  - **Maximum Throughput (or Saturation) Capacity:**
    The expected (“average”) number of operations (takeoffs and landings) that can be performed in one hour on a runway (or set of active runways) without violating ATC rules, assuming continuous aircraft demand.

  - **Declared Capacity:**
    The capacity per hour used in specifying the number of slots available for schedule coordination purposes; used extensively outside US; no standard method for its determination; generally set to about 85-90% of saturation capacity; may be affected by apron capacity and/or capacity of passenger terminal

- **Scheduling behavior**
  - **U.S. → Schedule the use of airport at the <u>VMC capacity</u>**
    - *+ use resources in good weather conditions that would otherwise not be utilized*
    - *- as capacity is reduced during IMC, congestion and delay occur*

  - **Outside U.S. (e.g. Europe) → Schedule the use of the airport at the <u>declared</u> capacity**
    - *+ limits congestion in IMC*
    - *- resources not utilized in VMC*

# Factors Influencing Airport Capacity

**Airside**

- **Overall runway capacity**
  - number of runways,
  - runway configuration at a specific time, (wind, direction and speed)

# Factors Influencing Airport Capacity

## Airside

- **Overall runway capacity**
  - number of runways,
  - runway configuration at a specific time, (wind, direction and speed)
  - weather conditions
    Instrument Meteorological Conditions IMC,
    Visual Meteorological Conditions VMC.
  - Separation requirements

- **Wake Turbulence Requirement**

**Trailing Aircraft**

| Leading Aircraft | Heavy | Large | Small |
|---|---|---|---|
| Heavy | 4 | 5 | 5 |
| B757 | 4 | 4 | 5 |
| Large | 3(2.5) | 3(2.5) | 4 |
| Small | 3(2.5) | 3(2.5) | 3(2.5) |

- **Airbus A380:**
  **Separation standard: 10 nm***

*** Provisional standard. Final guidance should be released by ICAO in November 2006**

# Factors Influencing Airport Capacity

## Airside

- **Overall runway capacity**
  - number of runways,
  - runway configuration at a specific time, (wind, direction and speed)
  - weather conditions
    Instrument Meteorological Conditions IMC
    Visual Meteorological Conditions
  - Separation requirements
  - Mix of aircraft
  - Mix between AAR and ADR, as runways can be used for both departure and arrivals.
  - Runway exit (location and shape –high speed exits)
  - Environmental
    - *Noise*
    - *Emissions*
  - Safety

- **Gates**
  - Turn-around time
  - Boarding efficiency

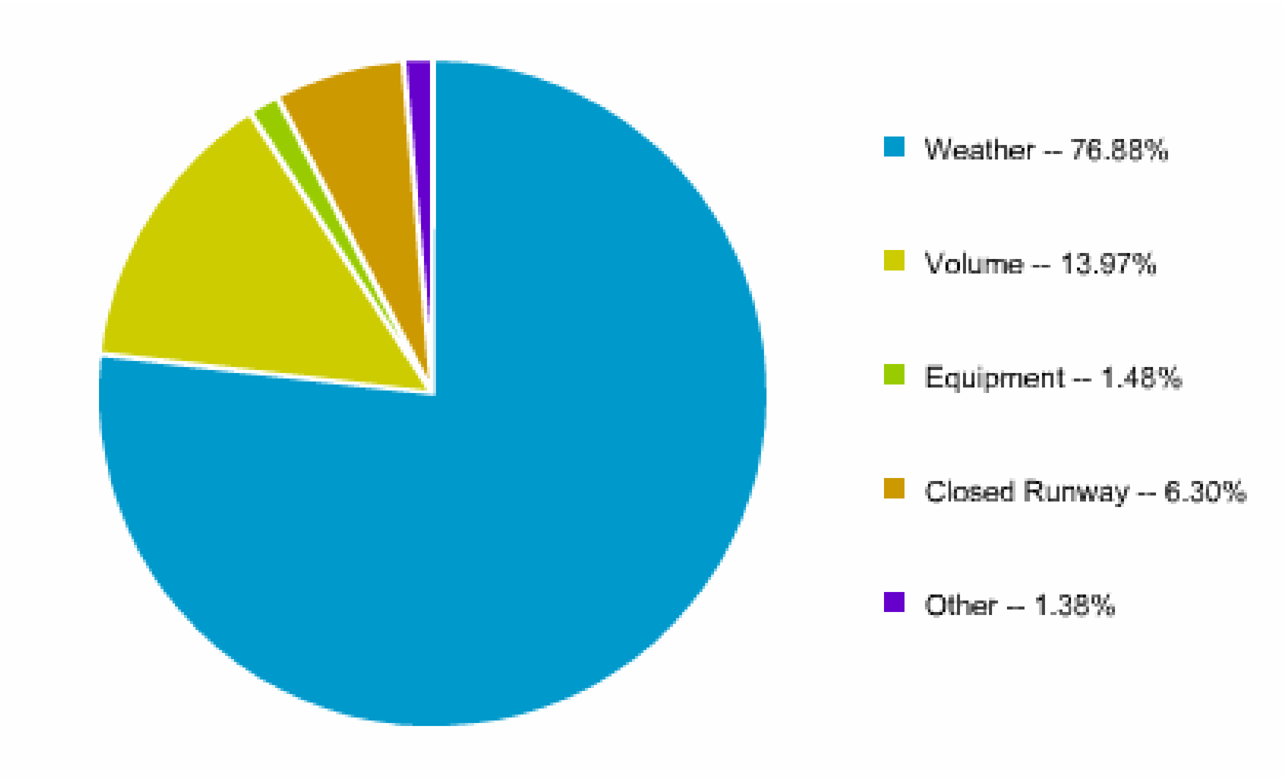
- **Taxiways and runways**
  - Controller Workload

## Landside

- **Terminals**
  - Security
  - Road Access

# Causes of National Aviation System Delays

- **Data from July 2006**




**Source: Bureau of Transportation Statistics BTS, Airline On-Time Statistics and Delay Causes.**

# Capacity Adjustment at OEP Airports

## Year: 2000

| Airport code | Airport name | Percentage of operations delayed | OEP new runway project (date completion/ capacity benefit) |
|---|---|---|---|
| LGA | LaGuardia | 15.6% | |
| EWR | Newark | 8.1% | |
| ORD | Chicago | 6.3% | |
| SFO | San Francisco | 5.7% | |
| BOS | Boston | 4.8% | 2006 / +2% |
| PHL | Philadelphia | 4.5% | |
| JFK | Kennedy | 3.9% | |
| ATL | Atlanta | 3.1% | 2006 / +33% |
| IAH | Houston | 2.8% | |
| DFW | Dallas/Ft.Worth | 2.4% | |
| PHX | Phoenix | 2.2% | |
| LAX | Los Angeles | 2.2% | |
| IAD | Dulles | 2.0% | |
| STL | St. Louis | 1.8% | 2006 / +48 % |
| DTW | Detroit | 1.8% | |
| CVG | Cincinnati | 1.5% | 2005 / +12 % |
| MSP | Minn./St. Paul | 1.3% | 2005 / +19 % |
| MIA | Miami | 1.1% | |
| SEA | Seattle | 1.0% | 2008 / +46 % |
| LAS | Las Vegas | 0.8% | |
| DCA | Reagan National | 0.8% | |
| BWI | Balt.-Wash. Intl | 0.7% | |
| MCO | Orlando | 0.6% | |
| CLT | Charlotte | 0.6% | 2008 / +11% |
| PIT | Pittsburgh | 0.4% | |
| SAN | San Diego | 0.3% | |
| DEN | Denver | 0.2% | |
| SLC | Salt Lake City | 0.2% | |
| TPA | Tampa | 0.2% | |
| MEM | Memphis | 0.0% | |

