FRANKFURT UNIVERSITY OF APPLIED SCIENCES

MBA in Aviation Management

Part 7: Capacity

Frankfurt, 2023, January

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MBA AVIATION MANAGEMENT


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AIRLINERS.NET

Halifax, 12. September 2001

Airport Capacity

Determined as:

Passenger per time

Aircraft movements per time

Part-Capacity for every single part of the airport

For capacity planning it shall be divided in:

- arriving/departing passengers(Transit)
- Arrivals and departures
- Operational units for apssengers and aircraft are considered in a row
- the unit with the critical capacity determines the overall capacity.

Airport Capacity

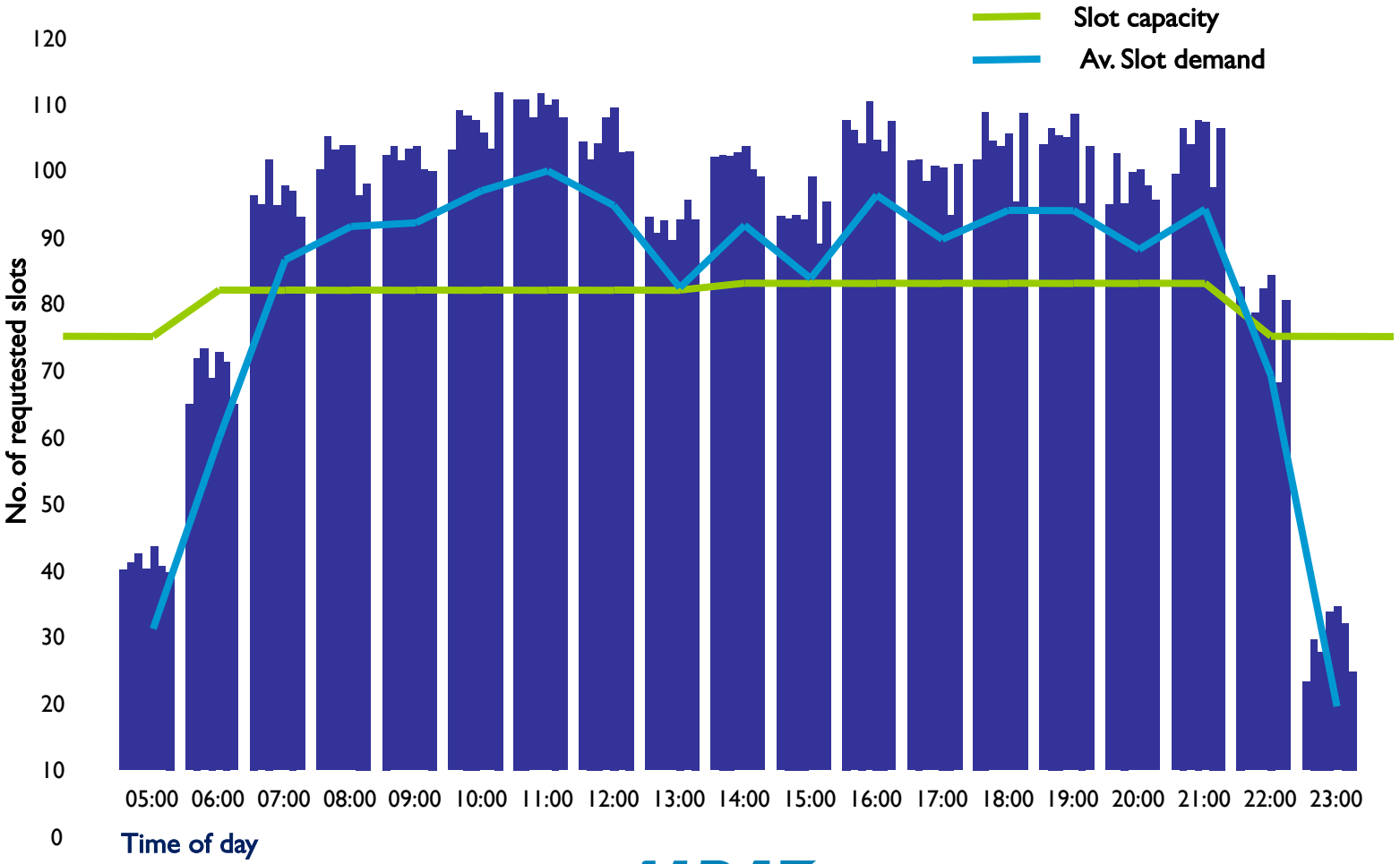
Critical elements:

- Terminal: Check-in-counters, Gates
- Apron: number of aircraft parking stands (positions)
- at busy airports: runways

- Based on calculations ans experiences the declared capacity is determined.
- Example: Declared capacity at Frankfurt (Summer 2017):

100	Movements / h
57	Arrivals / h
55	Departures / h

Airport Capacity
Slot-Demand is beyond Capacity



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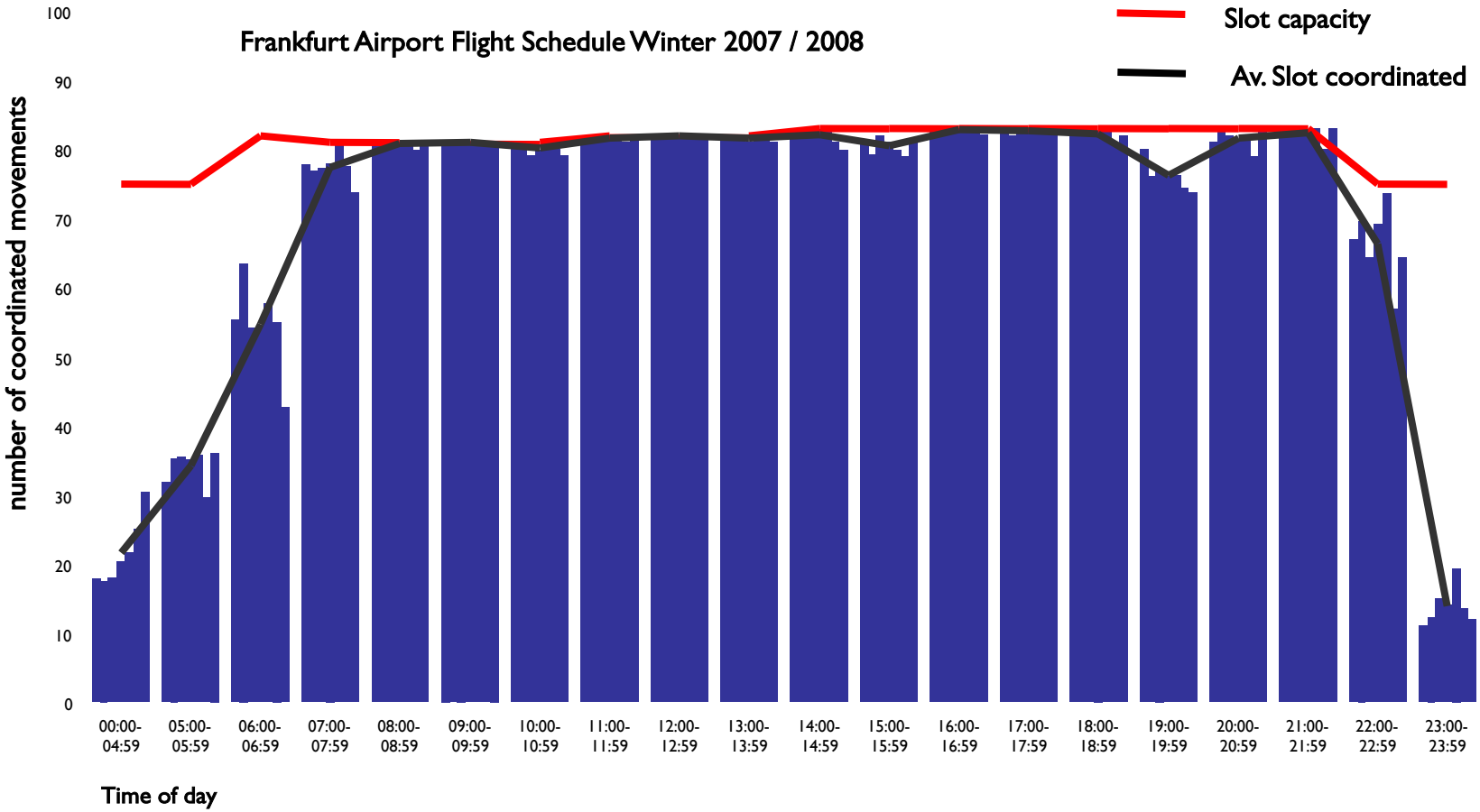
Airport Capacity
Slot-Demand is beyond Capacity
Free slots only in Off-Peak-hours



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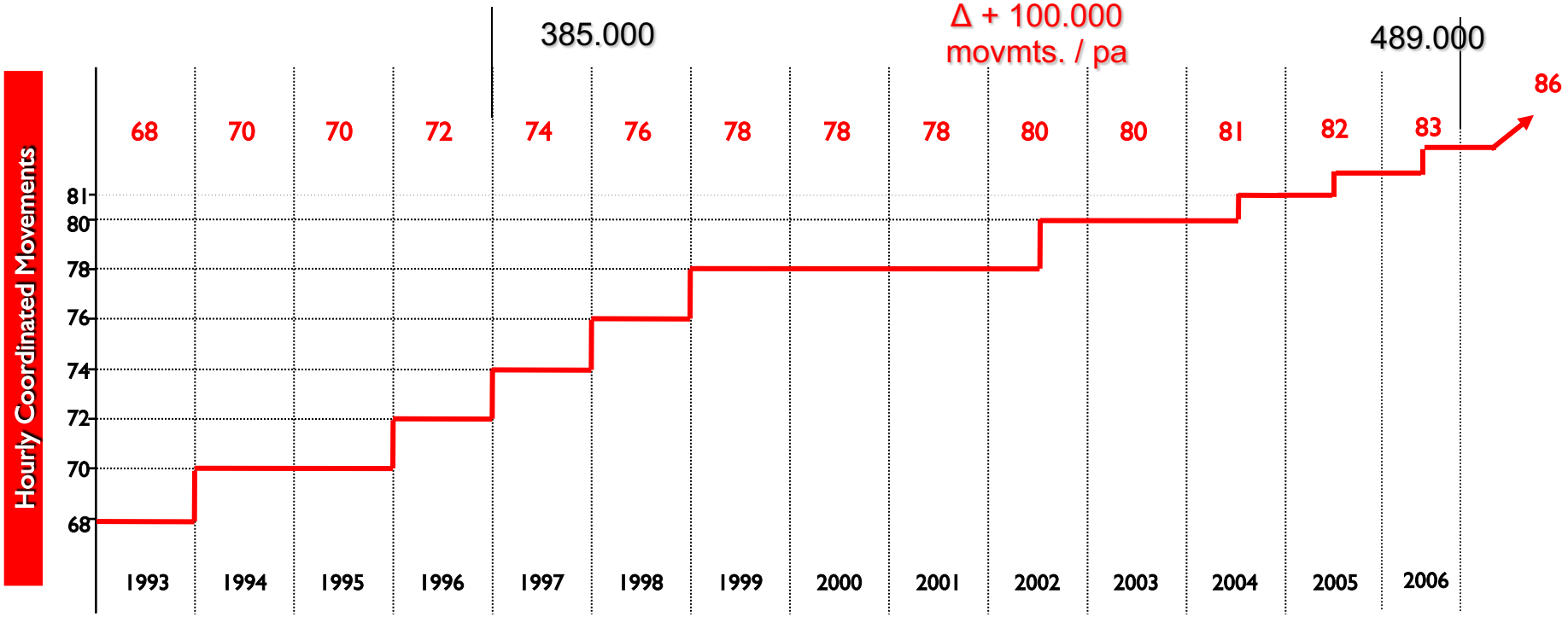
Airport Capacity
Capacity enhancement: Step-by-step

