Efficiency gains through flight centered Air Traffic Management approach

How to meet future needs with a dynamic airspace sectoring

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Research Workshop
Volatility in air traffic and its impact on ATM Performance

Warsaw, 16 May 2018
Agenda

1) Motivation
2) Status quo and challenges
3) Approach of dynamic sectorization
4) Application and results
5) Conclusion and outlook
Motivation

Addressed Issue: Volatility in
  • Traffic numbers
  • Flow and distribution

Traffic numbers expected to be increasing
However: Uncertainties

Traffic flow and distribution depends on short-, medium-, and long term effects, e.g.:
  • Weather
  • Military activity
  • Route Charges
European Airspace current situation

- 37 ANSP, 63 ACCs
- Different Systems and Procedures
- Differently affected by traffic

One Approach: Functional Airspace Blocks (FABs)
- However: Studies indicates diseconomies of scale for some ANSPs
Air Traffic Management

European airspace structure and operations
Moving from Airspace to 4D Trajectory Management

handling of new entrants – space liner
Research Targets (1) – General Approach

- Data Methodology
- Performance Benchmarking
- Model Aggregation

- Dynamic Sectorization
- Implementation
- Root Cause Analysis
- Airspace Structure

Development Circle
Feedback Loop, Requirements
Research Targets (2) – Goals of dynamic sector boundaries

Higher flexibility at airspace sectorization dynamically considering traffic demand and density

Adaption to
• Changing traffic demands over the day
• Smooth transition between succeeding traffic phases

Balancing of
• Complexity, traffic density, work load of controllers

Transition between
• sector-less, aircraft centric approach and structural airspace designs
Approach (1) – Procedure and Analysis Steps

Three-step, scalable approach:

**Fuzzy Clustering**
- identification of traffic hot spots

**Voronoi-diagrams**
- provide an initial airspace structure

**Evolutionary Algorithms**
- optimization of the airspace structure
Approach (2) – From Trajectory to Clustering
**Approach (3) – Optimization by Evolutionary Algorithms**

**Procedure**
- Clustering of air traffic - hot spots
- Create a start structure - Voronoi diagrams
- Derive valid airspace structures and evaluate
- Combine best structures for new iterative phase
- Stepwise optimize structure with regards to objective function

**Objective function could aim at**
- Overall controller task load
- Standard deviation in controller task load
- Shape of sector area, boundaries
- …
**Objective Function**

*determination of controller task load*

Data based on necessary task times used by DFS and EUROCONTROL

Identified 55 tasks for radar, planning, arrival, airport, tower and apron controller (129 sub-tasks in total)

### Example

<table>
<thead>
<tr>
<th>Controller</th>
<th>Main Type</th>
<th>Sub Type</th>
<th>Task-Name</th>
<th>Time [s]</th>
<th>Per x Seconds</th>
<th>Group</th>
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<td>Monitoring</td>
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<td>Initial Monitoring</td>
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<td>-</td>
<td>Coordination</td>
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<td>Receipt Flight Strip</td>
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<td>-</td>
<td>Coordination</td>
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<td>Conflict Search</td>
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<td>Conflict Resolution</td>
<td>60</td>
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</tbody>
</table>

### Conflict Types

- **Opposite:**
  - Radar Telephony
  - Monitoring
  - Coordination

- **Recurring Monitoring:**
  - Monitoring

- **Rectangular:**
  - Monitoring
  - Coordination
  - Conflict Search
  - Conflict Resolution

- **Consecutive:**
  - Monitoring
  - Coordination
  - Conflict Search
  - Conflict Resolution
German Upper Airspaces

task load
Dynamic Airspace Sectorization
three step approach (Maastricht/Amsterdam airspace - EDYYDUTA)

traffic sample
Dynamic Airspace Sectorization

continuous change of EDYYDUTA

Change of air traffic flows over the day

Stepwise adaptation of sectors

Consideration of controller expectations
Volatility – Causes and Effects

contribution of dynamic sectorization

- Weather
- Politics
- Strikes
- Military

Exogenous Events

Dynamic sectorization

Airspace structure

Influence

Airspace management

External Effects

Avoid

Provide

Delay

Detours

Emissions

Costs

Internal Effects

...
Conclusion and Outlook

• Dynamic sectorization provides
  • Systematic flight centered ATM approach: structure follows air traffic flow (paradigm change)
  • High flexibility on operational level (uncertainties, disturbances)
  • Reduced volatility: avoid and/or reduce external effects by disruptions (exogenous events)
  • Efficient consideration of special events: military operations, new entrants, severe weather
  • Optimization with regards to multiple objectives (e.g. task load, network effects)

• Further steps
  • Integration into current projects, addressing economic and ecological constraints
  • Introduction to ATC controllers to verify a suitable degree of dynamic sector adjustment
  • Usability study with humans-in-the-loop
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