## Year: 2005

| Airport code | Airport name | Percentage of operations delayed | OEP new runway project (date completion/ capacity benefit) |
|---|---|---|---|
| EWR | Newark | 8.8% | |
| ATL | Atlanta | 6.8% | 2006 / + 33% |
| LGA | LaGuardia | 6.7% | |
| ORD | Chicago | 5.8% | ? |
| PHL | Philadelphia | 5.0% | 2008 / ? |
| JFK | Kennedy | 4.0% | |
| BOS | Boston | 2.8% | 2006 / ? |
| SFO | San Francisco | 2.6% | |
| PHX | Phoenix | 2.4% | |
| IAH | Houston | 2.0% | |
| IAD | Dulles | 1.9% | 2008 / +12% |
| LAS | Las Vegas | 1.5% | |
| CLT | Charlotte | 0.9% | |
| DTW | Detroit | 0.8% | |
| MSP | Minn./St. Paul | 0.7% | |
| DCA | Reagan National | 0.6% | |
| DFW | Dallas/Ft.Worth | 0.6% | |
| CVG | Cincinnati | 0.6% | |
| MIA | Miami | 0.4% | |
| SAN | San Diego | 0.4% | |
| BWI | Balt.-Wash. Intl | 0.4% | |
| MEM | Memphis | 0.3% | |
| SEA | Seattle | 0.3% | 2008 / + 46% |
| DEN | Denver | 0.3% | |
| LAX | Los Angeles | 0.3% | 2008 / Not Avail. |
| MCO | Orlando | 0.3% | |
| SLC | Salt Lake City | 0.2% | |
| TPA | Tampa | 0.2% | |
| STL | St. Louis | 0.1% | 2006 / + 48% |
| PIT | Pittsburgh | 0.1% | |

**Data source: [Delay data: FAA Operational Network, OPSNET], [Capacity improvement: FAA Operational Evolution Plan OEP].**

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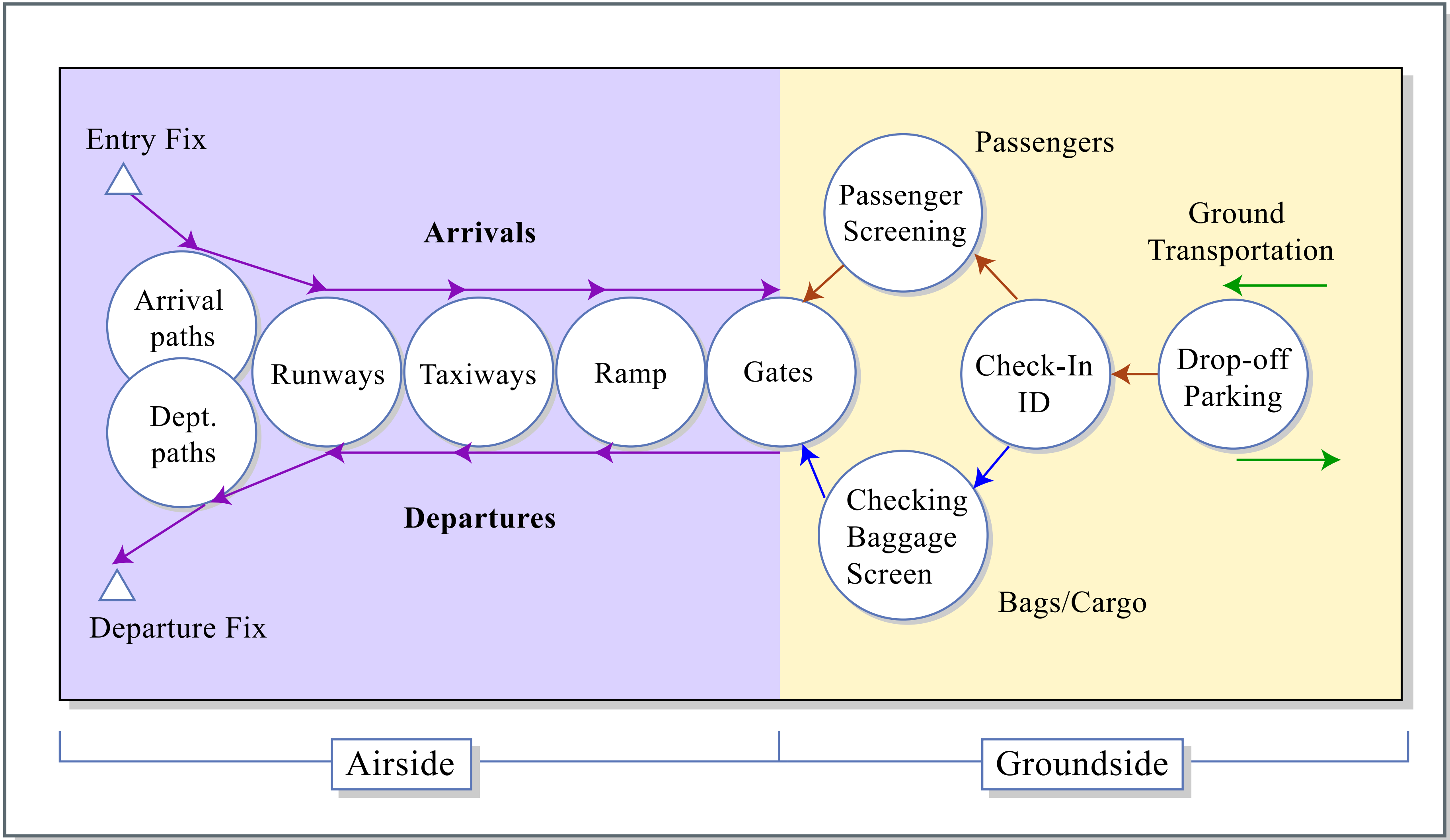
# Operations

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# Terminal Areas (Airspace)

## Overview

- **Terminal Area extends to typically**
  - 30 - 50 miles around a major airport
  - 18,000 ft with multiple layers of airspace (inverted "wedding cake")

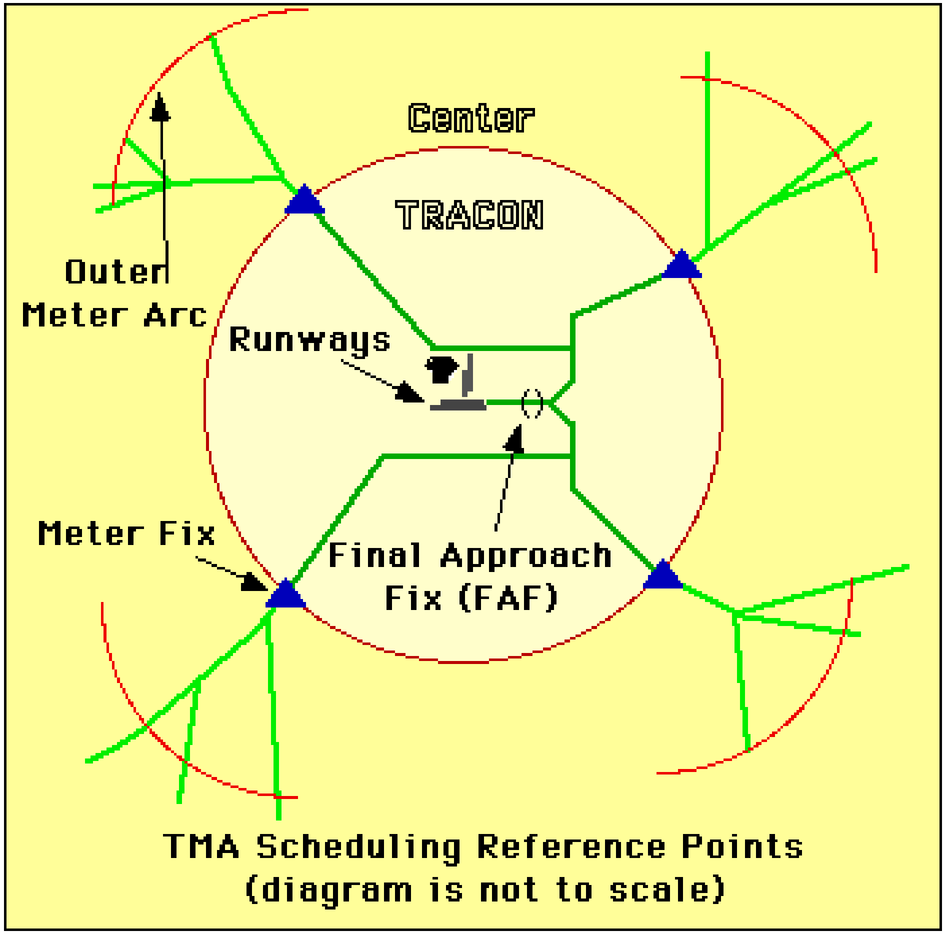
- **Terminal Area have exit and entry points by which aircraft transition in and out of the center**