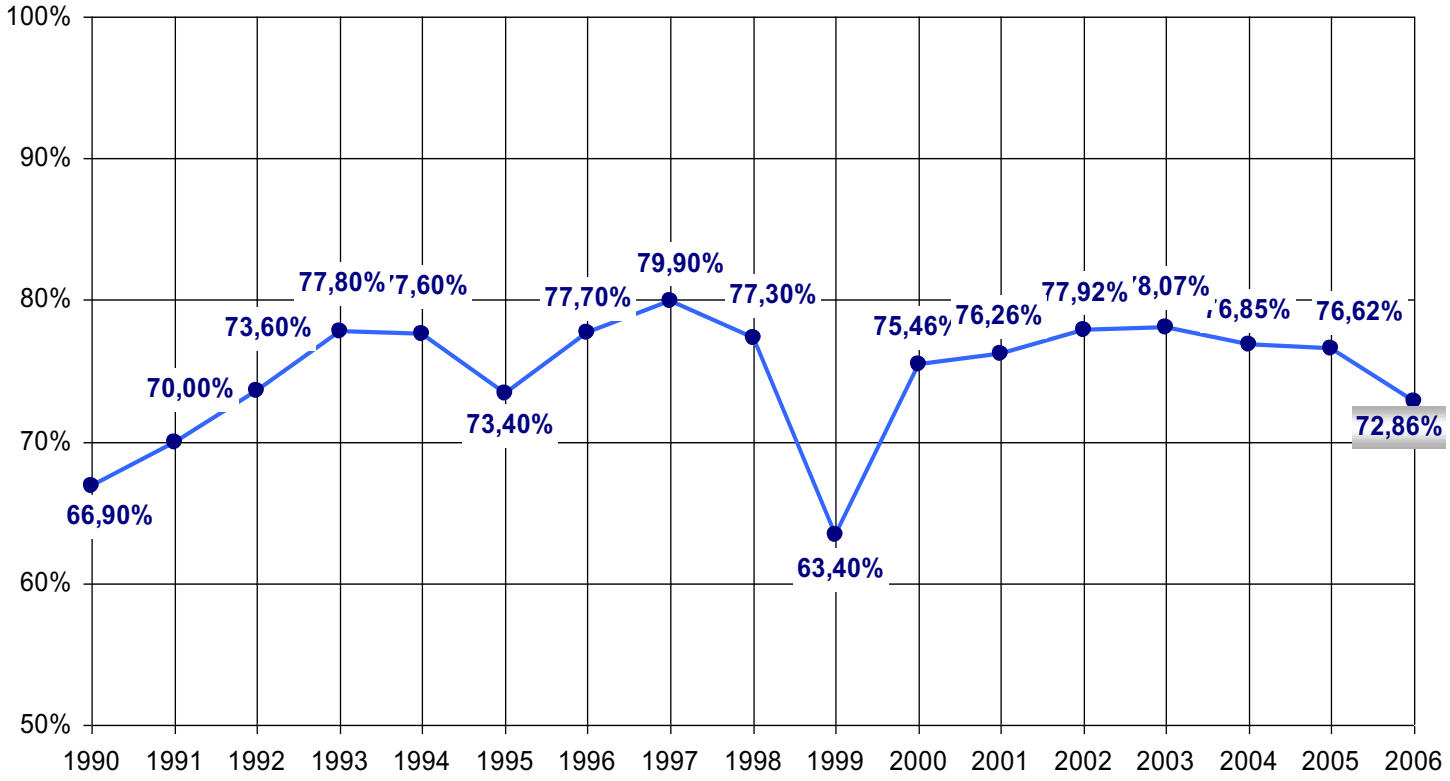
Frankfurt Airport has increased significantly its capacity in the past ten years. This was achieved by new ATC technologies and ATC / airport procedures.



Development of hourly declared capacity in Frankfurt (1993 – 2006)

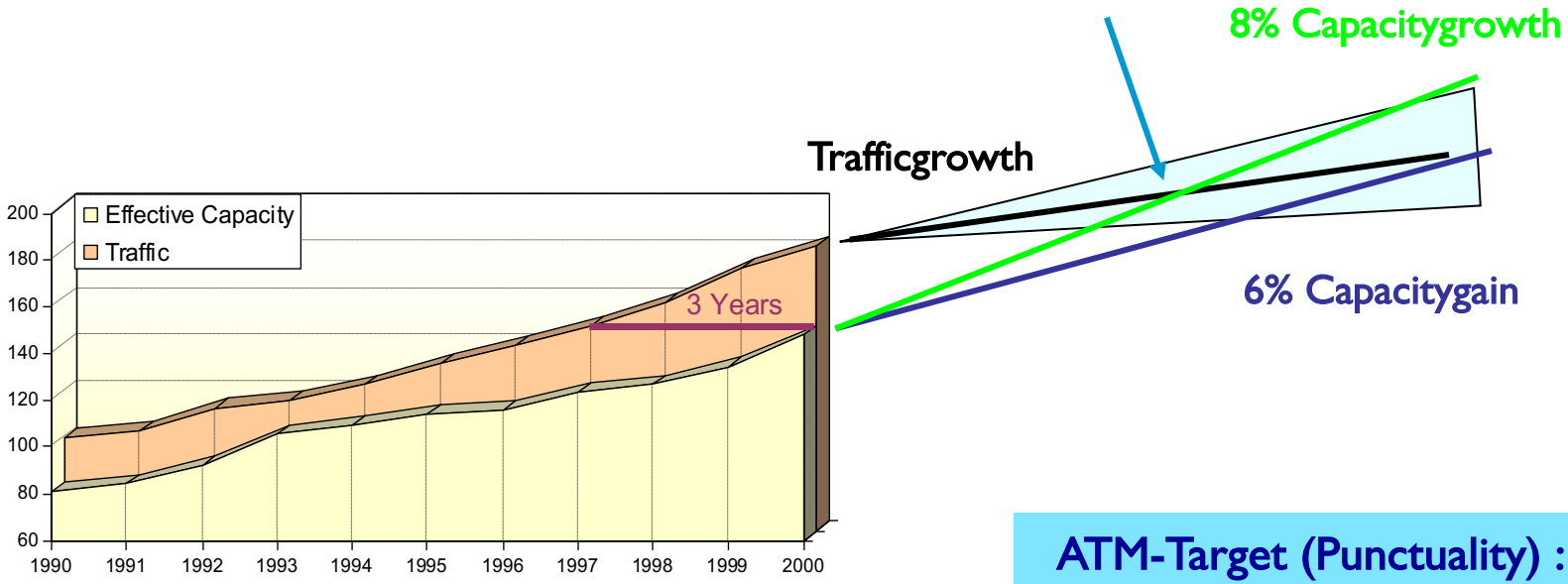
Airport Capacity
Target Setting: Punctuality

Frankfurt is one of the leading hubs in Europe concerning punctuality, with the integration of new ATC technology and ATC / airport procedures Frankfurt Airport is operating the increasing traffic volume with high punctuality.



Development of Punctuality in Frankfurt (1990 – 2006)

