Efficiency gains through flight centered Air Traffic Management approach

How to meet future needs with a dynamic airspace sectoring

Dr. Michael Schultz

Thomas Standfuß

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

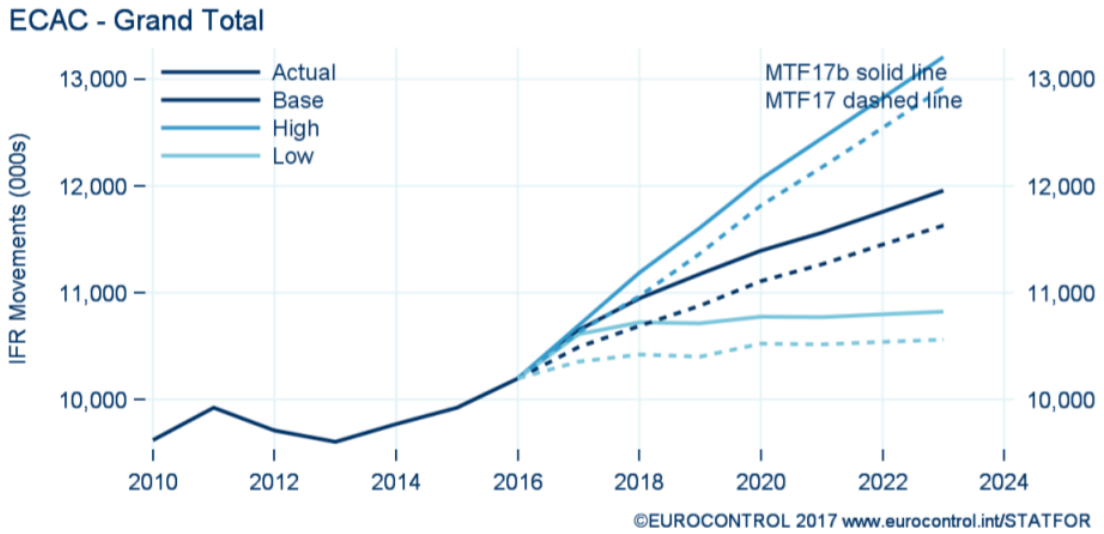
Traffic numbers expected to be increasing

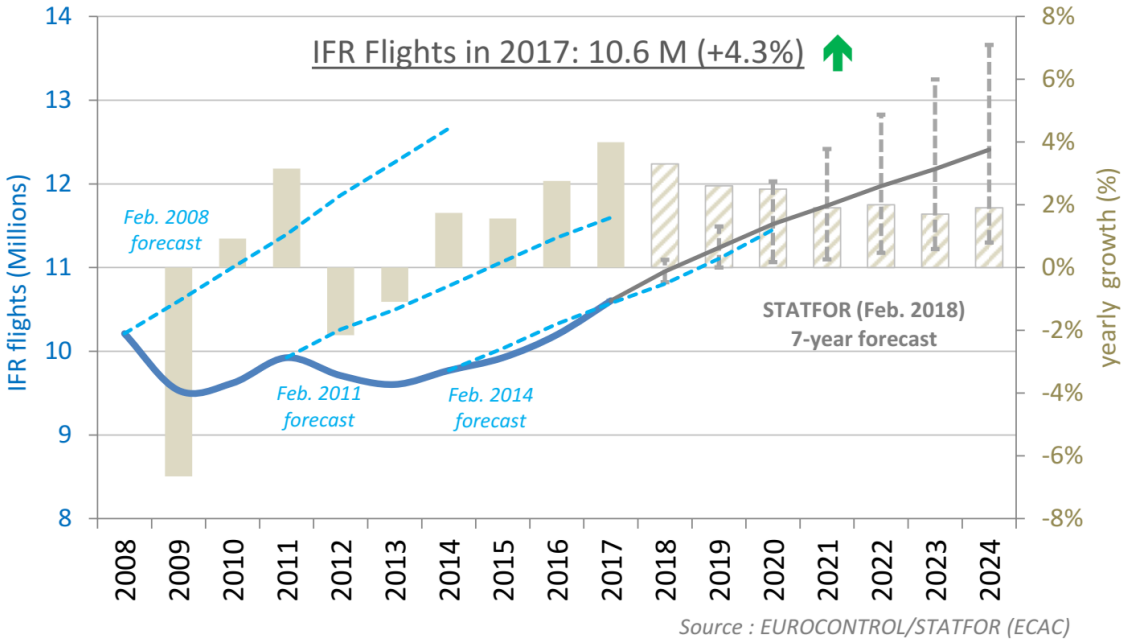
However: Uncertainties

Traffic flow and distribution depends on short-, medium-, and long term effects, e.g.:

- Weather
- Military activity
- Route Charges

Figure 28. For total Europe, current forecast is shifted up compared to the previous forecast (dated February 2017).