- **Air Traffic Control run by TRACON (Terminal Radar Control) Controllers**
  - Manage the airspace in the terminal (except for airspace controlled by the tower ≈ 5 miles around the airport)
  - Function:
    - *Ensure separation*
    - *Merge and meter upstream traffic flows*

# Terminal Areas (Airspace)

# Control Points

- **Entry fixes**
  - Interface between the center and the terminal airspace
- **Initial Approach Fix (IAF)**
  - possible holding at IAF
  - starting point of the initial approach leading to the Final Approach Fix (Intermediate Approach can be required in more complex approaches).
- **Final Approach Fix (FAF)**
  - Located between 4 and 12 NM from the runway threshold (usually in the alignment of the runway)

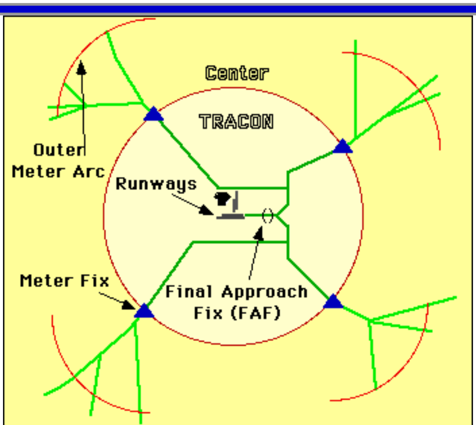



Source: NASA, ctas

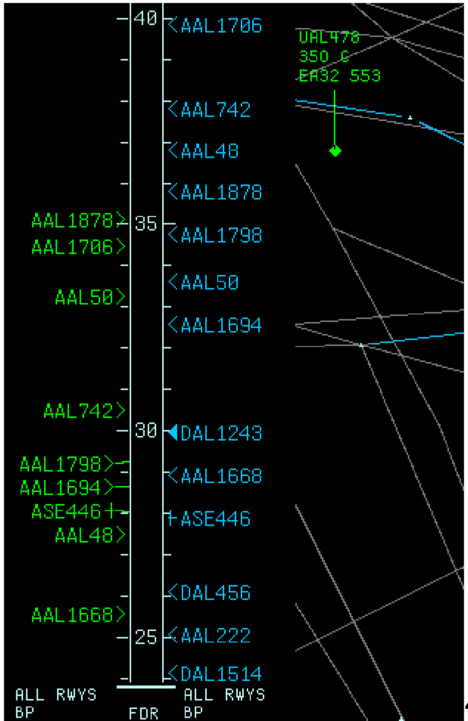
# Upstream Synchronization

# Traffic Management Advisory (TMA)

- **The Traffic Management Advisor (TMA) assists, but does not replace, the Center TMCs and air traffic controllers in several ways.**
- **TMA:**
  - increases situational awareness through its graphical displays and alerts.
  - generates statistics and reports about the traffic flow.
  - computes the un-delayed estimated time of arrival (ETA) to the outer meter arc, meter fix, final approach fix and runway threshold for each aircraft.
  - computes the sequences and scheduled times of arrival (STAs) to the outer meter arc, meter fix, final approach fix, and runway threshold for each aircraft to meet the sequencing and scheduling constraints entered by the TMC.
  - assigns each aircraft to a runway to optimize the STAs. (FAST may overrule these STAs)
  - continually updates its results at a speed comparable to the live radar update rate in response to changing events and controller inputs.




TMA Scheduling Reference Points
(diagram is not to scale)

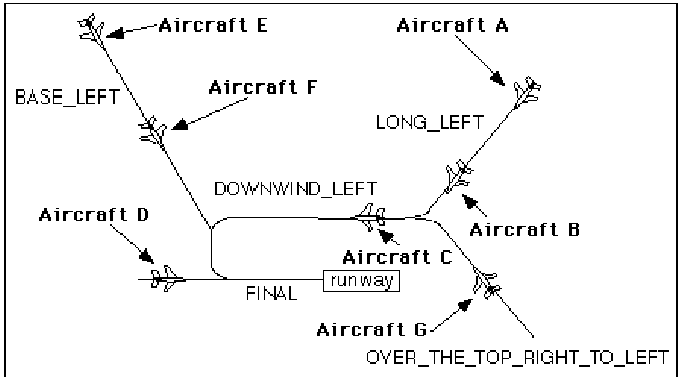



Source: NASA ctas

# Upstream Synchronization

# Final Approach Spacing Tool (FAST)

- FAST provides landing sequences and landing runway assignments, as well as speed, and heading advisories that help controllers manage arrival traffic and achieve an accurately spaced flow of traffic on final approach.



Sequencing Example

- Passive FAST Operational at Dallas/Fort Worth TRACON
in 1999,

Source: http://ctas.arc.nasa.gov/project_description/tma.html.

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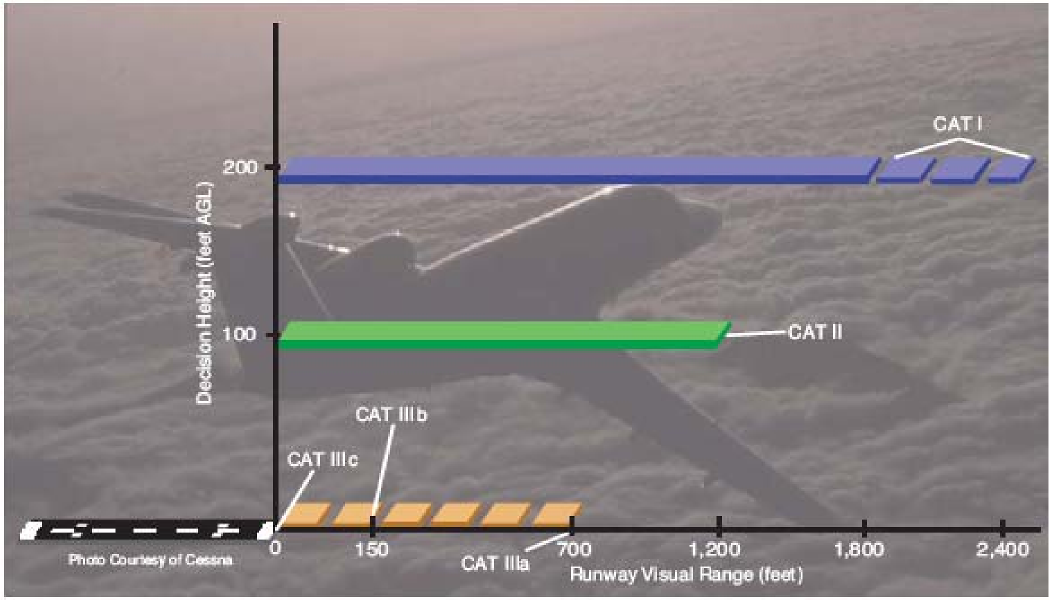
![MIT ICAT logo]

# Approach Requirements

- **Requirements**
  - Horizontal Visibility
    - *Human visual estimation*
    - *RVR (Runway Visual Range)*
  - Ceiling  (decision height)
  - Runway conditions
- **Communicated to the pilot by ATC**
  - ATIS
  - Directly