Airport Capacity
Reaching Optimum Capacity
1 minute average per flight



Source: EUROCONTROL PRC

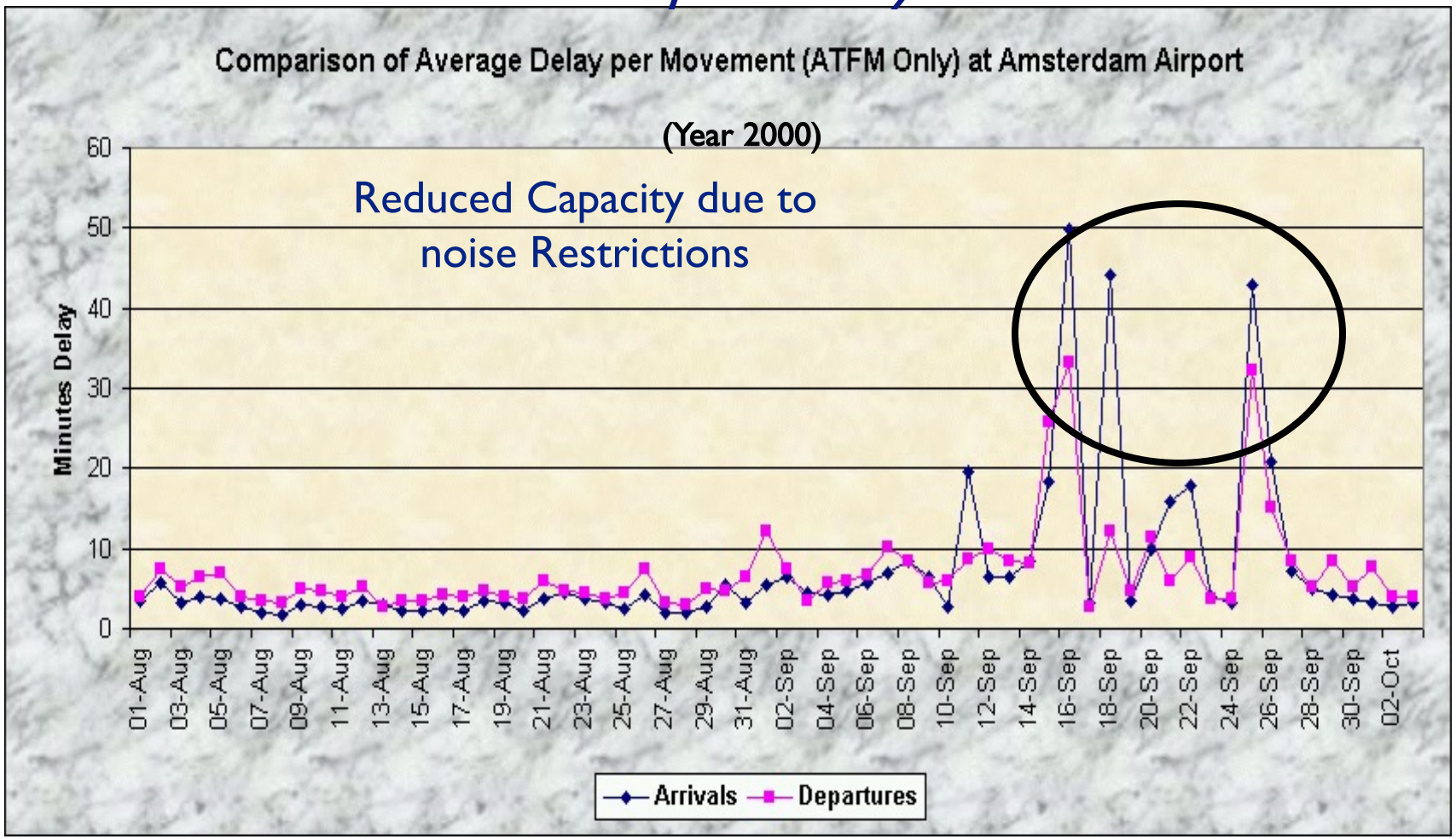
80% Capacitygain 1990-2000

3- Years gap
Capycity vs. Trafficgrowth

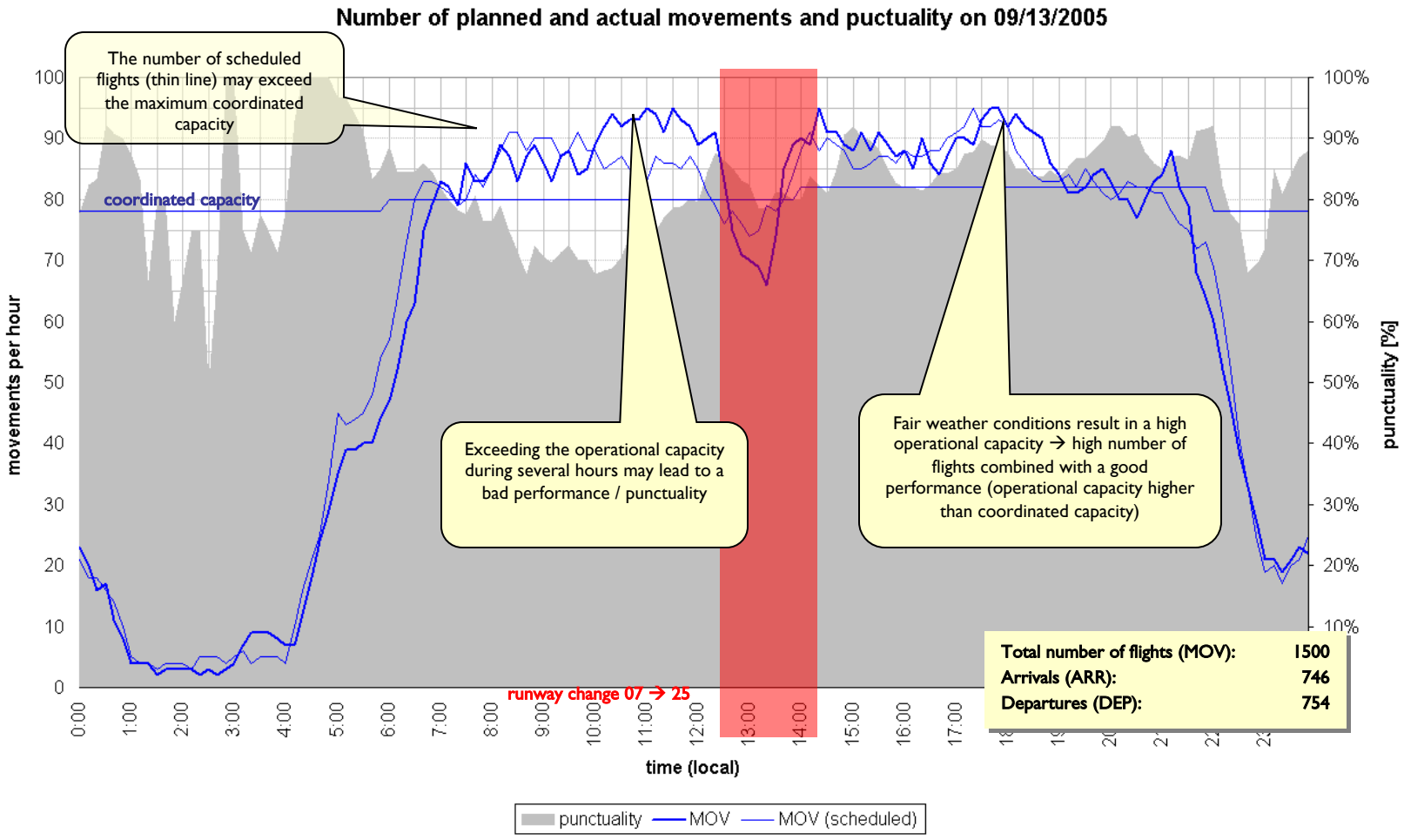
ATM-Target (Punctuality) : 1 Minute Delay

Capacity Growth must increase to meet the demand

Airport Capacity Interdependency



Airport Capacity
Total Movements and punctuality



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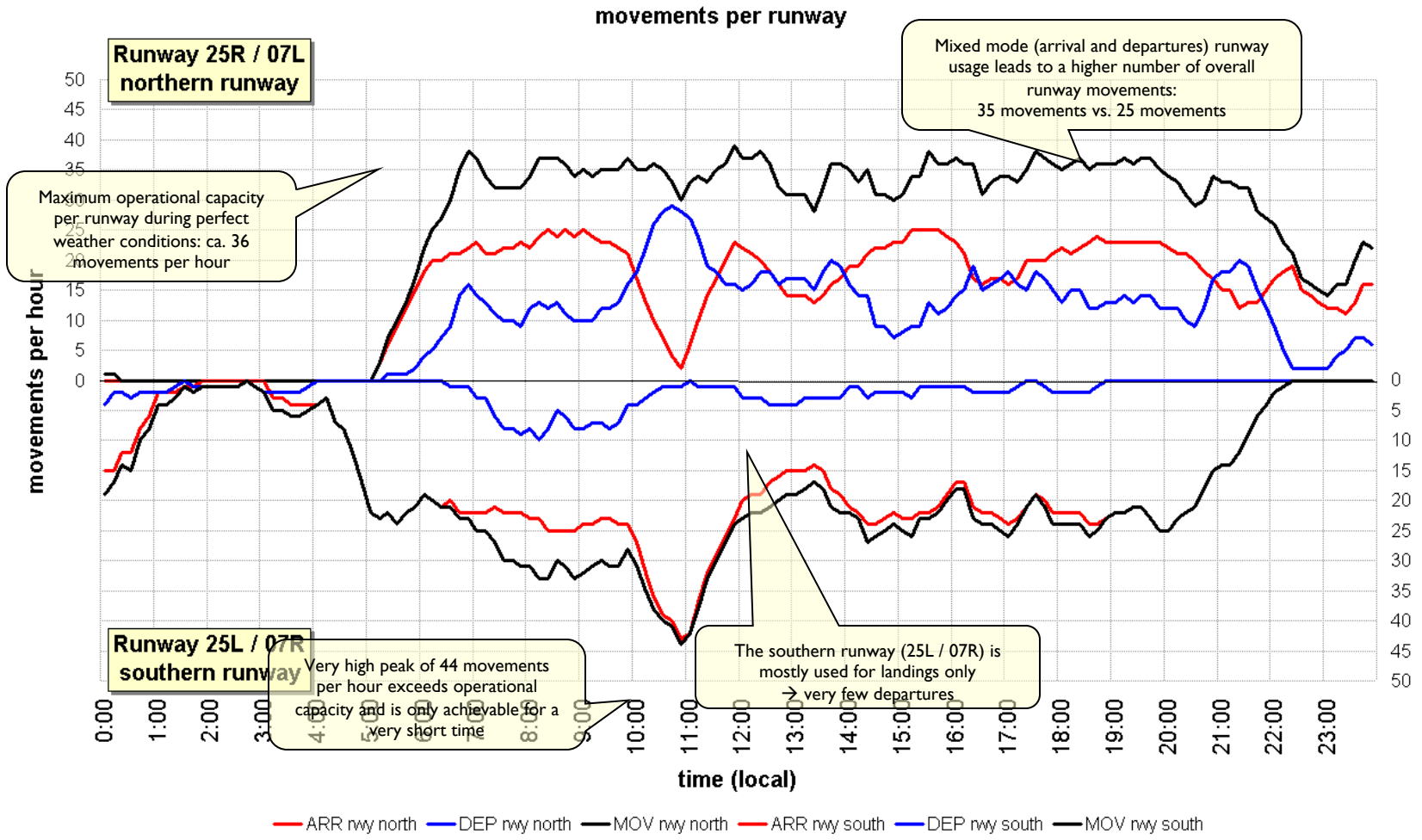
Airport Capacity
Runway usage