Source : EUROCONTROL/STATFOR (ECAC)

European Airspace
current situation

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

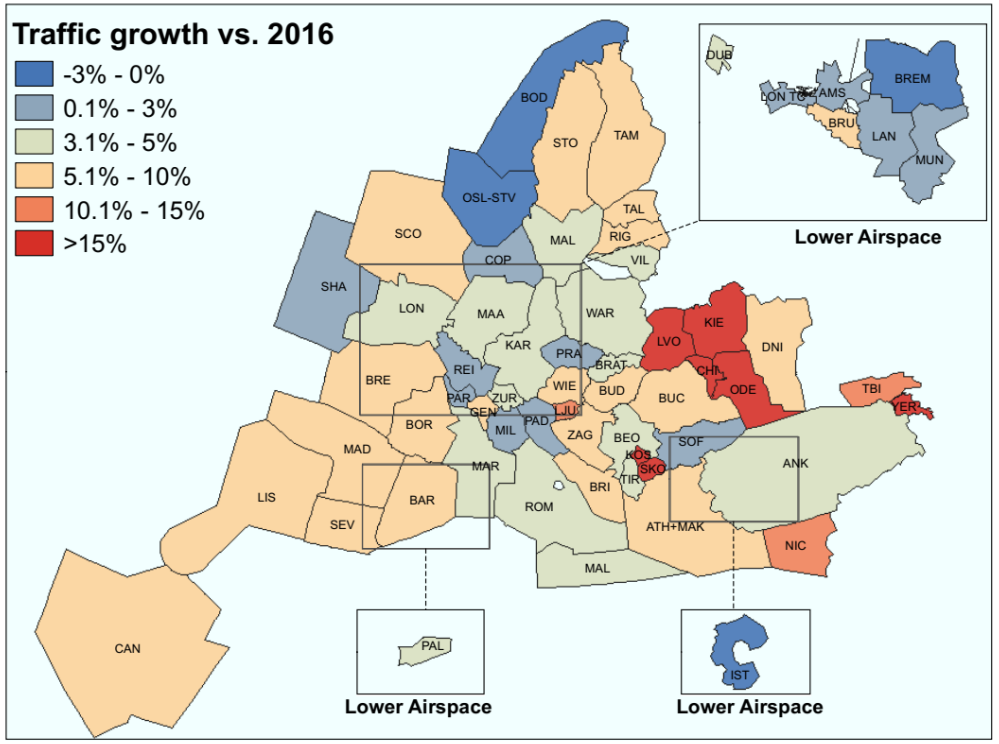
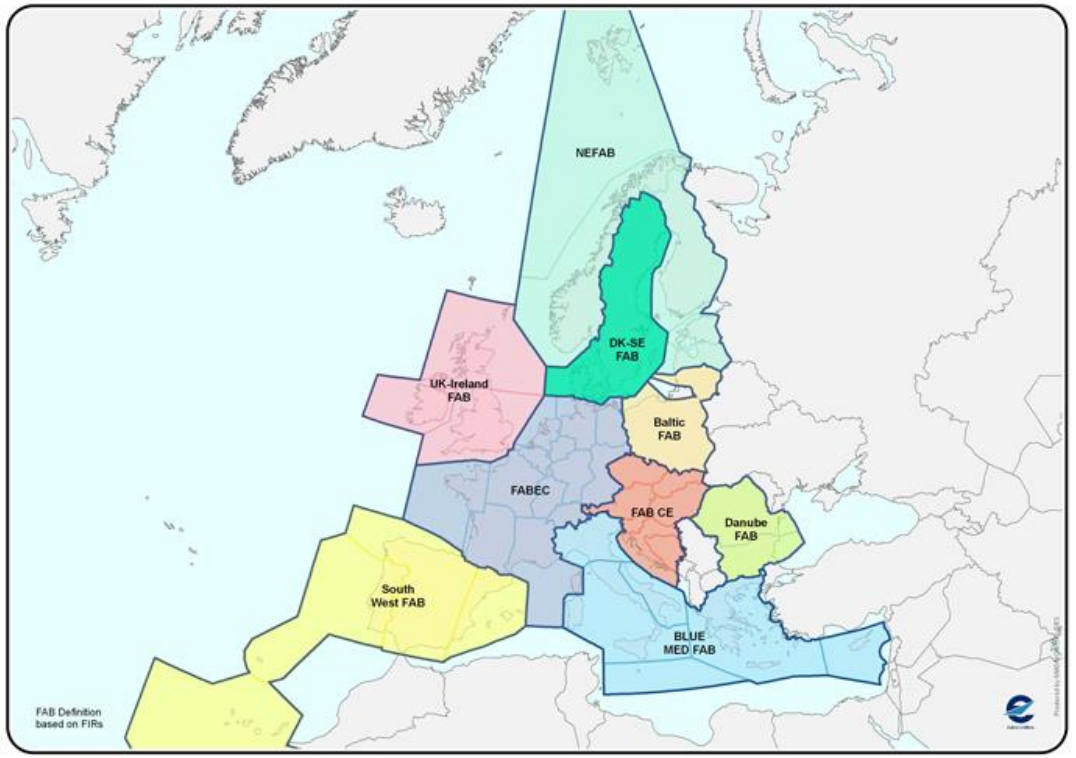