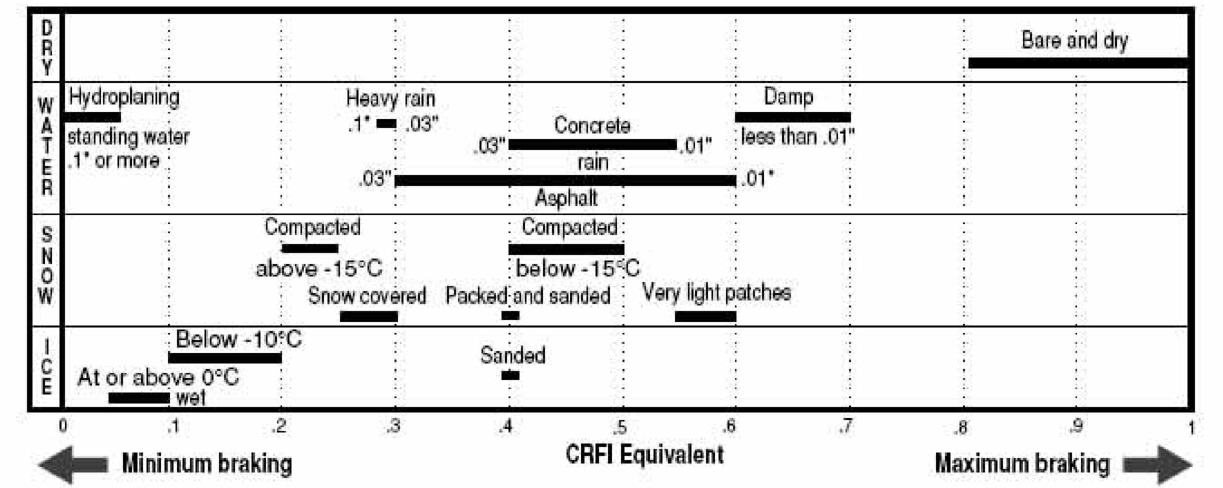


# RVR Measuring System

- **Runway Visual Range (RVR) measuring system**
  - Optical measurement system that measures the amount of light scattered by atmospheric particles of fog, dust, or precipitation (extinction coefficients)
  - Extinction coefficients are converted into visibility distance that are communicated to the pilot
  - Located close to the runway threshold, pointing in the alignment of the runway

# Runway Conditions & Effect on Braking Efficiency

- **Runway condition measurement:**
  - Friction coefficient measurement
  - Decelerometers
- **Reporting:**
  - U.S. Condition:
    Qualitative: WET-FAIR, WET-POOR
  - Outside U.S. (e.g. Canada).
    Quantitative: Canadian Runway Friction Index CRFI from 0 to 1




- **Communication:**
  - Notice to Airmen NOTAMs & ATIS
  - Directly to the pilot from the controller

Source: [FAA Runway Friction Program], [CRFI Table: Transport Canada], [Pictures: NASA/TC Joint Winter Runway Friction Program report]

# Runway Overrun Accident

# Southwest Flight 1248 at MDW

- **Accident: Runway overrun**
  - Airport: Chicago Midway (MDW), Runway 31C
  - Aircraft: Boeing 737-700
  - Date: December 8 2005
  - Fatalities/Injuries: 1+1

- **Conditions:**
  - Wind 11 knots 100 degrees (20 min. before accident)
  - Visibility (1/4 mile), Ceiling (200ft) (23 mi. after acc.)
  - Moderate snow and freezing fog,
  - Snow: 1 inch of new show in the last hour, 10 inches on the ground.
  - Runway 31C was used as landing runway because it contained lower landing minimums for aircraft using the ILS approach. (unable to land on runway 13C).

- **Computation of runway length requirement**
  - Runway condition WET-FAIR (Safety buffer with WET-POOR: 30 ft of runway length) safety
  - Included reverse thrust credit

**Source: NTSB Report December 15 2005**

# Engineered Materials Arresting System (EMAS)

- **Runway Safety Area (RSA) for Part 139 airports.**
  - 500 feet wide and extends 1000 feet beyond each end of the runway.
  - Prevents aircraft overruns, undershoots, or veers off the side of the runway.

- **Not practical for some airports due to land area constraints.**

- **Solution: Engineered Materials Arresting System (EMAS)**
  - Materials of closely controlled strength and density placed at the end of a runway to stop or greatly slow an aircraft that overruns the runway: (lightweight, crushable concrete).

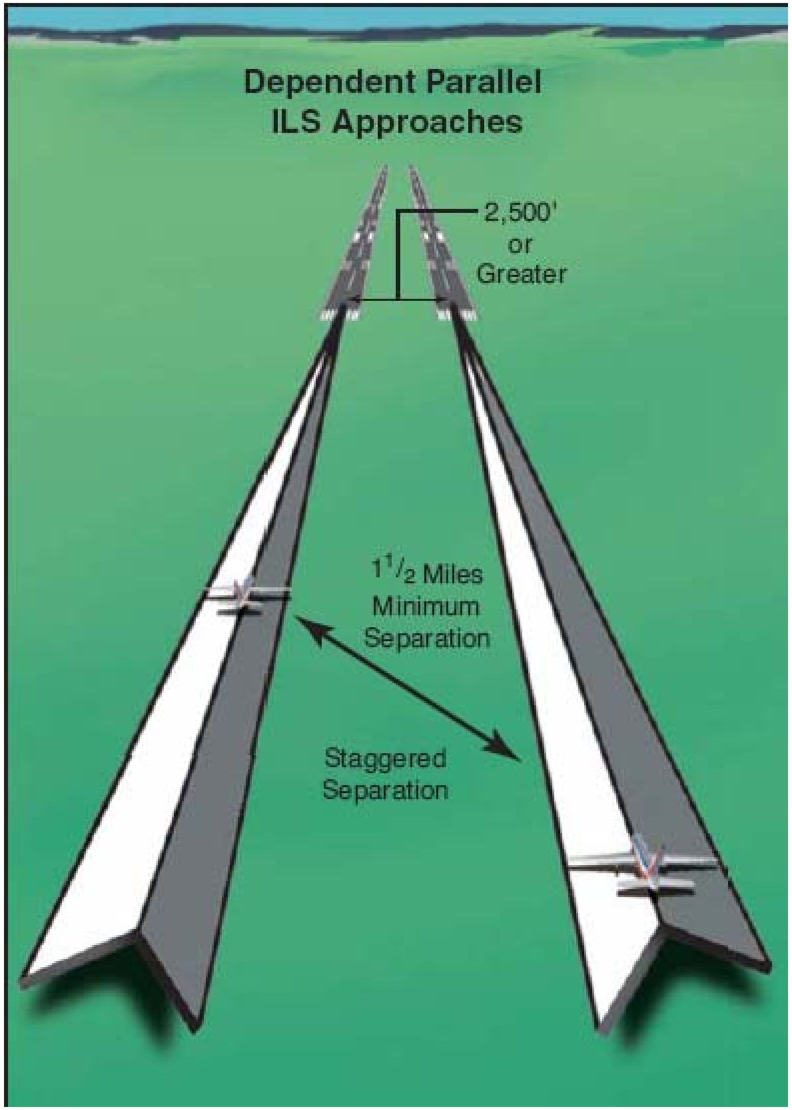
**Source: NTSB Report December 15 2005**

# Final Approach

# Parallel Approaches

- **Parallel Dependent ILS approaches**
  - Parallel runway centerlines separated by at least 2,500 feet.
  - Aircraft must be staggered by a minimum of 11/2 NM diagonally.