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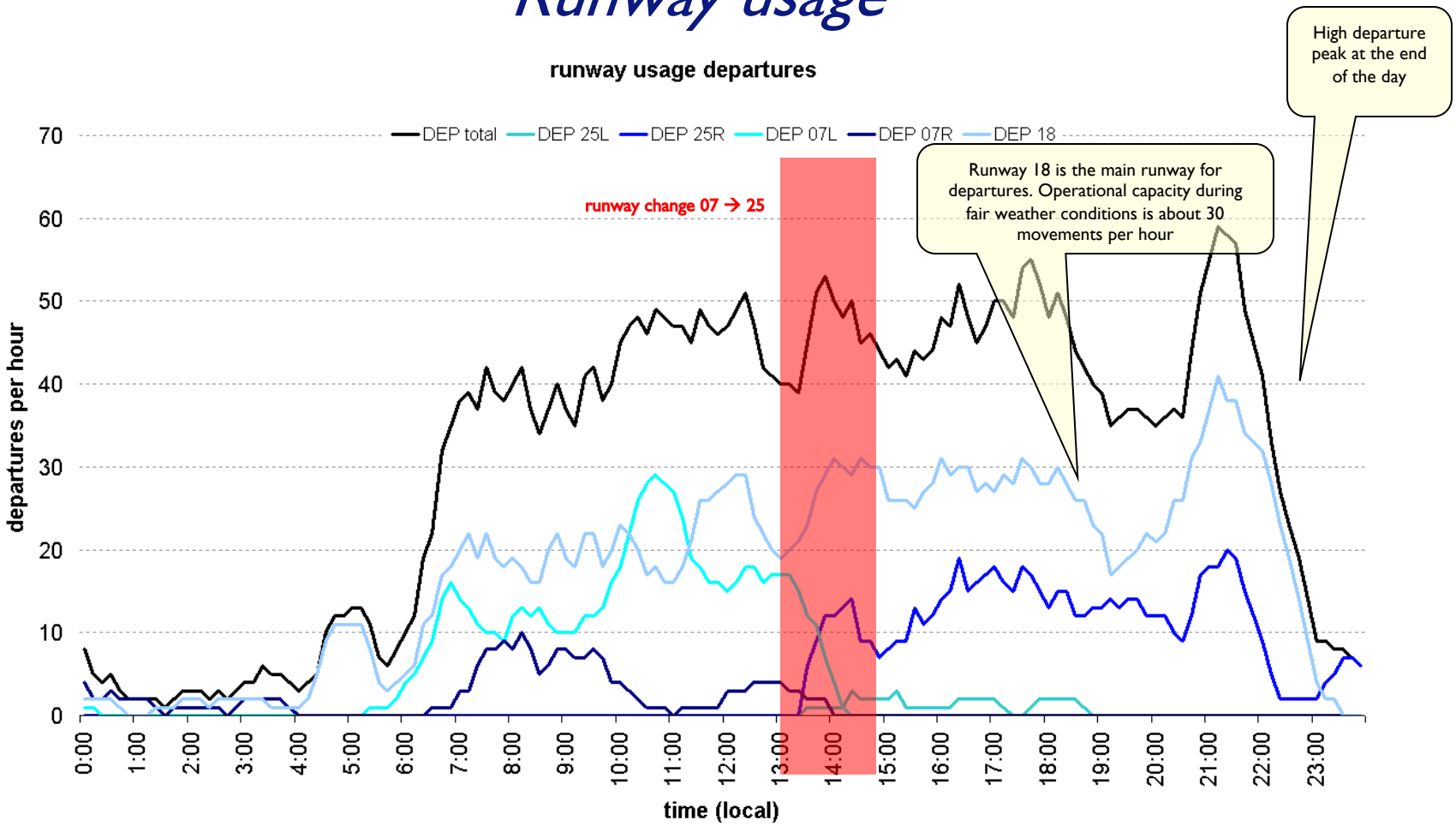
Airport Capacity
Runway usage



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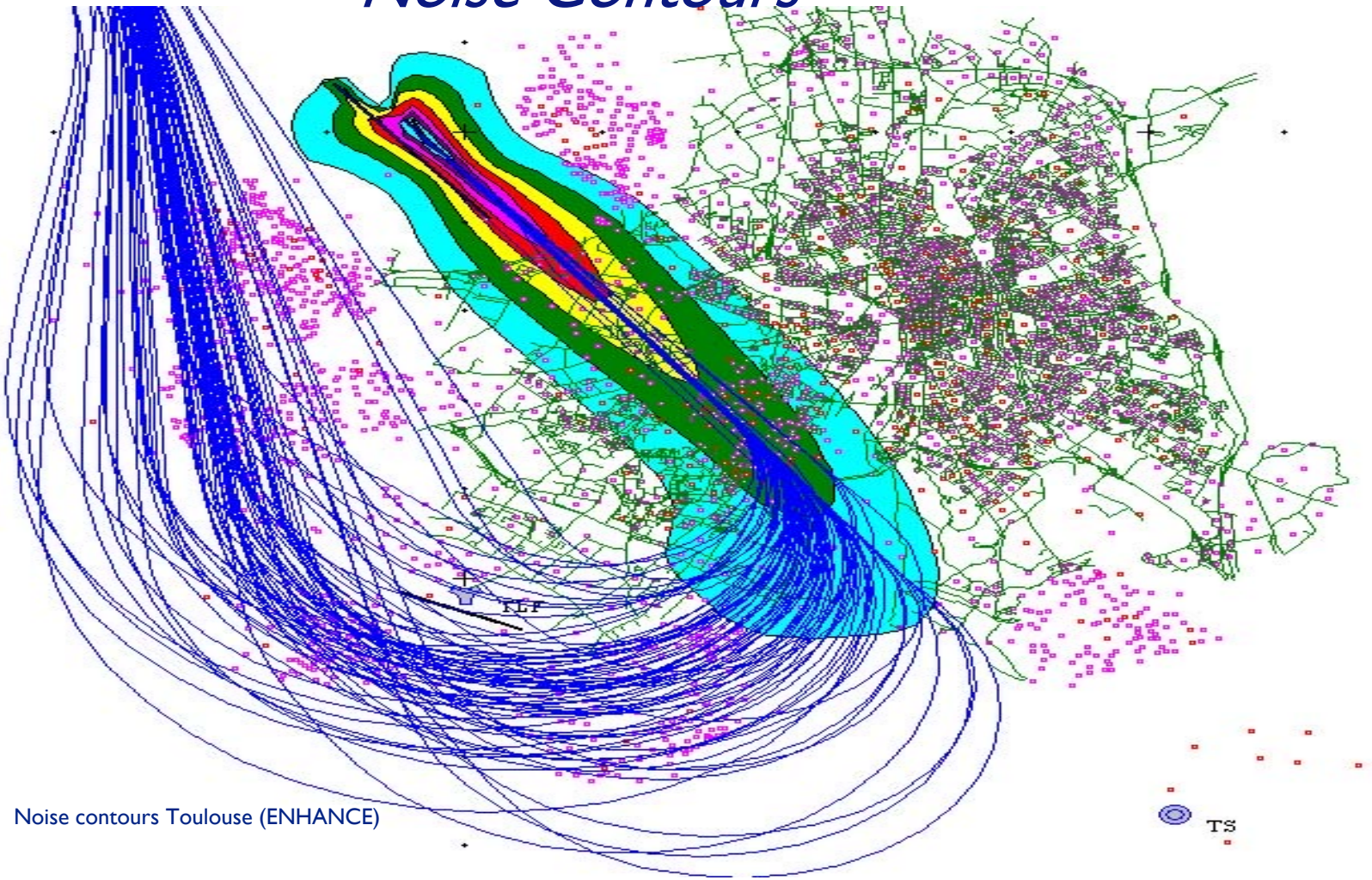
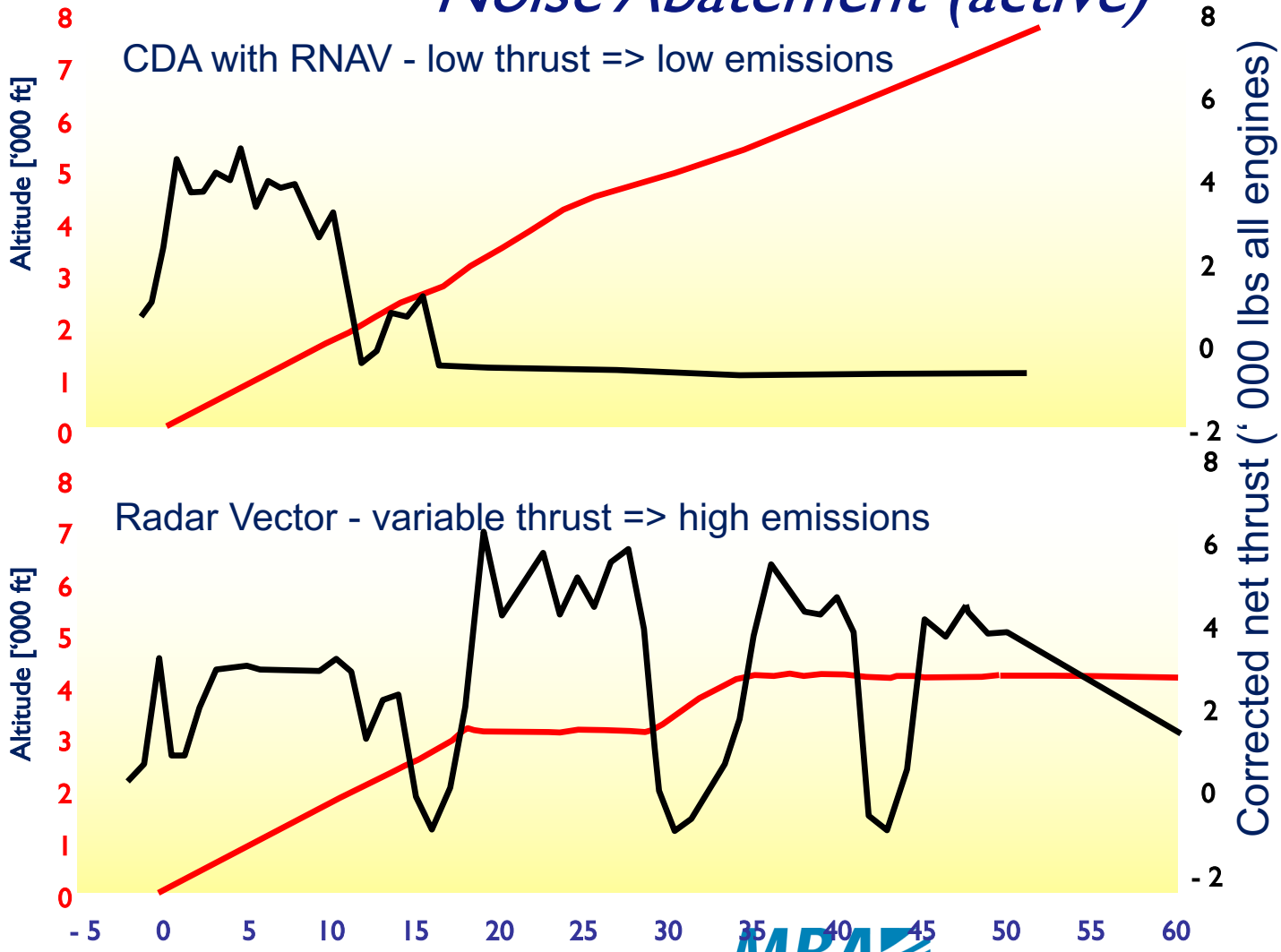
Airport Capacity
Noise Contours



Noise contours Toulouse (ENHANCE)

Airport Capacity

Noise Abatement (active)



Decent Path and engine power setting

("Continuous Descent Approach-CDA" vs. Radar Vector)