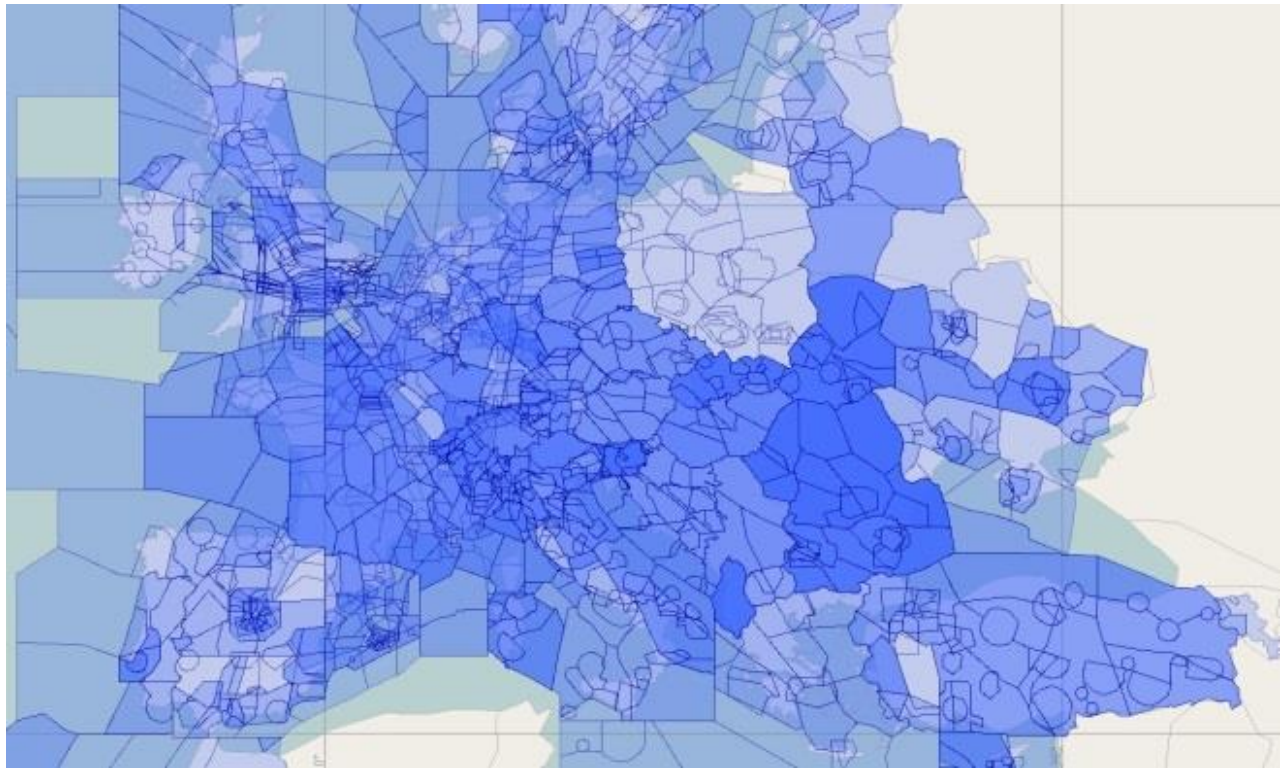
Figure 3-2: Traffic growth by ACC (2017)

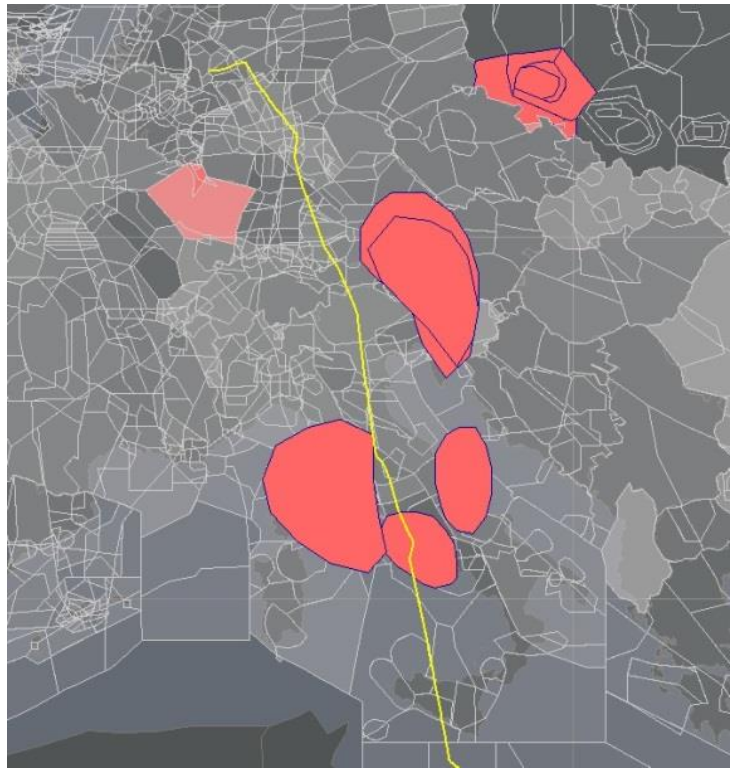
- One Approach: Functional Airspace Blocks (FABs)
- However: Studies indicates diseconomies of scale for some ANSPs