- **Normal operating zone (NOZ)**
  - zone within which aircraft remain during normal approach
  - > 1,400 ft wide and 700 feet of space on either side of the runway centerline

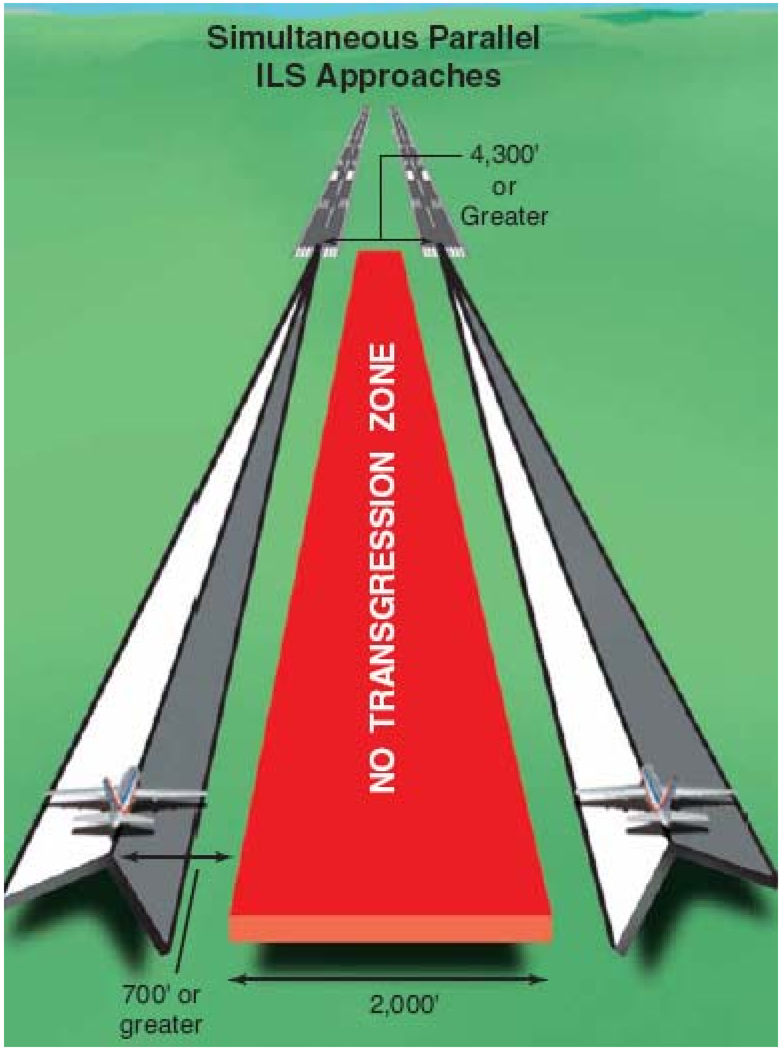



Source: FAA Instrument Approach Procedure Manual

# Final Approach

# Parallel Approaches

- **Parallel Simultaneous ILS Approaches**
  - runway centerline between 4,300 feet and 9,000 feet
  - dedicated final monitor controller is required to monitor separation for this type of approach (eliminates the need for staggered approaches).




- **Triple simultaneous approaches**
  - runway centerlines: at least 5,000 feet and are below 1,000 feet MSL

- **No transgression zone (NTZ)**
  - 2,000-foot wide area located between the parallel runway final approach courses.

Source: FAA Instrument Approach Procedure Manual

# Converging Approaches

- **Operational characteristics**
  - Runways with an angle between 15° and 100°
  - ILS equipped runways
  - MAP at least 3 NM apart with no overlapping of the protected missed approach airspace.
- **Pilot informed of converging approaches by the tower**
- **Airports operating converging approaches (e.g. DFW)**

**Source: FAA Instrument Approach Procedure Manual**

# Landing Requirements

- **Decision point:**
  - Decision height (DH)
  - Missed Approach Point (MAP)
- **Pilot's responsibility to continue the approach**
- **Required references:**
  - Approach light system (not below 100 feet TDZ),
  - Runway threshold,
  - Runway threshold markings,
  - Runway threshold lights,
  - Runway end identifier lights,
  - Visual approach slope indicator,
  - Touchdown zone or touchdown zone markings,
  - Touchdown zone lights,
  - Runway or runway markings,
  - Runway lights,

**Source: FAA Instrument Approach Procedure Manual**

# Airport Lighting Aids

- **Approach Light Systems (ALS)**

- **Visual Glide slope Indicators**
  - Visual Approach Slope Indicator (VASI)
  - Precision Approach Path Indicator (PAPI).
  - Tricolor system
  - Pulsating Systems.
  - Alignment of Elements Systems.

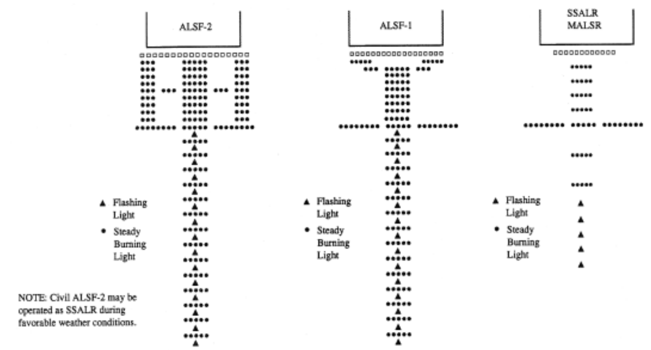
- **Runway End Identifier Lights (REIL)**
  - Pair of synchronized flashing lights located laterally on each side of the runway threshold

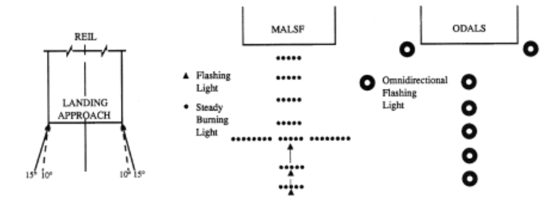
- **Runway Edge Light Systems**
  - White on the side and red lights at the end of the runway

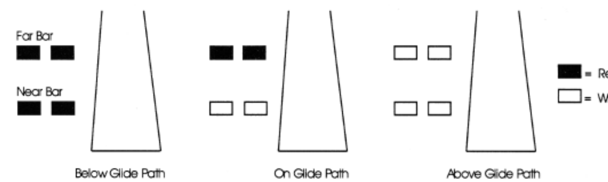
- **In-runway Lighting**
  - Runway Centerline Lighting System (RCLS) (white lights)
  - Touchdown Zone Lights (TDZL). (steady-burning white lights)
  - Taxiway Centerline Lead-Off Lights. (Alternate green and yellow lights)
  - Taxiway Centerline Lead-On Lights. (yellow light)
  - Land and Hold Short Lights (row of pulsing white lights)

- **Taxiway Lights**
  - Taxiway Edge Lights
  - Taxiway Centerline Lights
  - Clearance Bar Lights
  - Runway Guard Lights
  - Stop Bar Lights

- **Airport/Heliport Beacons**



# Missed Approach Procedures

- **Missed Approach:**
  - Optional phase used if required visual reference for landing have not been obtained at the decision height (DH) or missed approach point (MAP)
  - Procedure: climb to a safe altitude in a protected part of the airspace and hold before attempting a new approach or diverting.

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  - Capacity, Utilization & Delays

- **Operations**
  - General ATC structure and functions

  - Terminal Approach
  - Final Approach
  - Ground (arrivals)

# Land And Hold Short Procedures (LAHSO)

- **Simultaneous Operations on Intersecting Runways (SOIR)**
  - Used to increase airport capacity (aircraft taking-off or taxing on intersecting runways at the same time)
  - Started in 1968
  - Used at 220 airports in the U.S. (850 intersecting runway combinations)

- **Land and Hold Short Operations (LAHSO)**
  - Increase efficiencies for intersecting runway operations
  - Implemented in 1997
  - 215 airports (785 intersecting runway configurations).
  - include landing and holding short of an approach/departure (not included in SOIR)

- **Operational conditions:**
  - Infrastructure: signs, lights,
  - Procedural: runway surface approval, continuous friction measurement,

# Taxiing

# (Arrival)

- **Landing**
  - High Speed Exits to Taxiways
    at least 550m long with 30 deg. angle to the runway
    Maximum speed: 93 km/h (50 kts)

- **Runway/Taxiway control point**
  - Clearance to taxi from the holding point to the gate
  - Taxi-path control

- **Runway crossing control point**
  - Clearance to cross an active runway

- **Taxiway/Ramp control point**
  - Clearance to exit the taxiway and enter the ramp/gate

# Surface Control Tools

- **In the tower**
  - Visual
  - Radar based: (e.g. ASDE-X)
  - Future tools: ADS-B

- **In the cockpit**
  - Airport surface diagram
  - Digital map
  - Future tools:
    - *Digital maps integrating TIS-B information*

# Helicopter Operations

- Helicopters operations have to be integrated with aircraft operations without interference
- Mixed operations
  e.g. Boston
- Dedicated helicopter operations facilities
  e.g. Downtown Manhattan Heliport (DMH)

- Helicopter Route Chart Boston (HELBOS)

Chart source: FAA National Aeronautical Charting Office (NACO)