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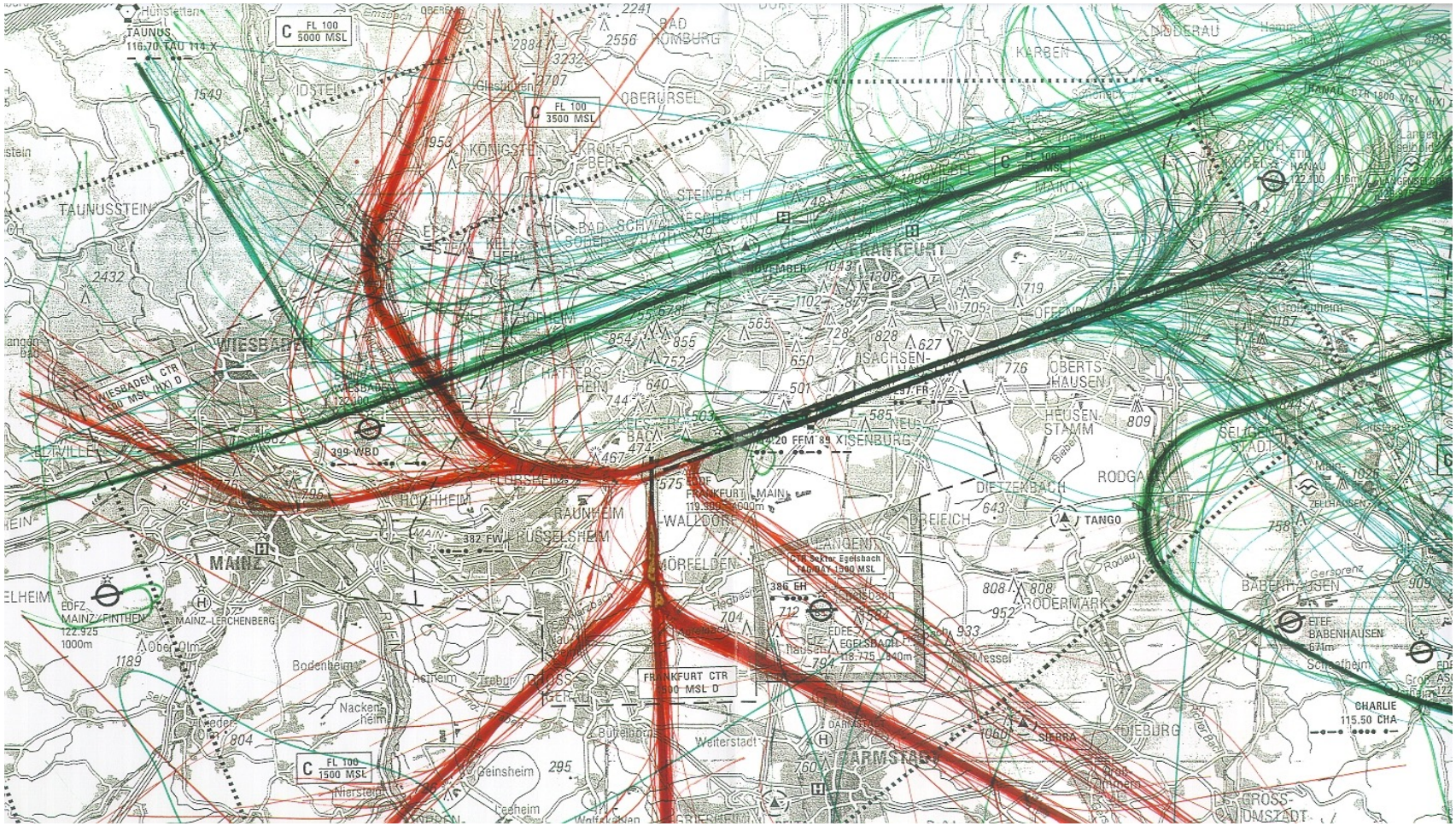
Airport Capacity
Flight track recording



Frankfurt RWY 25

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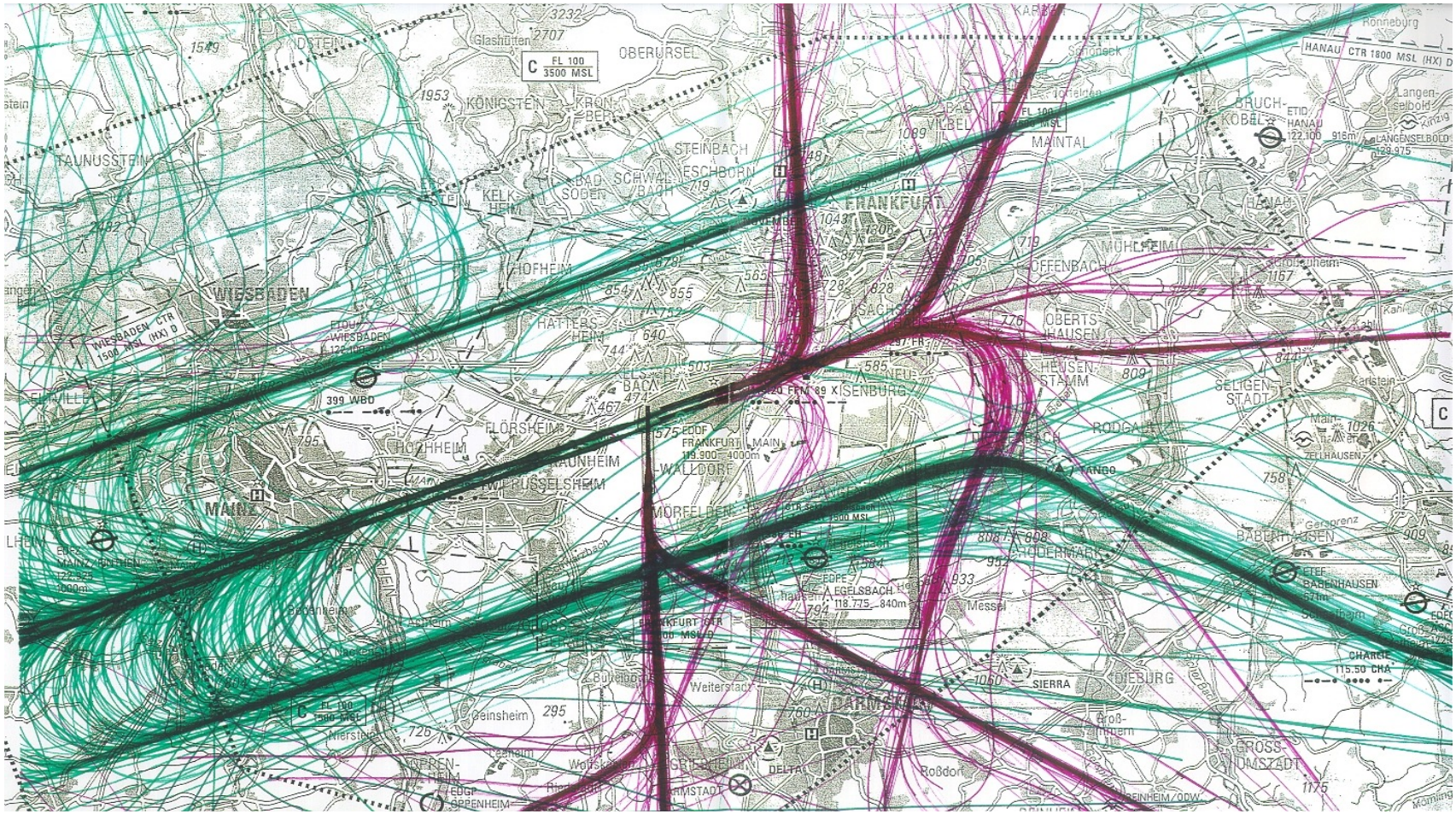
Airport Capacity
Flight track recording