Air Traffic Management

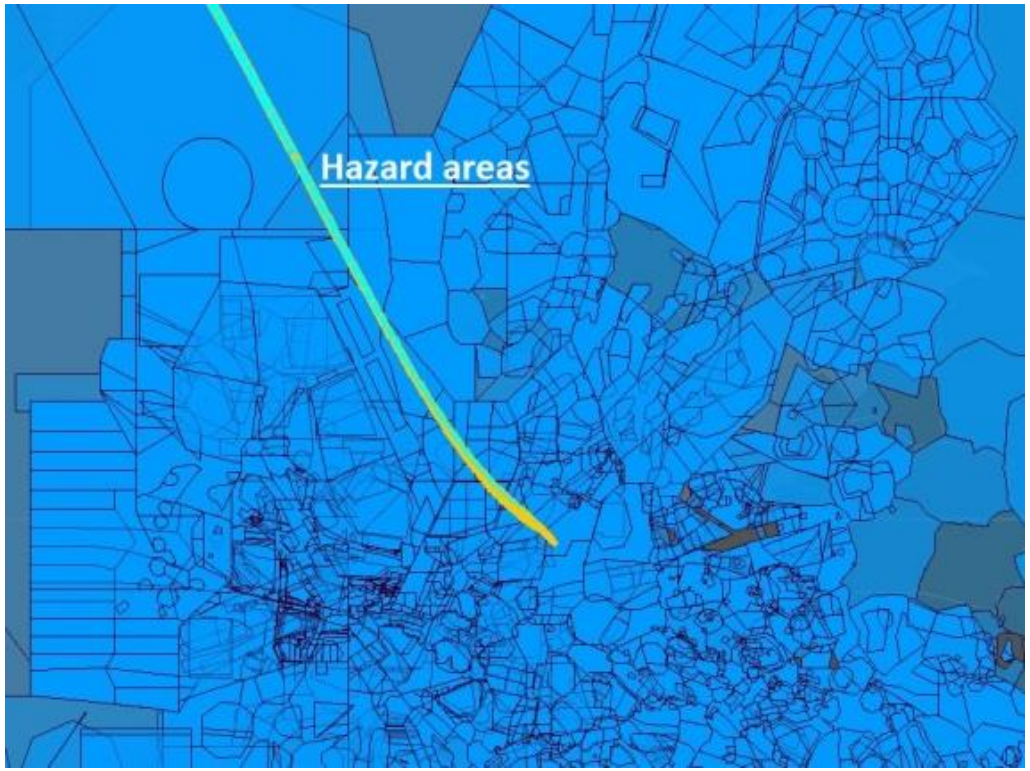
European airspace structure and operations