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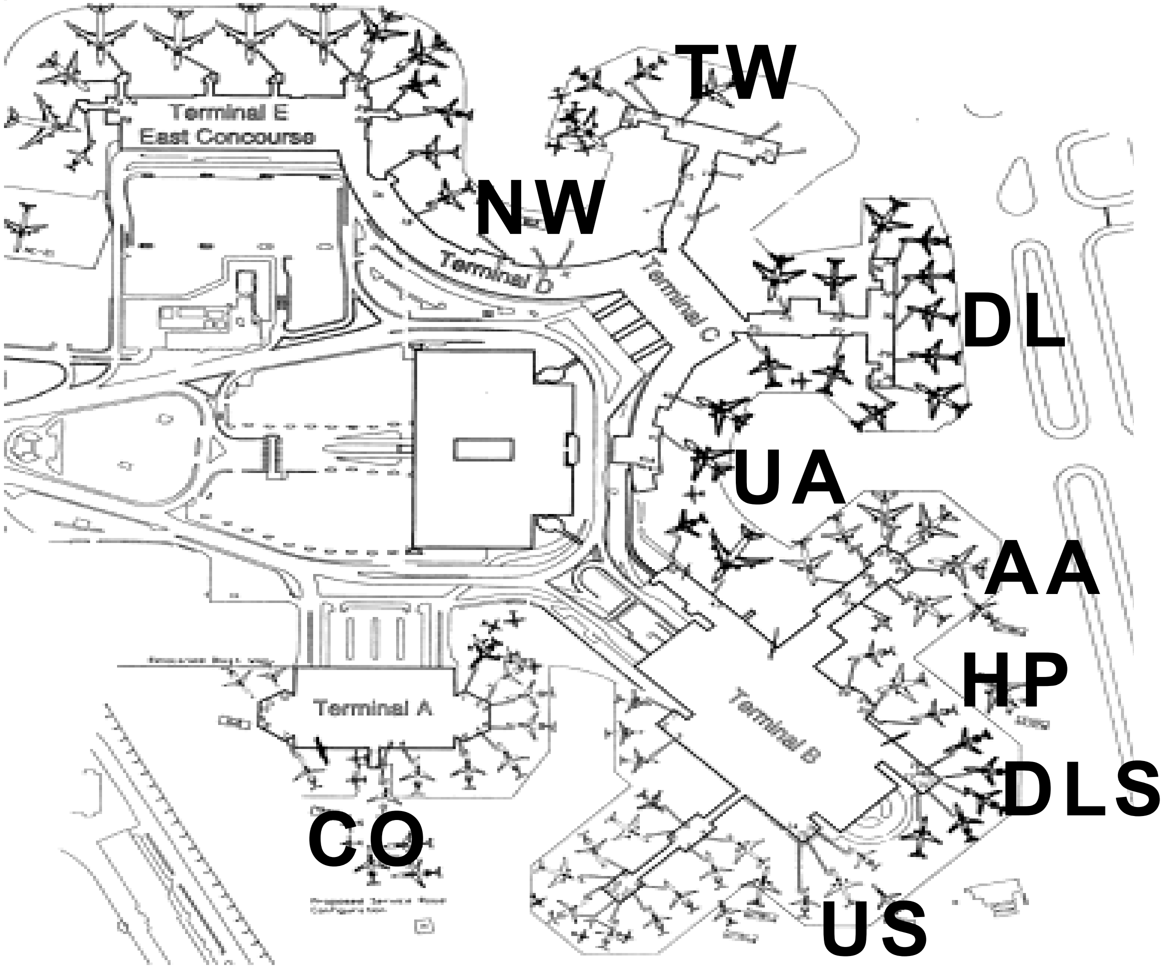
  - Gate operations (arrivals)

# Gates & Ramps

- **Traffic flow on the ground is influenced by gate capacity (availability) and taxi-way/ramp configuration**




**Source: Hansman R.J., Odoni A., "Airport" presentation, 2005.**

# Gates

# Aircraft Specific Gates

## Aircraft type

Gate number

| C | 747 400 | 747 200 | 777 | 767 | 10/ 10 | 10/ 30 | DC 9 | 757 | 727 | 737 | 319 320 | B/S | DULLES C-GATE CAPABILITIES REVISED 01/15/01 — NOTES |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | X | X | X | X | X | X | | X | X | X | X | Y | MD-11 gate, SP on 67 spot, DC-9/10 on 27 spot, A340 gate now, A310-200 now A330/200 on 67 stop |
| 2 | X | X | X | X | X | X | | X | X | X | X | Y | MD-11 gate, SP on 67 spot, DC-9/10 on 27 spot, A340 gate now, A310-200 now A330/200 on 67 stop |
| 3 | X | X | X | X | X | X | | X | X | X | X | Y | MD-11 gate, SP on 67 spot, DC-9/10 on 37 spot, A340 gate now, A310-200 now [1L/2L] |
| 4 | | X | X | X | X | X | | X | X | X | X | Y | MD-11 park on 10 spot, SP on 67 spot, DC-9/80 on 27 spot, A310-200 now A330/200 on 67 stop |
| 5 | | | | X | X | | | X | R | | | Y | 727 storage only- NO jetway, A310-200 now |
| 6 | | | | X | X | X | | X | X | X | X | Y | A310-200 now |
| 7 | | | X | X | X | X | | | | | X | Y | 727 storage only- NO jetway, A310-200 now |
| 8 | | | X | X | X | X | | X | X | X | X | Y | MD-11 park on 10 spot, A-310-200 now [A300] |
| | | | | | | | | | | | | | NOTE: 727 or 737, PULL bridge away fm A/C and raise bridge to 767 height BEFORE moving to box |
| 9 | R | R | R | R | R | R | | | X | X | X | Y | C11-Out of Service w/67, 77, all 747, 10/10, 10/30, A340, MD11, A310 on C9 |
| | | | | | | | | | | | | | LUFTHANSA WILL USE gate flying A340 on wide body line - **SHUTS DOWN** gate **C11** |
| 11 | | | | | | | | R | R | R | R | Y | 'C11 Out of Service w/67, 77, 10/10, 10/30, A340, MD11, A310 on C9 |
| 12 | | | R | X | X | | | X | X | X | X | Y | No DC10-30, A310-200 now, 27,37,57,A-319-320 req tanker fill [A300] |
| | | | | | | | | | | | | | 777 on gate ***RESTRICTS*** *C14 to 737, 727 or A319/320* ***ONLY*** |
| 14 | | | | R | R | | | | X | X | Re | Y | DC-9/80 park on 67 spot. **A319** = **e**-EMERGENCY **ONLY** A319 MUST BE TANKER FILL |
| | | | | | | | | | | | | | 777 on gate C12 - ***RESTRICTS*** *gate to 737,727 or A320* ***ONLY*** |
| 16 | | | | | | | | R | | X | | Y | 757 on C16 INOP C18. CL65 spot marked. |
| | | | | | | | | | | | | | 757/C16 w/ACA on C18 remote,757 first in, last out NO CL65 on C18 if 57 on C16 |
| | | | | | | | | | | | | | DC9/80 on C18 - CL65 **ONLY** an C16 |
| 17 | | | | X | X | | | X | X | X | X | Y | NO ACFT on C17 w/mobile lounges on Intl arvl C19 [A300] |
| 18 | | | | | | | R | | | R | | Y | DC-9/80 park on 37 spot, *RESTRICTS C16 to CL-65* ***ONLY*** |
| | | | | | | | | | | | | | 757 on C16, **INOP** C18. CL-65 SPOT MARKED |
| | | | | | | | | | | | | | **NO** CL65 w/57 on C16. A-319-320 on C20 INOP C18. OK UAX remote |
| 18R | | | | | | | | | | | | | |
| 19 | | | | X | X | | | X | X | X | X | Y | DC-9/80 park on 37 spot. 67 Intl arvl ok JB on Int'l spot ***NO ACFT C17 til lounge leaves*** |
| 20 | | | | | | | X | R | R | X | R | Y | (**R**) 57on C20 **INOP** C18, C22 - CL65 O.K. NO RESTRICTIONS DC-9/80 park on 27 spot |
| | | | | | | | | | | | | | (**R**)A319/320 on C20 -- C18 & C22 - CL65 O.K. NO RESTRICTIONS |
| | | | | | | | | | | | | | 727 on C20 **INOP** C-22, CL65 spot mrkd, 57 can arrive C20 w/UAX on C18 remote |
| 22 | | | | | | | R | | | R | | Y | DC-9 park on 37 spot, *RESTRICTS C24 to* *NO* *757* |
| | | | | | | | | | | | | | CL65 spot mrkd, MD80, 27,57,A319-320 on C20 **INOP** C22 |
| | | | | | | | | | | | | | CL65 on C22 - **CANNOT** have 27,57,A319-320 on C20 |
| 22R | | | | | | | | | | Xx | | | Xx = CL65 on 737 SPOT - 737 REQUIRES REMOTE STAIR AVAILABILITY |
| 23 | | | | X | X | | | X | X | X | X | Y | [A300] |
| 24 | | | | | | | | R | X | X | R | Y | DC-9 on C22 *RESTRICTS C24 to* ***NO*** *757* |
| | | | | | | | | | | | | | 57 on gate **NO** A319/320 on C26. DC-9/80 park on 27 spot |
| | | | | | | | | | | | | | NO 57, A320 w/inop APU,ground power WON'T support |
| | | | | | | | | | | | | | CL65 on 727 spot - no jet bridge |
| 26 | | | | R | R | | | R | X | X | R | Y | DC-9/80 park on 67 spot ( **R**) 67,10/10,10/30 on C26 **INOP** C28 (R), |
| | | | | | | | | | | | | | (**R**)A319/320 on C26 - **NO** 757 on C24 wingtip pass-by |
| | | | | | | | | | | | | | 27,37,57 on C28 WILL block C-26, 57 on C26 must be first in, last out |
| | | | | | | | | | | | | | 757 on C24 **NO** A319/320 on C26 |
| 27 | R | R | X | | | | | X | X | X | | | **NO 747/400 on C27 w/777on D1, 757-DOOR 2 OPERATION ONLY - NO FIXED BRIDGE** |
| 28 | | | | | | | | R | R | R | | Y | 57 on C28 restricts C26 to 27, 37, A319/320 ONLY. 57 C26 - C28 dual 57 parking, C28 ACFT |
| | | | | | | | | | | | | | WILL block in C26. **27, 37, 57 MUST be LAST IN....FIRST OUT on C28** |
| | | | | | | | | | | | | | *NOTE - DC-9 FITS ON TWA GATES D10 , D12 (if avail) & UAL GATE D14* |
| | | | | | | | | | | | | | B/S = Bag Slide |