Frankfurt RWY 07

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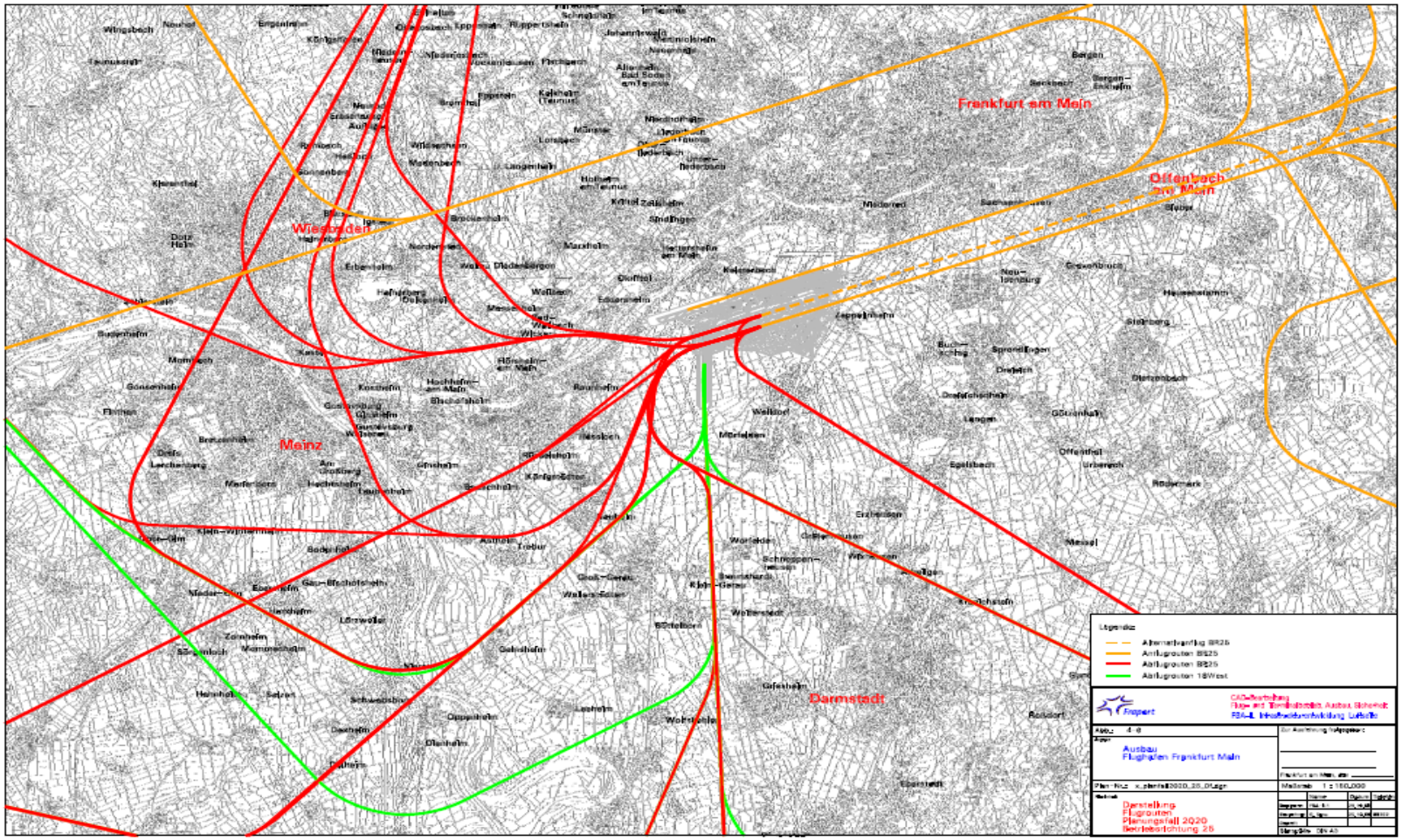
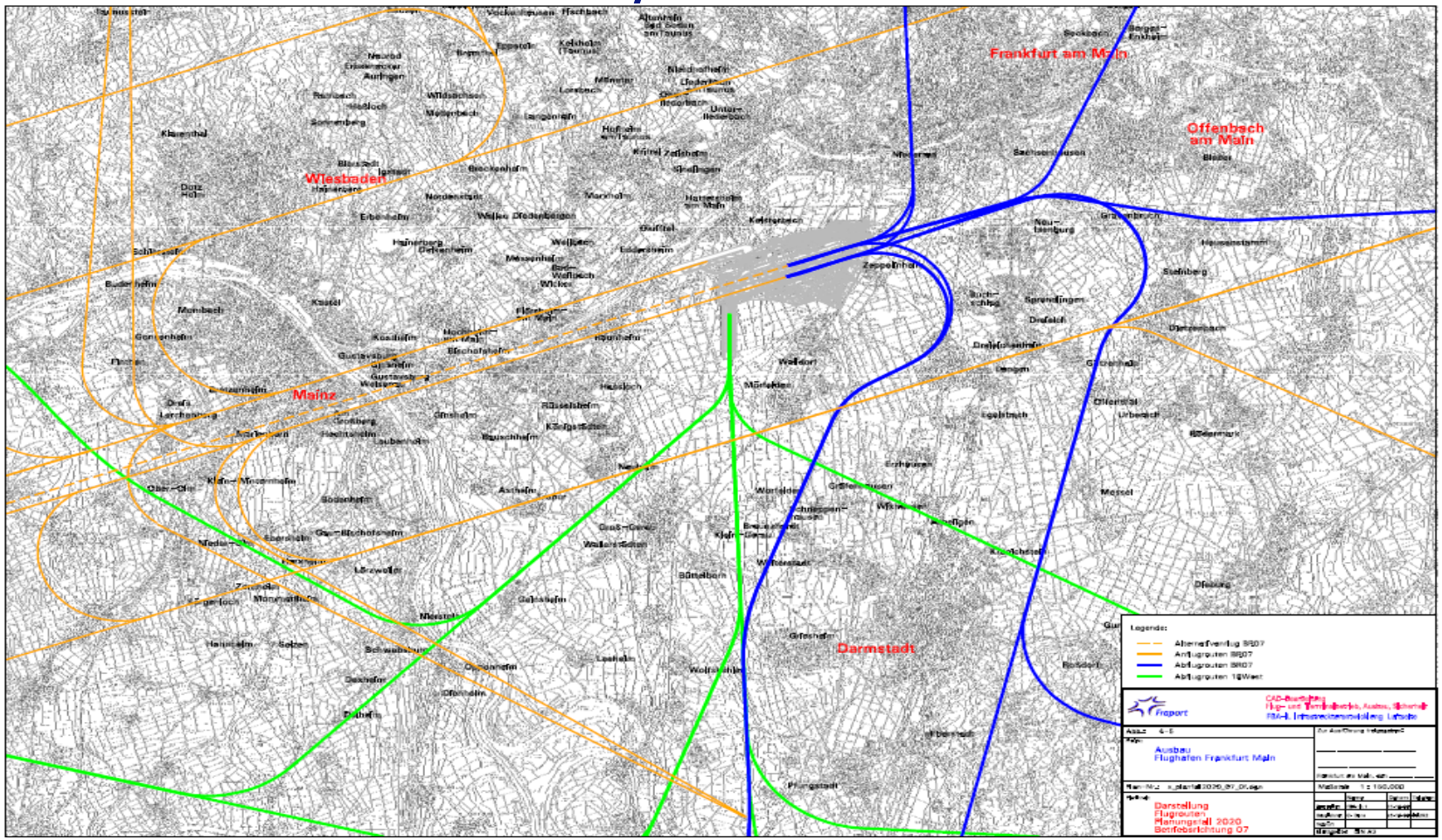
Airport Capacity
Planned Departure Routes



Frankfurt RWY 25

MBA AVIATION MANAGEMENT

Airport Capacity
Planned Departure Routes



Frankfurt RWY 07

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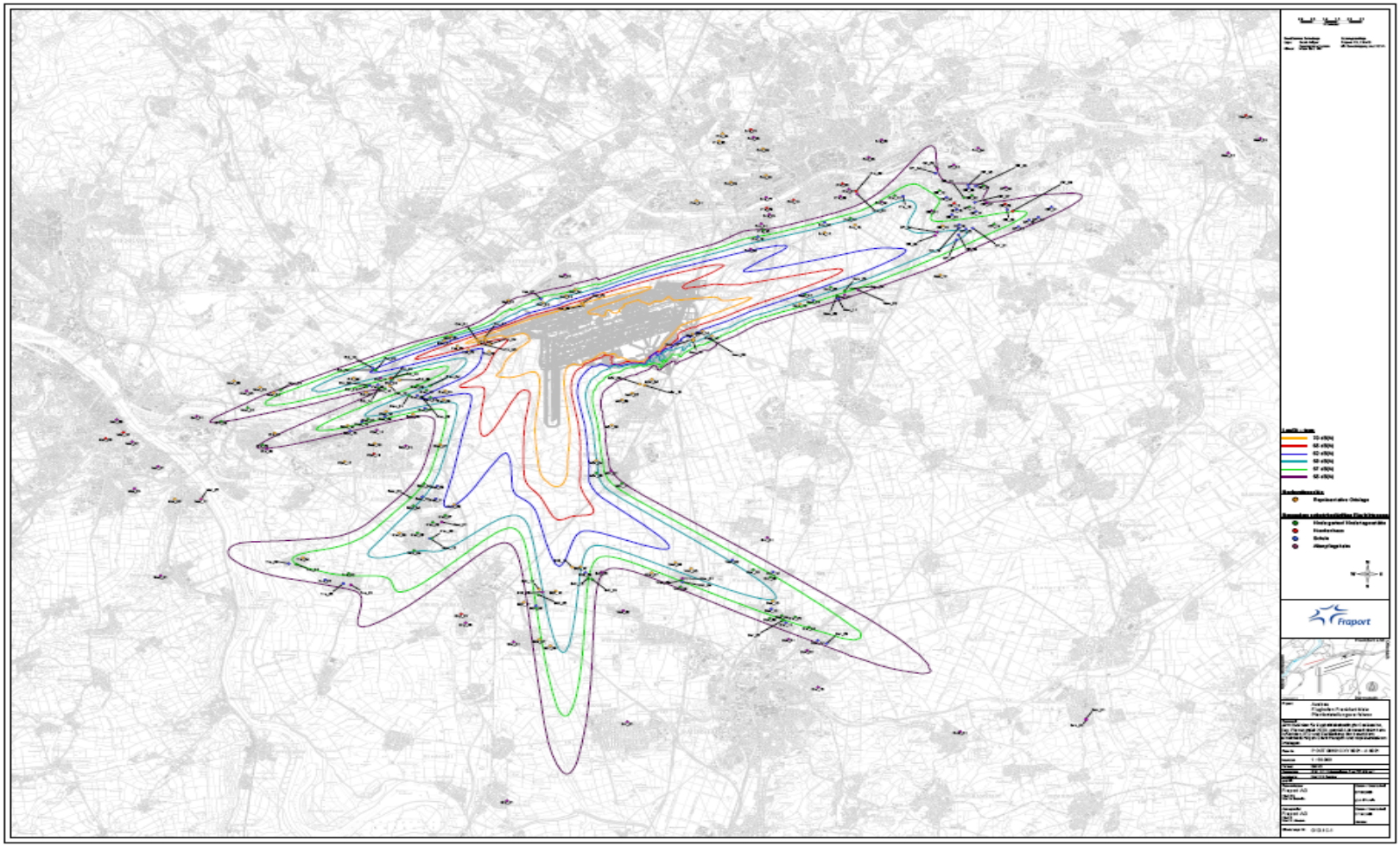
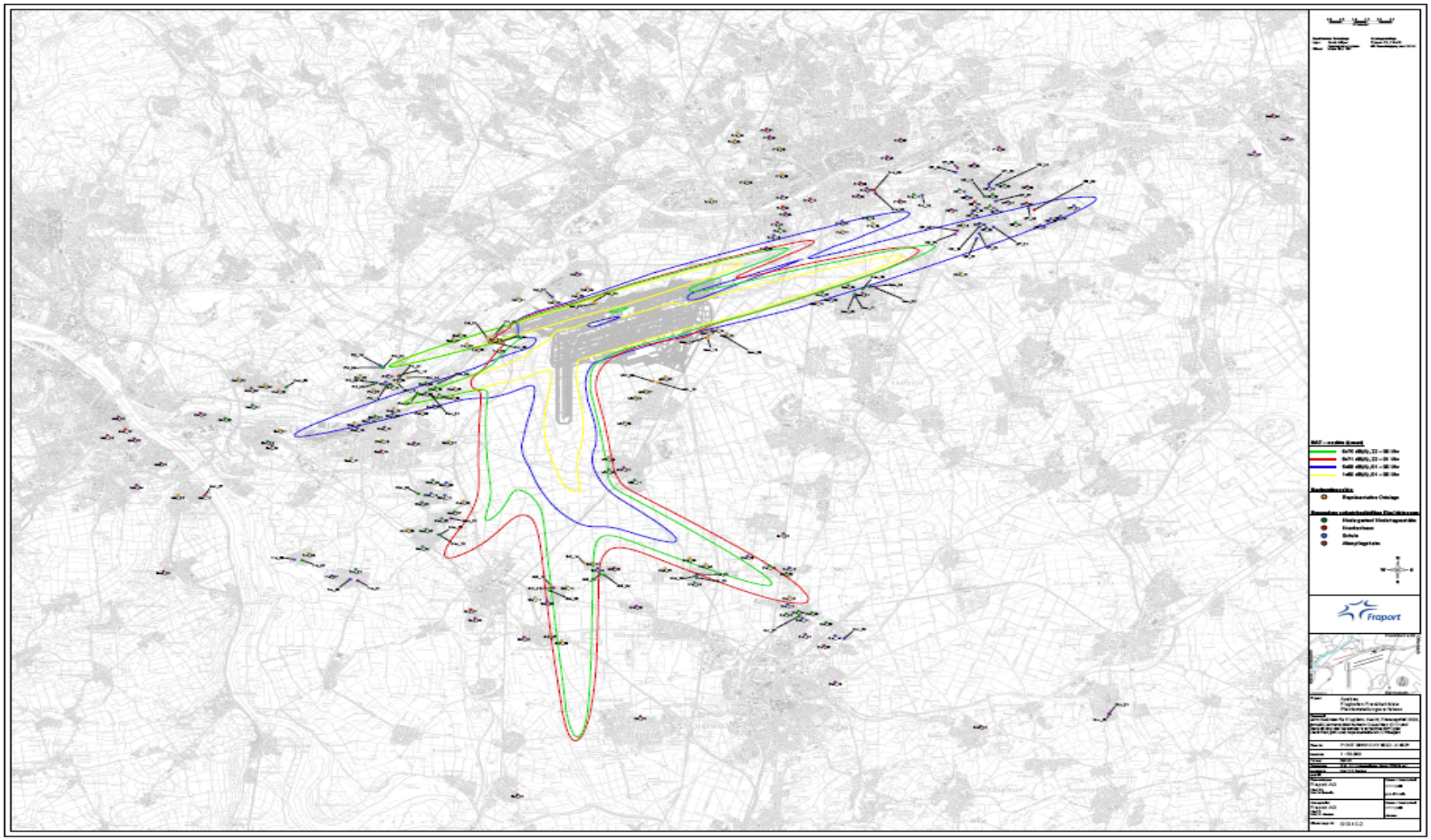
Airport Capacity
Calculated noise contours