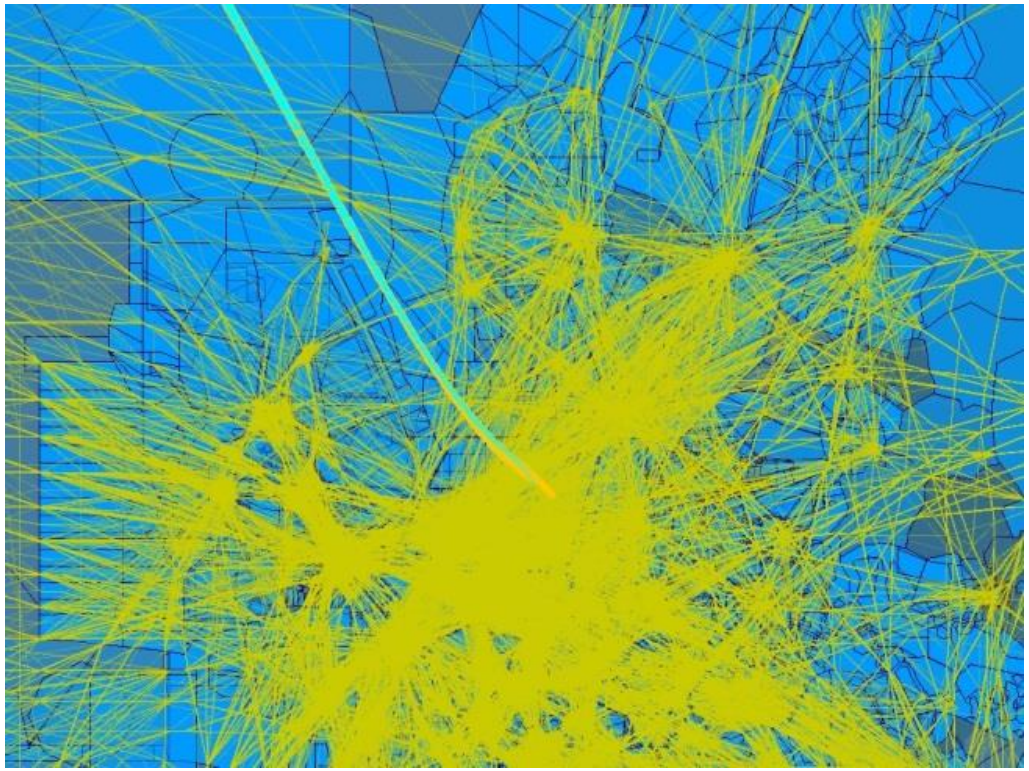




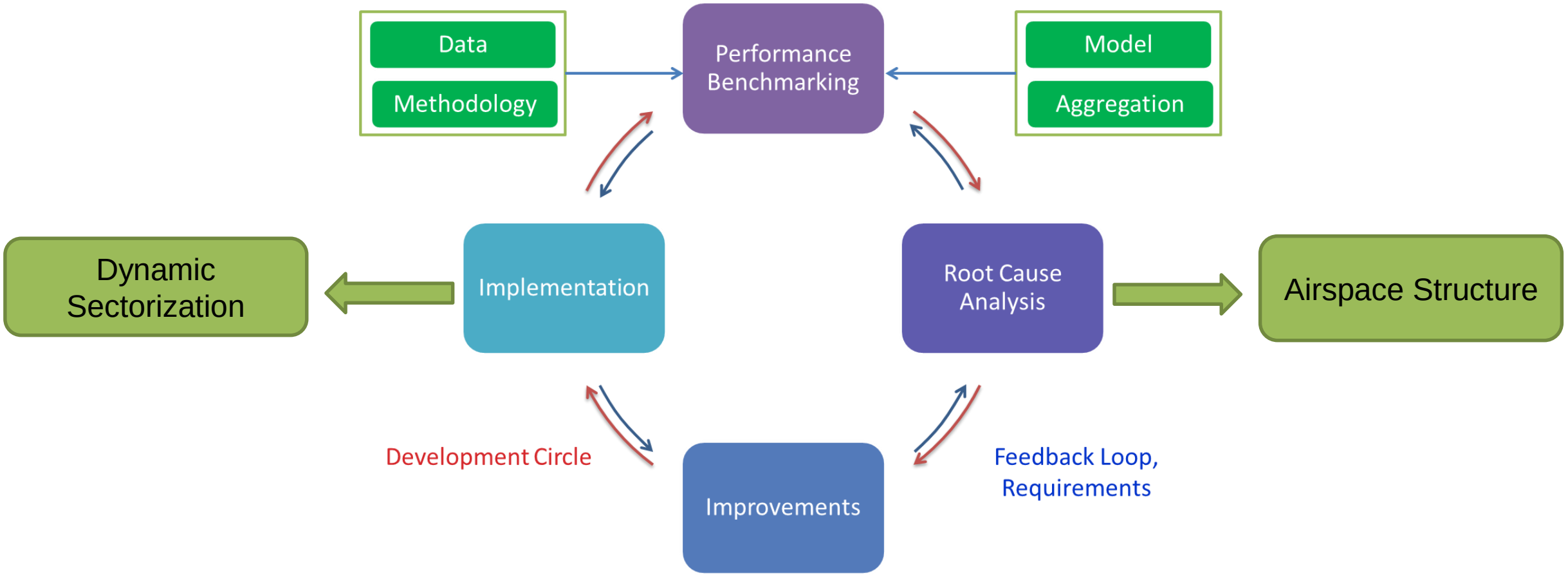
Moving from Airspace to 4D Trajectory Management

handling of new entrants – space liner





Research Targets (1) – General Approach



Research Targets (2) – Goals of dynamic sector boundaries

Higher flexibility at airspace sectorization dynamically considering traffic demand and density

Adaption to

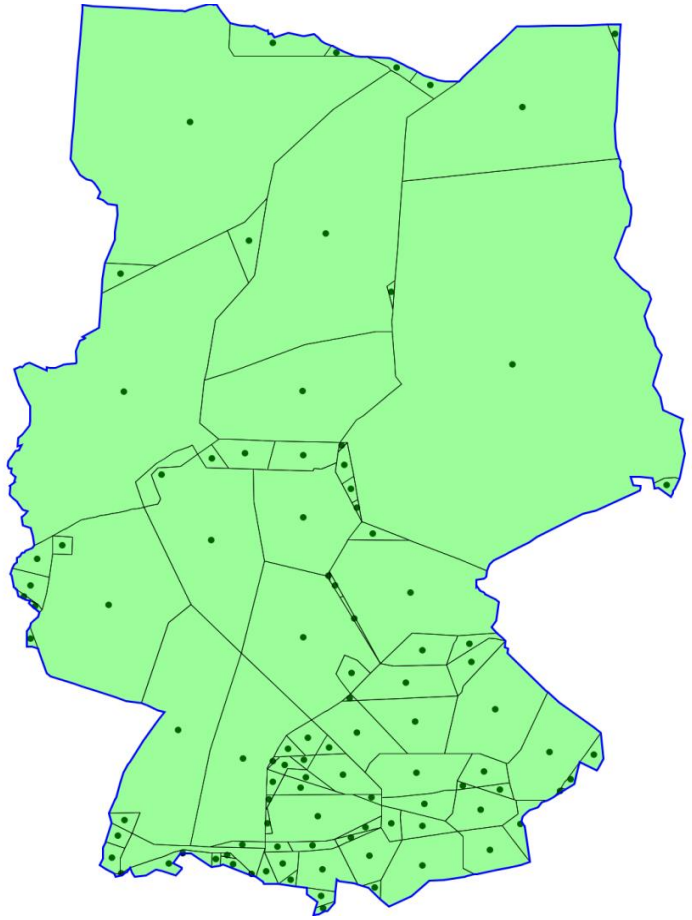
- Changing traffic demands over the day
- Smooth transition between succeeding traffic phases