# Airport Terminal Topology

- **With respect to processing departing passengers:**
  - Centralized vs. decentralized

- **With respect to the configuration ("concept") of the building:**
  - Linear
  - Transporter
  - Finger (or pier)
  - Conventional satellite
  - Midfield satellite

- **These distinctions become blurred as an airport becomes busier and older**

- **All configurations have advantages and disadvantages**

# Linear, pier/finger and satellite concepts

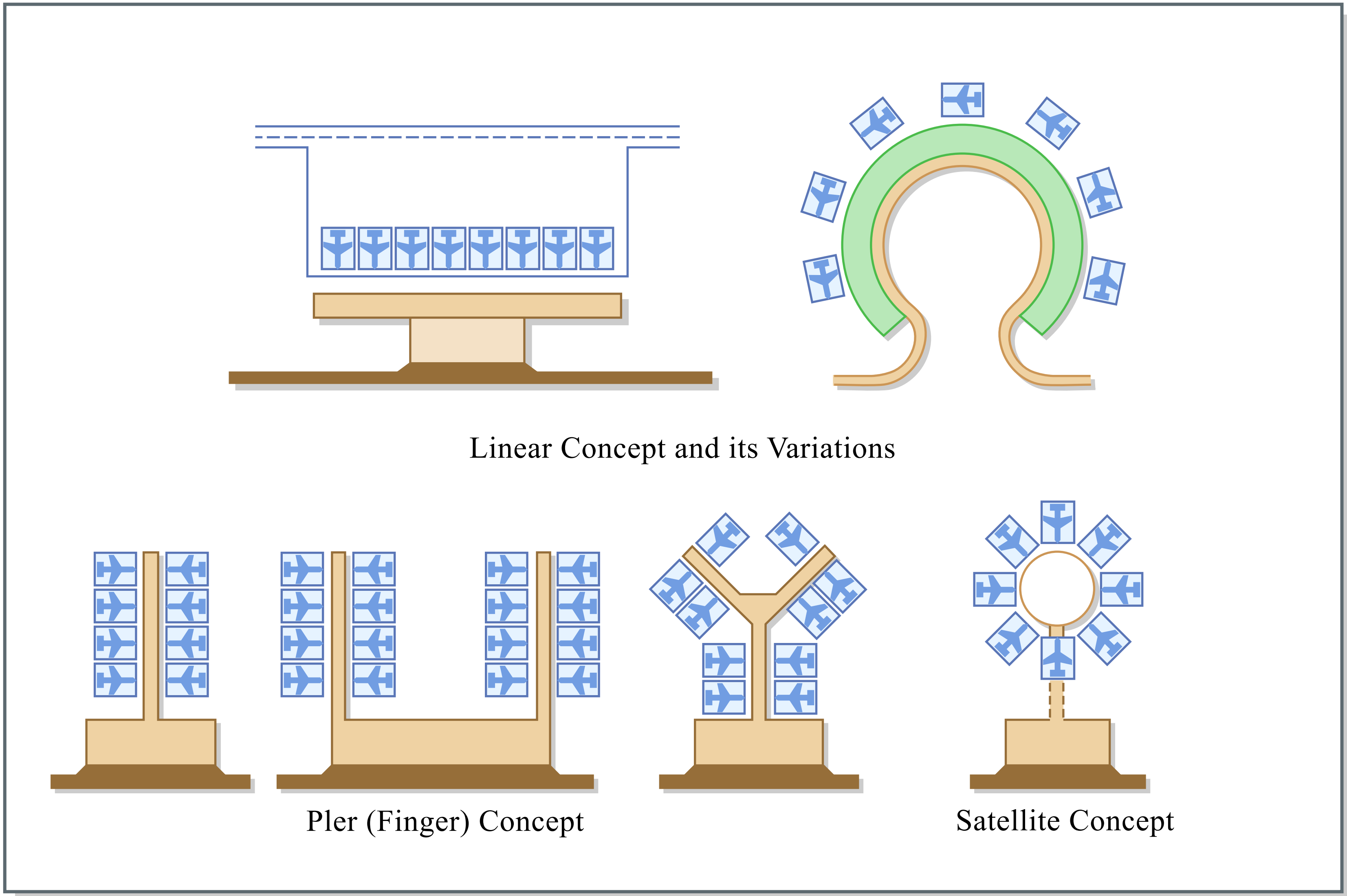



Figure by MIT OCW.

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  - Gate operations (arrivals)
  - Airport Surface

# Ground Handling Services

## Traffic Handling

- Communications
- Handling documents and load control
- Passenger handling with exception of State services
- Cargo and mail handling services
- Airport information services

## Ramp Handling

- Baggage handling
- Loading/unloading
- Catering transport
- Interior cleaning
- Toilet service
- Water service
- Passenger transport
- De-icing
- Fueling
- Starting
- Marshalling, parking

# Aircraft Rescue and Fire Fighting (ARFF)

- **Airports operators (Part 139) are required to provide Aircraft Rescue and Fire Fighting (ARFF) services during air carriers operations.**

- **ARFF services are provided by local firefighting services at non certified airports (small airports) are**

- **Characteristics of airport operations:**
  - Aviation fuel
  - Confined environment (aircraft)
  - Wheels-up landings,…

Source: [FAA Part 139]

# Snow & Ice Control

- **Snow and ice reduce surface friction coefficient:**
  - reduce aircraft braking performance,
  - affect aircraft directional control particularly in cross wind situations.

