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Flight Route Optimization

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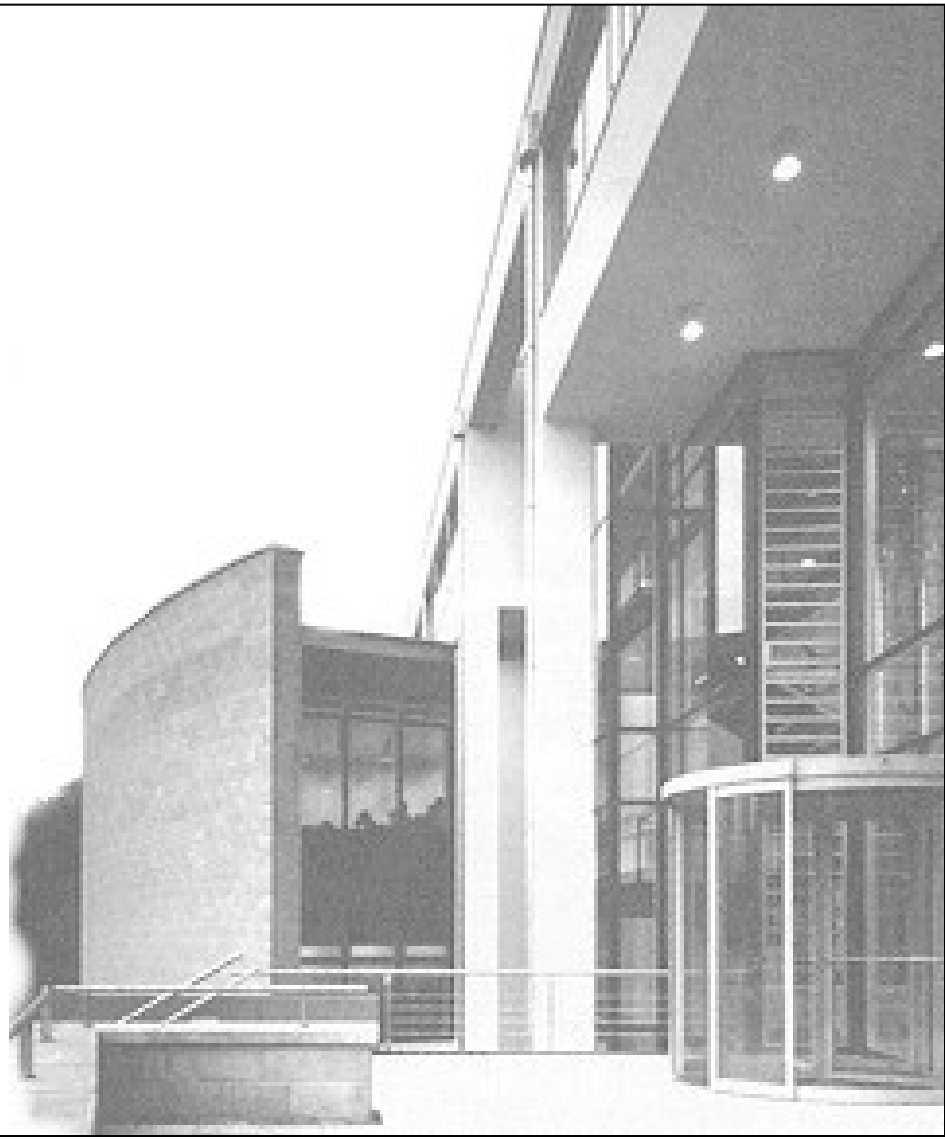


Agenda

1. Introduction
2. Literature review
3. Research framework
4. Flight phases
5. Case study
6. Conclusion

1. Introduction

- Air traffic will grow in the next years (4% p.a.)
- The airspace has already full capacity
- Current Air Traffic System (ATS)-routes are inefficient because
  - for navigation aircrafts use radio beacons which are installed severed fixed points on the ground
  - so complex network develops with many lines and knots
- Legal restrictions prevented that aircrafts can fly direct distance (great circle)
- International Organizations and Institutions efforts to create more efficient routes (GPS for navigation etc. modern/reorganized airspace)

2. Literature Review

- One of the earliest tasks in logistics and operation research (OR) is network configuration and related tasks such as the decision of location and route optimization
- Particular OR deals intensively with route optimization
- Simulation are modern methods to analyse complex structures and systems
- Major tasks in air transport management and logistics are planning, organization, implementation, management and control of transport operations by airway of passage, cargo and mail
- GPS-Technology is largely researched in engineering science
- Literature describes that GPS has potential to replace the conservative radio beacons