Frankfurt RWY 25

Airport Capacity
Calculated noise contours



Frankfurt RWY 07

Airport Capacity
Variability of Operation

- Seasonal (e.g. summer – main holiday season)

- Weekly (e.g. weekdays - weekends)

- daily (e.g. morning - evening)

- Challenge: Staff and ressources planning in accordance

- Basis for the determination of capacity:

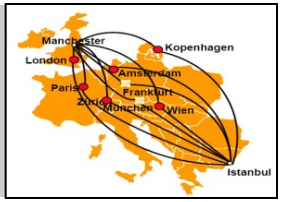
  Traffic Volume of the typical peak hour (thirty busiest hour of the year)

Airport Capacity
Deviation from Flight Plan

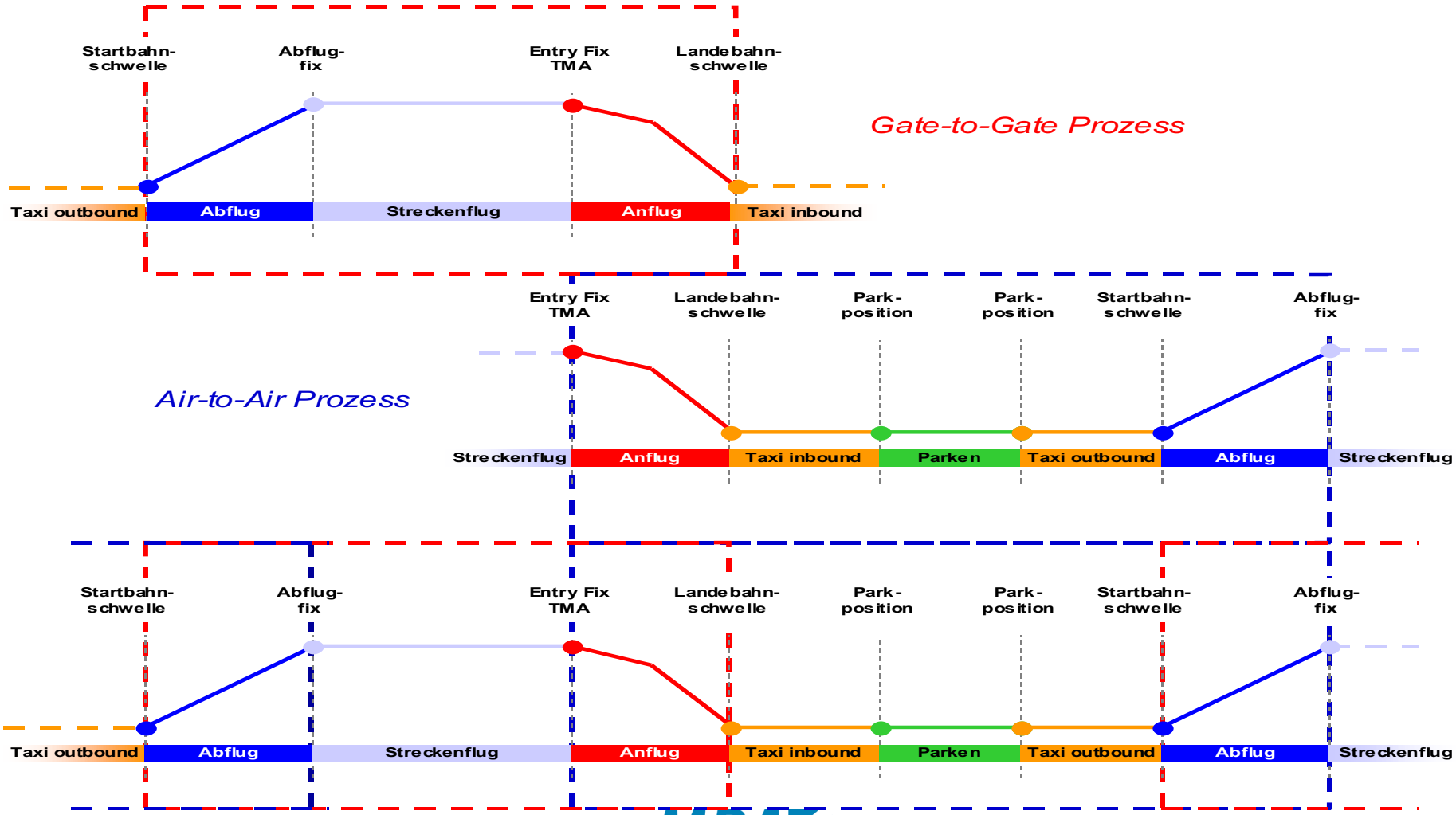
- Too Late AND Too Early !
- Cause for disruption of operation due to overload on process elements
- A Definition according to ADV:
  Talking about a delay when deviation from schedule by > 15 minutes


Frankfurt
Main
Lufthansa

Airport Capacity
Future challenges

Low Cost Carriers	**More and more passengers search for Low-Cost Airlines. Traditional Airlines are losing market shares Major airports are under strong pressure**	
Airline-Alliances	**Relationship to a powerful airline alliance means chance and challenge. Strong strategic partner is evident**	
Transit-competition	**More and More direct connections are available. For Hub-Airports there is strong competition in the Transit-Segment. Airlines put pressure on the price structure of Hubs**	
Political Environment	**Regulations: Bilaterals, safety, security, competition, privatisation, noise, pollution, etc.**	
Quality of location	Quality aspects beyond aviation creates attraction e.g. Airport City Concepts	

Airport Capacity
Gate-to-Gate and Air-to-Air



MBA AVIATION MANAGEMENT

Airport Capacity
Technology

Close Co-operation with Industry, Universities and Research Institutes

Close Co-operation with Standardisation institutes

Close contact with approving authorities: from ICAO to Region

To develop future technologies and transfer into operation

Challenges and Effects e.g.:

- Galileo / EGNOS
- A380

→ Marketing of Know How

Airport Capacity
Airlines: other Indicators

Seatloadfactor:

Relation between offered and sold seats

- e.g.: scheduled traffic: 60 ... 70 %

charter traffic: 75 ... 85 %

Payloadfactor:

Relation between real to maximum possible payload mass

Transport Performance: Product of:

- Number of transported passengers or
- Amount of transported freight and distance

(Passengerkilometer or tonkilometer)

Airport Capacity
Airport Categories

Airport Reference Code (ICAO)

Code-Element 1		Code-Element 2	
Number	Runway Length in m	Letter	Wingspan in m
1	... < 800	A	... < 15
2	800 ... < 1200	B	15 ... < 24
3	1200 ... < 1800	C	24 ... < 36
4	1800 ...	D	36 ... < 52
		E	52 ... < 65
		F	65 ... < 80

Example: An Airport with a runway length of 2200 m and license for aircraft with a wingspan up to 40 m = Code 4D

Airport Capacity
Airport Components

Landside:

- airport roads
- curbside and parking
- airport transportation means

Air- and landside:

- Terminals (Passengers, Freight, Mail)

Airside:

- Apron with aircraft parking stands
- Taxiway system
- Runway system

Airport Capacity
Definition

Airside ?

ATM world:

- The area where aircraft are moving (-> manoeuvring area)

Concessaire world:

- The area beyond security control

Airport Capacity
Runway System

The airport confuration is dominated by the arrangement of runway(s)

Single runway

Dresden, Nürnberg, Bremen, Stuttgart, Saarbrücken, Münster, Hahn

Multi runway

- parallel
- staggered threshould
- Crossing
- Non-parallel / non-crossing Zurich
- Combinations

Airport Capacity
Passenger Terminal

Components

- Arrival- and Departure Hall
- Counter for Check-in, Security-check, Passport- and Customs-Control
- Waiting areas
- Gates
- Baggage handling, Sorter and Delivery
- (Concessionaires)

Terminalkonzepte

1. Linear-Concept
2. Pier-Concept
3. Satelliten-Concept
4. Mobil-Concept

Airport Capacity
Passenger Terminal

Criteria for the rating of Terminal concepts

- Arrangement of curbside
- average walking distance
- expandability
- aircraft manoeuvrability
- relation to neighbouring installations
- amount of investment

Airport Capacity
Passenger Terminal

Recommendation for Terminaldesign

- passengers should be selfguided
- continuous traffic flow – not in controlled groups, without opposite traffic (Passenger-streams should not cross each other or move in opposite direction)
- Transition from ground- to air-transport should be uninterrupted as far as practicable
- It should be possible to recognize without effort an d easy to understand

Airport Capacity
Companies at an airport

- Airport Operator (Operator - Owner)
- Handling Companies (e.g.. Catering, Fueling)
- Airlines (Offices, Handling and Information-Counters)
- Air Navigation Services
- Border Control, Security, Customs,
- Forwarders, Car Rental Companies, Travel Agents, Hotels, Restaurants

Example: (Airport Frankfurt, 2012):

Total amount of people employed at the airport:
~ 78.000 in more than 520 Companies.

Fraport AG itself in Frankfurt: 12.134

Fraport Group Total 20.708

Airport Capacity
Ground Handling

Airport Capacity
Ground Handling

Who / What is handled?

- Passengers, Baggage, Cargo, Mail, Aircraft

By whom?