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

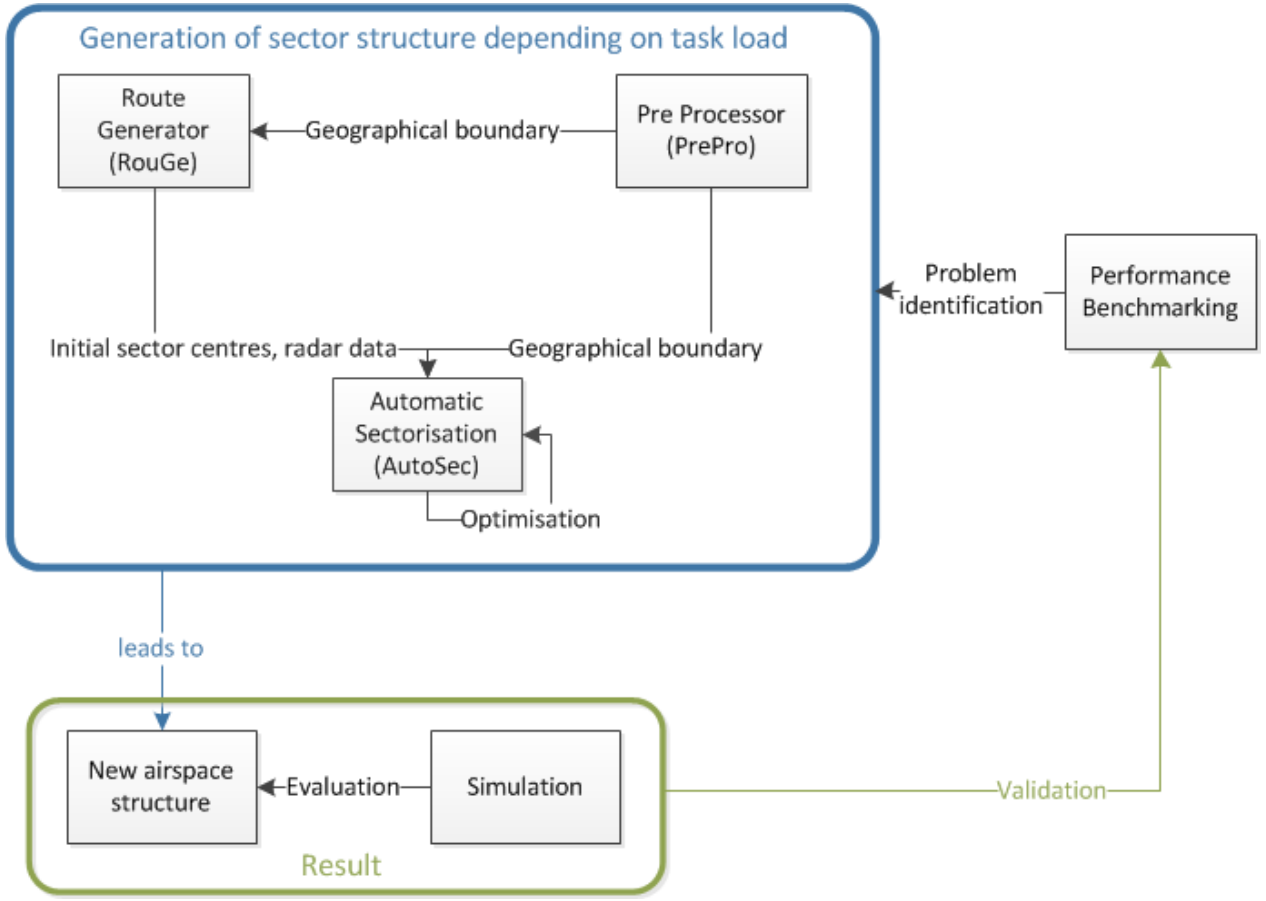
- identification of traffic hot spots

Voronoi-diagrams

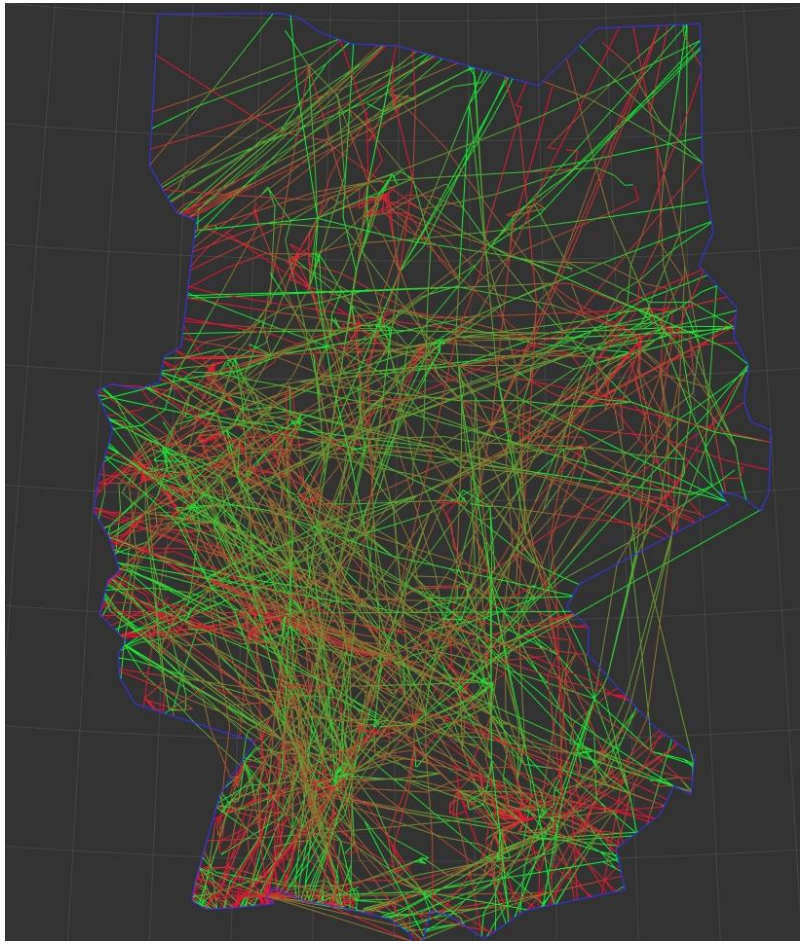