2. Research Framework

Research framework:

- Original aviation charts were used
- Interviewed persons:
  - Air traffic controllers
  - Flight instructors
  - Institutions
  - Pilots
- Different flight planning programs has been applied and verify (if programs work correct – find shortest way)
- Modelling without considerations of:
  - Variable Wind components
  - Different runway directions
  - Temperature components
  - Elevations
  - Weights and balances
  - Kerosene consumptions in different Flight Levels (FL)
  - Traffic (no holding pattern)
  - Legal restrictions

2. Research Framework

Methodology:

- Simulation (planning) a flight from Hamburg to Munich
- Demonstration of flight in current ATS-Routes and optimized routes without specified network structures (GPS and “Free flight”)
- Objective: Comparison before/after flight route optimization

Research Questions:

- What are the ´theoretical´ potentials if radio beacons will be replaced by GPS e.g.?
- How much are savings in distance, time and fuel consumption?

3. Flight Phases

Different phases of flights are:

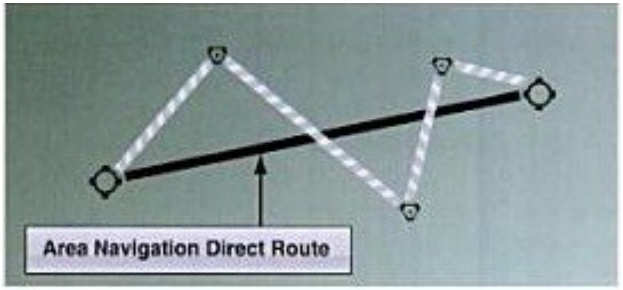
- Taxi out
- Takeoff
- Climb out and climb to en-route configuration
- Cruise
- Approach
- Final approach
- Taxi in

3. Flight Phases

Current flight processes for more efficiency:

RNAV (Random or area navigation):

- Waypoints are based on GPS technology
- Reduces the dependency of beacon location
- Aircrafts can fly the direct RNAV-route and not over the beacons which are installed on the ground



Source: FAA - Federal Aviation Administration (2009)

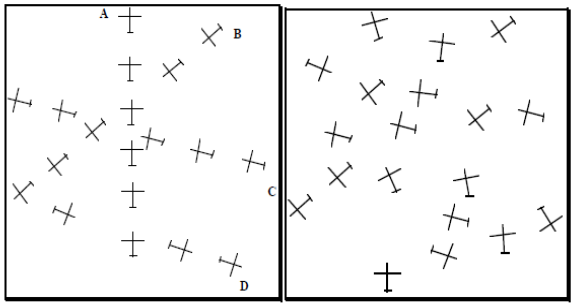
RVSM (Reduced Vertical Separation Minimum):

- Six additional cruising levels between FL 290 and FL 410 were implemented 2002 by 41 Countries
- For more capacity the vertical distance was minimized (2.000 ft → 1.000 ft)
- Reductions of fuel and delays are the main objectives

Source: EUROCONTROL (2010)

Examples of new approaches in future:

- Communication technologies:
  - Global Positioning & Communication (GP&C)
  - Precise identification and tracking systems for aircrafts and vehicles
  - GPS based landing system
  - GPS based navigation technology
- Single Airspace
  - Airspace without borders
  - Single European Sky
- Free flight concept
  - Defined as safe and economic method
  - Aircrafts have not to fly via airways
  - Higher capacity can be realized



Source: Hoekstra/Ruigrok/van Gent 2000)

4. Case Study

Background of case study:

- Exemplary aircraft: Boeing 737
- Origin: Hamburg (EDDH)
- Takeoff: Runway 05 (direction north-east)
- Destination: Munich (EDDM)
- Landing: Runway 08 (direction east)
- Cruising Altitude: FL 330 (33,000 ft. ~ 10,050 m)