- Airline / Airport Operators
- Third Party / Contractors
- Police, customs, Border-Control or other official bodies

Activities of ground handling

- Provision of Boarding bridges/-stairs
- Unloading and loading of Baggage, Cargo, Mail
- Cleaning
- Catering
- Water and Waste
- Air Condition
- Fueling
- Ground Power
- Airstarter
- De- /Anti-Icing
- Push back

Airport Capacity
Ground Handling

Information:	- Continuous provision of information is required (e.g. Flight plan, Handling location, other means of transportation)
	- staffed Info-Booths and displays,
	- acoustic information (in exceptional cases and for security reasons))
Flight irregulatities:	- continuous Information,
	- Restaurant vouchers,
	- Hotel,
	- Re-booking,
	- other transportation means,
Transit-/Transfer:	- Additional rooms,
	- Restaurant / Hotel
VIP:	- special handling facilities and rooms
PRM:	- appropriate design of facilities (e.g. Toilets, signage, communication, etc.)
UM:	- Assistance from and to Pickup
Mother and Child:	- Baby Care and Change Rooms

Customer Complaint and Care

Capacity of Airports

1. Definition of Capacity
2. Factors Influencing Capacity
3. Evaluation of Capacity
4. Delay Measurement
5. Slot
6. Tools to analyse capacity
7. Capacity Indicators
8. Runway capacity
9. Terminal capacity
10. Airport capacity

1. Definition of Capacity

Capacity of a transport system may be defined as the ability to transport / perform change of "**transport status**" to a defined volume of "**transport goods**" within a defined time and / or along a defined distance and / or through a defined „gate" within a given "**transport environment**".

If the defined volume can not be performed within the dedicated time frame, **delay** occurs.

If within the defined time frame less volume than the dedicated capacity is to be performed, **system imbalance** is given.

1. Definition of Capacity

Capacity of a transport system depends on a variety of changing parameters, which are related

- to the transport system itself

- to the „transport goods“

- to the „transport environment“

2. Factory influencing Capacity

- **Type of Traffic**
  Long range traffic with wide body aircraft, large number of passengers with baggage and in relative short time, **Charter traffic**, large number of passengers with extreme amount of baggage / oversized baggage, etc.

- **Traffic Mix and Distribution**
  Number and size of aircraft / passengers for inbound respectively outbound, etc.

- **Equipment and Procedures**
  e.g. support systems for flow planning, guidance of aircraft separation between aircraft, etc.

2. Factory influencing Capacity

- **Meteorological Conditions**
  low visibility, aircraft stagger by pilots decision (good visibility conditions only), etc.
- **Work load / Staffing / Skill**
  Efficiency and performance of staff, flexibility and decisive staff, etc.
- **Conditional Reasons**
  Jet Stream / Flight Planning, Political / Environmental Reasons (movement limit, noise restrictions etc.)
- **Preliminary Limitations**
  construction works, partly closure of infrastructure etc.

3. Evaluation of Capacity

In principle evaluation of capacity is based on measurement of **delay**. If delay occurs, capacity may be too low.

If there is no delay, system imbalance (over capacity) may be given. This can be identified by determination of **utilisation rate**.

In case of delay, **environmental conditions**, potentially causing or effecting the delay have to be investigated and their influence has to be quantified / qualified.

3. Evaluation of Capacity

Capacity related parameters are (e.g.):

- aircraft movements (runways) per time unit
- aircraft movements (ground) per time unit
- positioning of aircraft per time unit / position
- handled aircraft per time unit / position / time needed
- passenger movements per time unit / handling unit
- passenger per aircraft movement
- maximum take off weight (MTOW)
- traffic units per square meter
- etc.

4. Delay Measurement

Most important issue on delay measurement is the definition of the **reference time**.

Reference time may be related to

- **schedule:** delay is measured as being late or early (!) regarding a planned time e.g. flight plan time as printed in the ticket.
- **performance** of a system or system component e.g. in average time needed to perform a certain task / operation

For **customer reason** in general the schedule is most important, while for **efficiency** performance is the key element.

4. Delay Measurement

Due to different approaches, between **ATC** and **Airport Operator,** often two different delay levels are used (also in public):

Airports:
Delay measurement at airports is mainly passenger related, that means linked to schedule. If the aircraft is e.g. **on-** or **off block,** within **± 15 minutes** around scheduled time, it is taken as on schedule.

Capacity limit is reached, when the acceptable average delay per aircraft is exceeded for a certain amount of movements. The acceptable limit should be fixed together with the airport users

4. Delay Measurement

Air Traffic Control:

Delay measurement at air traffic control is mainly system related, that means linked to the performance of a defined task or system component. (e.g. crossing of a control sector).

If the performance exceeds the defined time limit by just only 1 minute, delay is given.

Capacity limit is reached, when the acceptable average delay per task / system component is exceeded. The acceptable limit often is in the range of 4 minutes.

5. Slot

For better use of available capacity and to harmonise traffic flow along the route, **time „slots“** (equal to the number of events during a specified time unit) are defined. Especially at congested airports and for air traffic control units, these slots are defined

The number of available slots correlates to available capacity.

Despite closely linked together, airport related slots are more strategic, while ATC slots are more operational.

5. Slot

„Airport Slot“

Is mainly defined by declared airport capacity (**X aircraft movements - take off ’s - landings per hour**), based on the requirement to provide traffic according to schedule. Slots are „distributed“ to airlines during the „Slot Conference“ (twice a year) and are used for strategic schedule planning. (Defined slot figures are **stable**)

„ATC-Slot“

Is mainly defined by system capacity of individual elements and components (performance related). ATC-slots are distributed according to operational needs and ability. (Slot figures **may vary** due to operational conditions)

5. Slot

- **ATM: Tactical Tool**

A time-interval - co-ordinated by the Central Flow Management Unit (e.g. CFMU, Brussels) - requiring a flight to cross over a certain point during en-route flight.

- **Airport: Strategic Tool**

A time-interval - co-ordinated by the flight plan scheduling office according to the declared capacity - to operate a flight at the airport.

6. Tools to analyse capacity

Fact oriented analysis:

Analysis based on available statistics e.g. on delays, movements and performance levels etc.

- Safe and actual data but potential problem to extrapolate.
- Capacity limit is difficult to identify before it occurs.
- Reason for capacity constraint may not be identified, as only the results (e.g. delay) are measured.

6. Tools to analyse capacity

Process oriented analysis:

Simulators, Test trials etc.

- Quality of results relies on validation and quality of simulation model / test environment.
- "Unlimited extrapolation" is possible, (analysis) of future traffic scenarios and future environments (e.g. new infrastructure, new procedures, different traffic mix etc.
- Reason for capacity constraints may be identified more easily.

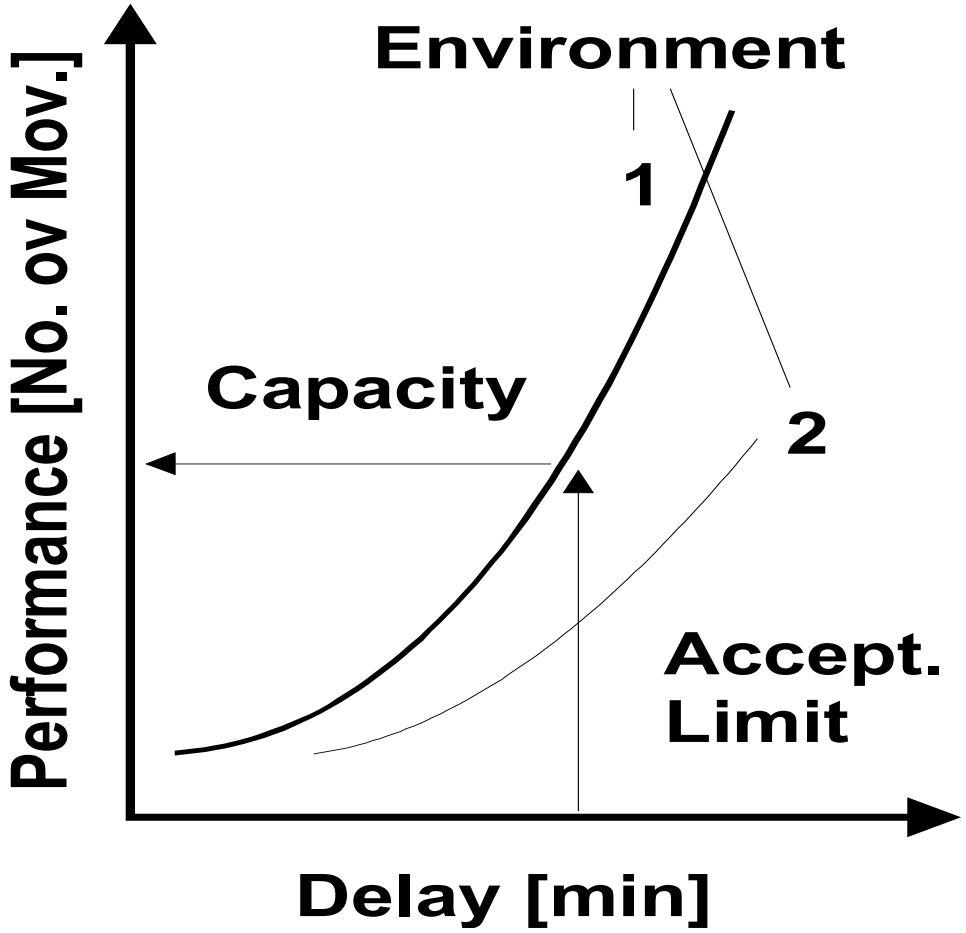
7. Capacity Indicators

The capacity is indicated by the parameters outlined in para 3.

The capacity itself may be individually different due to environmental parameters.

(e.g. visibility or runway condition wet / dry is relevant for operational runway capacity)

7. Capacity Indicators



1. e.g. good visibility
2. e.g. bad visibility

8. Runway Capacity

Capacity of a runway system is influenced by:

- location and number of runways
- aeronautical equipment of runway
- length and width of runways
- traffic mix
- meteorological conditions
- operational procedures
- equipment of air traffic control unit
- „soft“ aspects etc.

9. Terminal Capacity

Capacity of a terminal is influenced by:

- location, type, number and size of passenger handling systems (check-in counter, security etc.)
- passenger information (technology, location etc.)
- space and movement area
- location and size of retailing areas (conflict !!!)
- landside accessibility
- passenger transport systems
- „soft“ aspects etc.

9. Terminal Capacity

Airside / Landside

- **ATC World:** Airside is the area where aircraft operate**.**
- **ICAO Definition of Movement Area:**

That part of an aerodrome to be used for the take-off, landing and taxiing of aircraft, consisting of the manoeuvring area and the apron.

- **Concessionaire World.**

The area beyond Security / Customs Control.

10. Airport Capacity

The airport capacity is the result of each individual component and its capacity.

As the airport in total represents a functional unit -transferring passengers and goods from „landside requirements“ to „airside requirements“ and vice versa- the capacity of an airport is finally its ability to perform this “transformation” within a defined time.

Taking the processes at an airport as a sequence of different processes representing chain elements, the airport capacity is defined by its weakest element.


Thanks for your attention!
Any more questions?