- provide an initial airspace structure

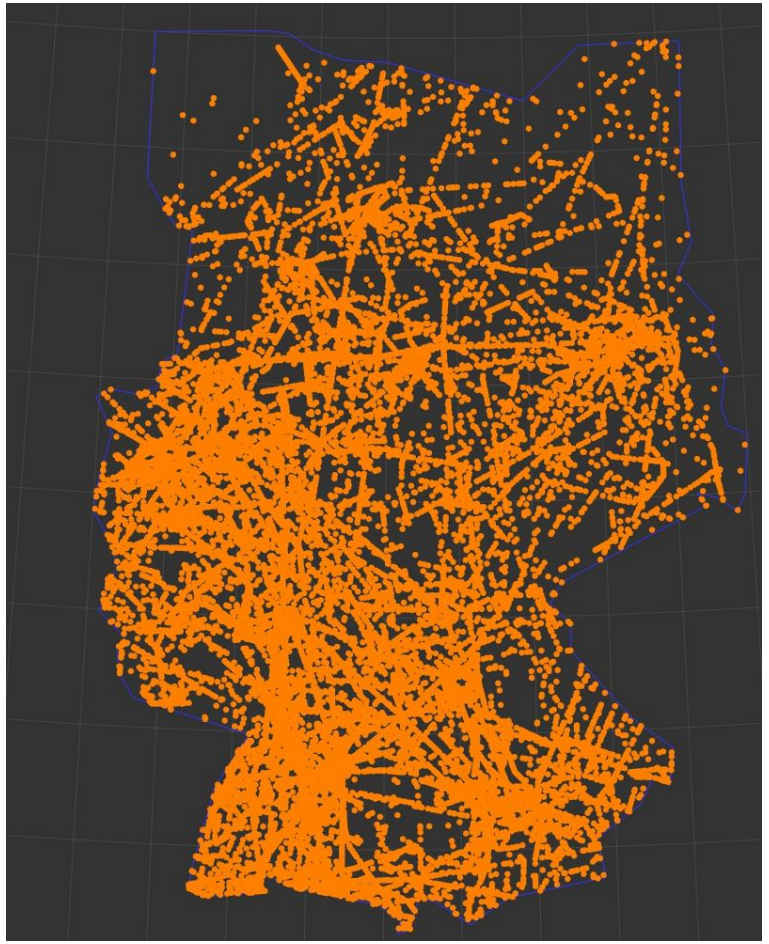
Evolutionary Algorithms

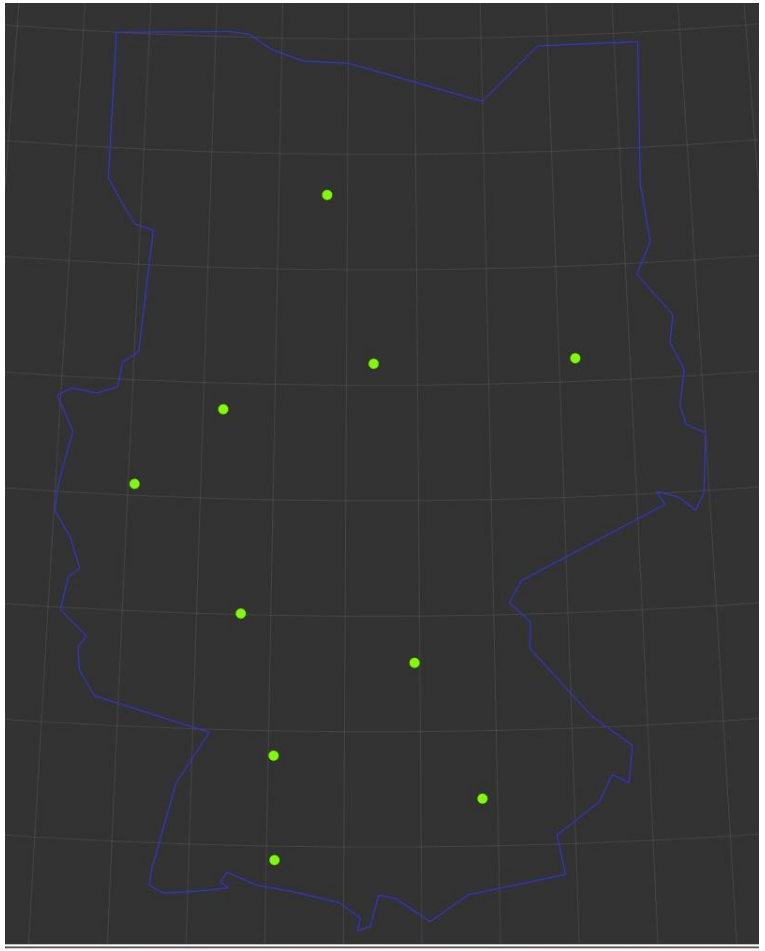
- optimization of the airspace structure