4. Case Study

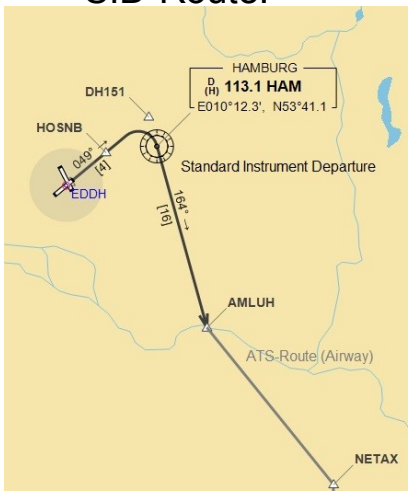
Takeoff, departure and route from Hamburg to Munich:

Data:

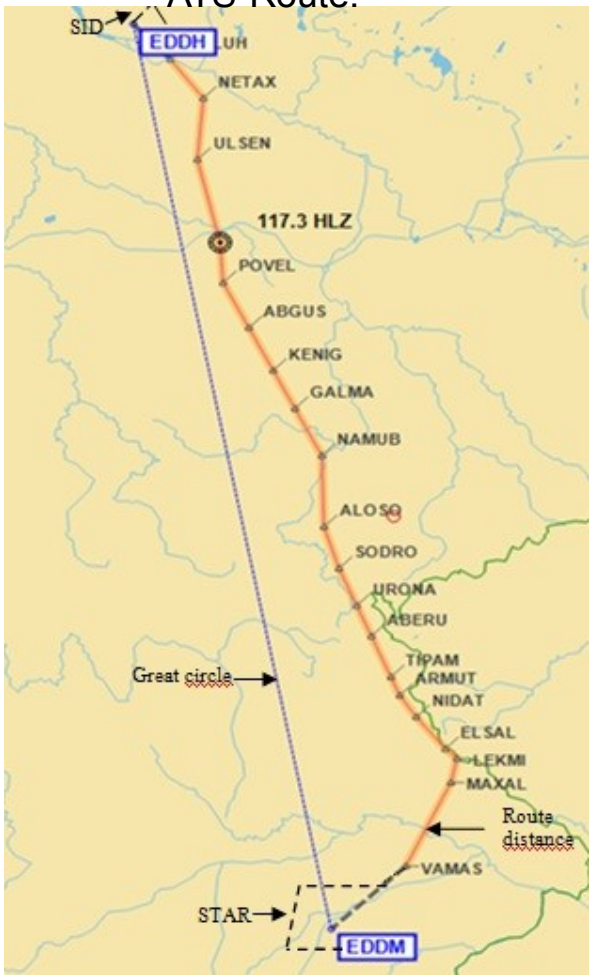
SID:	ALMUH (departure south west)
Airways:	Y901 / UM852 / UZ16 / T703 / T105 (5x)
Beacon:	HLZ (1x)
Waypoints*:	NETAX, ULSEN, POVEL,… (18x)
STAR:	VAMAS

* Only en-route

SID-Route:



ATS-Route:

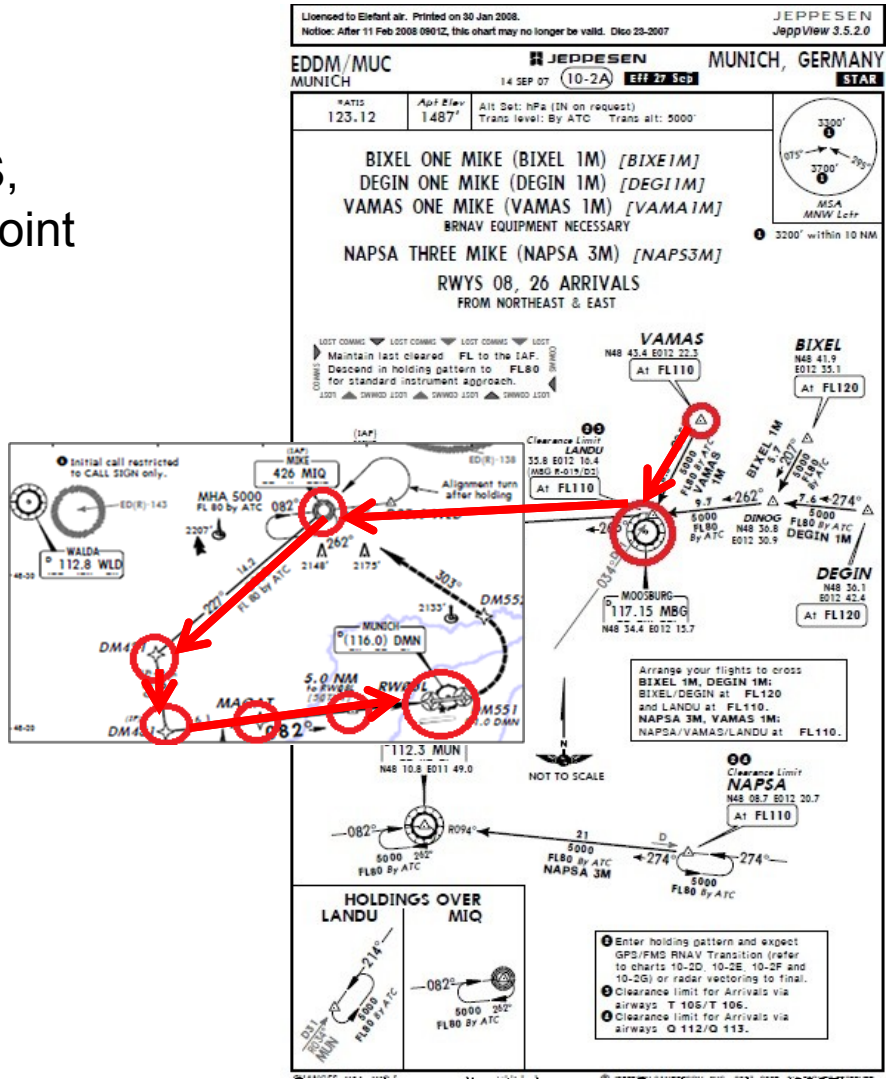


4. Case Study

Arrival and landing in Munich:

Last Waypoint on Airway T105 is VAMAS, then the aircraft will passing arrival-waypoint LANDU and MIQ. This point is approximately 27 NM northwest from the airport. Afterwards the route passes in direction south-west and south. Afterwards the aircraft will turn to landing heading east.

Distance: 410 NM (~ 760 km)
Great Circle: 324 NM (~ 600 km)
Fuel: 2.9 tons



Sources: In according to Jeppesen, Sanderson Inc. (2007)

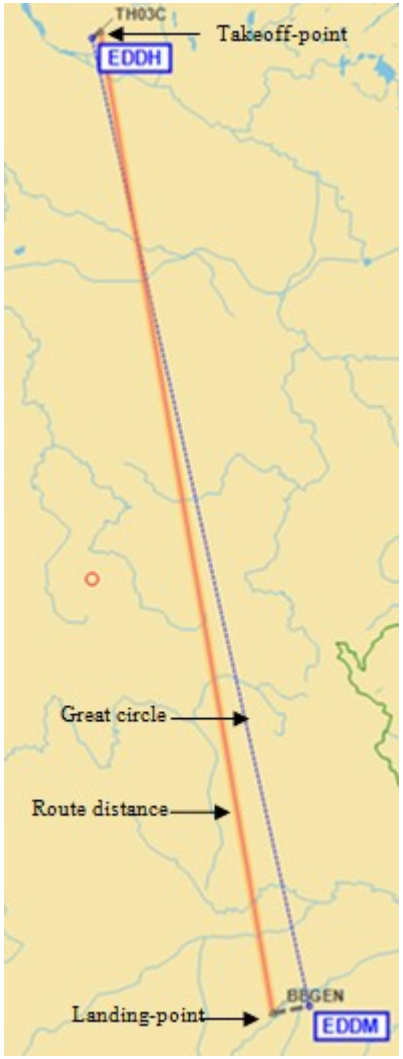
4. Case Study

Optimization with following assumptions:

- After takeoff the aircraft flies approx. 4 NM straight ahead
- Aircraft does not use the ATS routes, it applies GPS
- Landing-point is approx. 12 NM for runway (tracking)

Waypoints: TH03C / BEGEN (2x)
Distance: 341 NM
Great Circle: 324 NM
Fuel: 2.5 tons

Savings:	
Distance:	69 NM (~ 128 km)
Fuel:	0.4 tons
Time:	8 Minutes



5. Conclusion

- Increasing interest in science and practice illustrates the importance for a reorganized airspace
- New technologies and procedures can revolutionize ATM
- Potentials exists to save costs, time and environmental pollution
- New technologies are getting better and more accurately for e.g. GPS
- In practice a lot of restrictions like separation of airspaces and regulatory requirements exist
- Obstacles and noise protection in airport areas prevent some optimization
- Complete processes (from gate to gate) have to be considers for a significant optimization (compare with central idea of SCM)

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Thank you for your kind attention.

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