- **Elimination of snow, ice, and slush on airport surfaces:**
  - cleaning surface:
    - *plowing,*
    - *blowing,*
    - *sweeping,*
  - protecting the surface and restoring surface friction properties
    - *applying chemicals,*
    - *applying sand,*
  - storing
    - *loading and hauling snow,*
    - *melting*

# Airport Certification

# U.S. FAR Part 139

- **14 CFR Part 139 requires the FAA to issue airport operating certificates to airports that:**
  - Serve scheduled and unscheduled air carrier aircraft with more than 30 seats;
  - Serve scheduled air carrier operations in aircraft with more than 9 seats but less than 31 seats; and
  - The FAA Administrator requires to have a certificate.

- **Airports governed by Part 139 certificate: 655 (in 1999)**

- **Certification cover the following points:**
  - Administrative/paperwork (e.g. Airport Master Record (FAA Form 5010), Airport Certification Manual/Specifications (ACM/ACS)
  - Movement area operations (condition of pavement, markings, lighting, signs, abutting shoulders, and safety areas, ground vehicle operations)
  - Aircraft rescue and fire fighting operations,
  - Emergency planning and operations (Airport Emergency Plan)
  - Fueling operations
  - Night operations (runway/taxiway and apron lighting and signage, …)
  - Airport personnel training
  - Wildlife hazard assessments and management plans.

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  - Gate operations (arrivals)
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  - Gate operations (departures)

# Gate

# Departure

- **Procedure affecting -holding- departure**
  - Ground Stop (GS)
    - *Control air traffic volume to airports when projected traffic demand is expected to exceed the airport's acceptance rate for a short period of time.*
    - *Temporarily stop traffic to allow time for the implementation of a longer-term solution (e.g. Ground Delay Program)*
    - *Airport's acceptance rate has been reduced to zero.*
  - Ground Delay Programs (GDP)
    - *Control air traffic volume at airports where the projected traffic demand is expected to exceed the airport's acceptance rate for long period of time.*

# Collaborative Decision Making (CDM)

- **Objective**
  - Improve the Traffic Flow Management (TFM) system by increasing the exchange of information, data sharing, improved automated decision support tools.

- **Stakeholders**
  - Joint Government Industry program
    - *Airlines (24 airlines)*
    - *FAA: ATC and Air Traffic Flow Management*
    - *Airports*

- **Mechanisms**
  - Provision of accurate data to stakeholders (estimates of arrival and departure times, …)
  - Share information
  - Airline decide to cancel or delay flights
  - Rescheduling with priority constraints (to airlines that have cancelled flights)

# Gate

# Departure

- **Gate**
  - Clearance for IFR Flight Plan
  - Pushback request
  - Pushback clearance

# Aircraft De-Icing

- **De-Icing Fluids: composed of ethylene glycol or propylene glycol, thickening agents, corrosion inhibitors, and colored dye.**
  **Propylene glycol is more common (less toxic than ethylene glycol)**

- **For four types of deicing fluids:**
  - Type I:
    - *low viscosity,*
    - *short term protection,*
    - *sprayed on hot at high pressure to remove snow, ice, and frost,*
    - *dyed orange.*
  - Type II: "pseudoplastic“
    - *high viscosity ( with thickening agents),*
    - *remain in place until the aircraft attains 100 knots.*
  - Type III: compromise between type I and type II fluids.
    - *used for slower aircraft.*
  - Type IV: same viscosity as type II fluids
    - *longer holdover time,*
    - *typically dyed green.*

- **Anti-Icing fluids:**
  - prevent icing from re-occurring after de-icing with a type I fluid.

- **Fluid performance measured by holdover time**
  - Holdover time influenced by:
    - *ambient temperature, wind, precipitation, humidity*
  - Holdover time: Type I ≈ 15 minutes
    Type IV ≈ 30 and 80 minutes
- **Deicing fluids are toxic**
  - Airports have designated areas where the fluid is collected

# Taxiing

# (Departure)

- **Ramp/Gate to Taxiway entry point**
  - Clearance to enter the taxiway system
  - Path to the runway

- **Active Runway crossing point**
  - Clearance to cross an active runway

- **Runway entry point**
  - Clearance for alignment on runway

# Comair 5191 Accident at Lexington

- **Comair Accident:**
  - Date: 27 - Aug – 2006
  - Airport: Blue Grass Airport, Lexington, KY
  - Aircraft involved: CRJ-100
  - Casualties: 47 + 2 crew members

- **Take-off: Runway 26 instead of 22**

- **One controller at the time of the accident**
  - Radar and tower control

- **FAA directive requiring 2 controllers**

Data source: NTSB report

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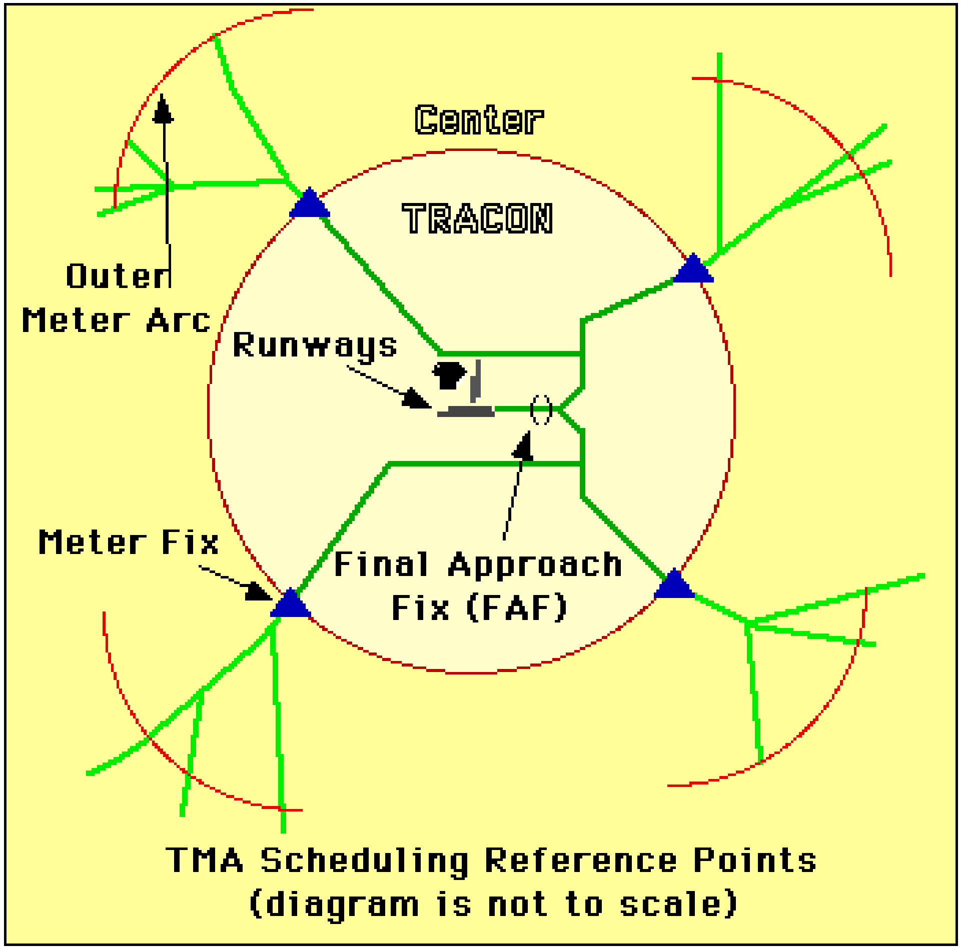
  - Gate operations (arrivals)
  - Airport Surface
  - Gate operations (departures)
  - Ground (departures)
  - Take-Off / Transition to Terminal and Center

# Take-Off & Terminal Exit to Center

- **Take-Off**
  - Clearance to take-off
- **Follow SID or vector**
- **Terminal Area (Airspace)**
  - Transition from airport to Center



MIT ICAT

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**Airport operations:**

- Instrument operations: FAA Instrument Approach Procedure Manual
- De-icing, www.faa.gov/library/manuals/examiners_inspectors/8400/fsat/media/fsat0405.doc
- CDM: http://www.fly.faa.gov/Products/Information/CDM/cdm.html