Approach (2) – From Trajectory to Clustering







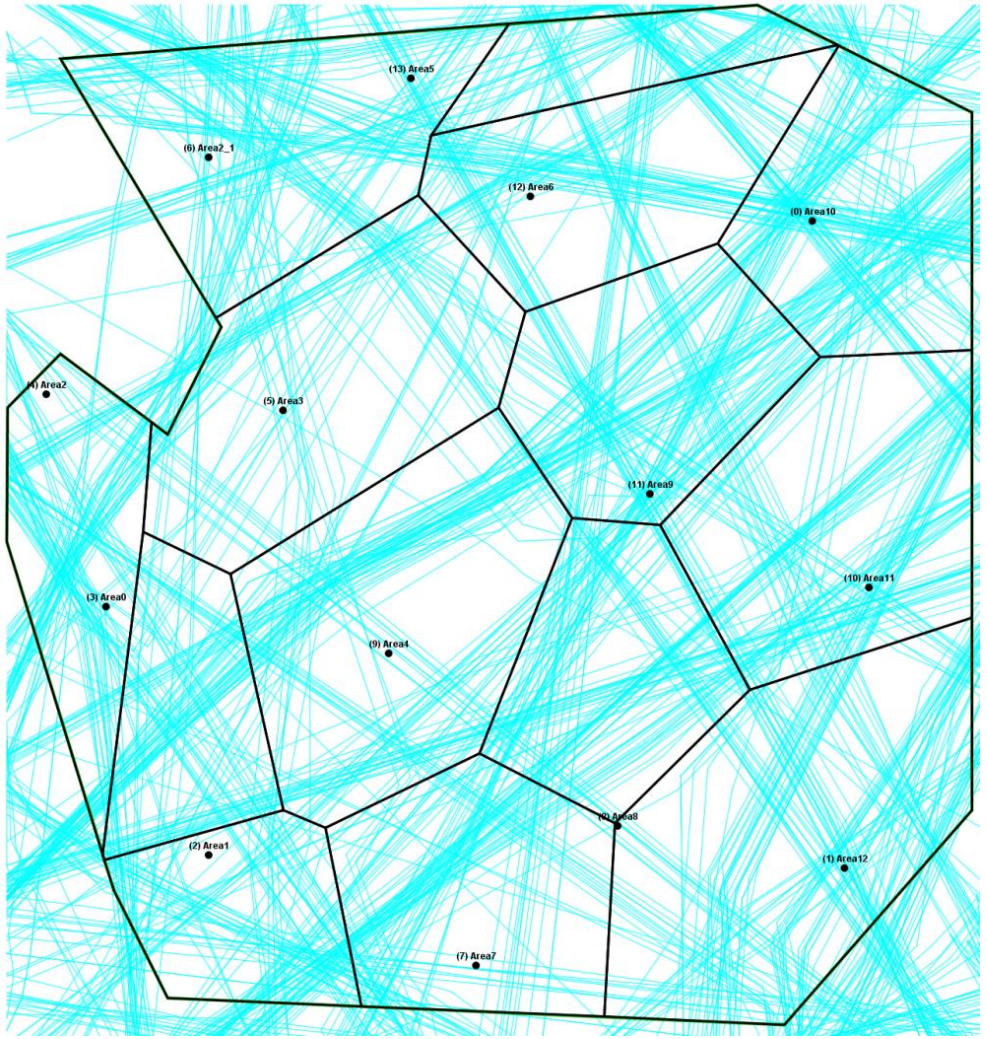
Approach (3) – Optimization by Evolutionary Algorithms

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

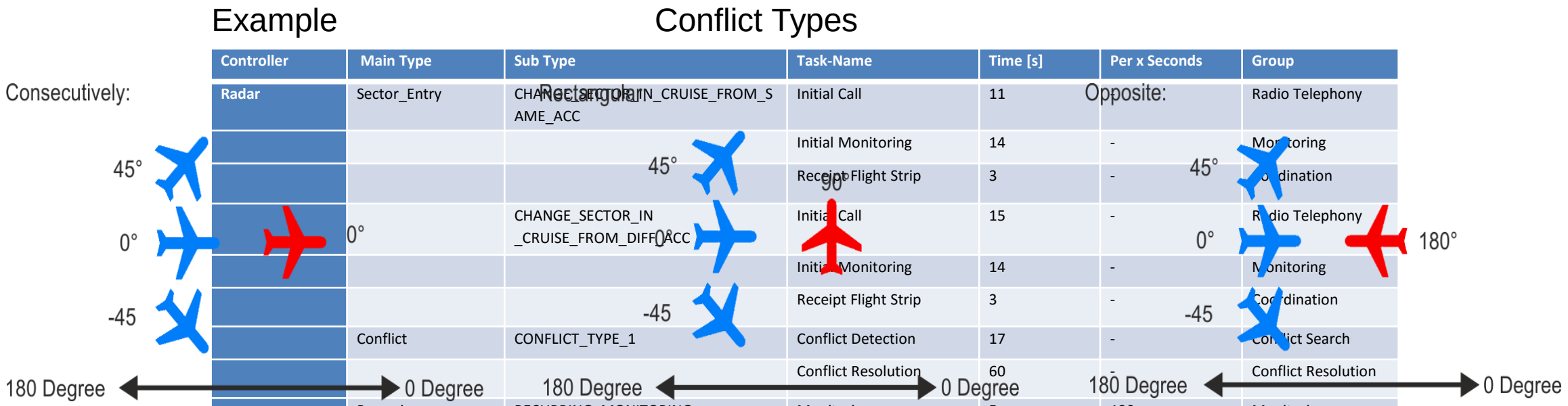
Data based on necessary task times used by DFS and EUROCONTROL

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

Example

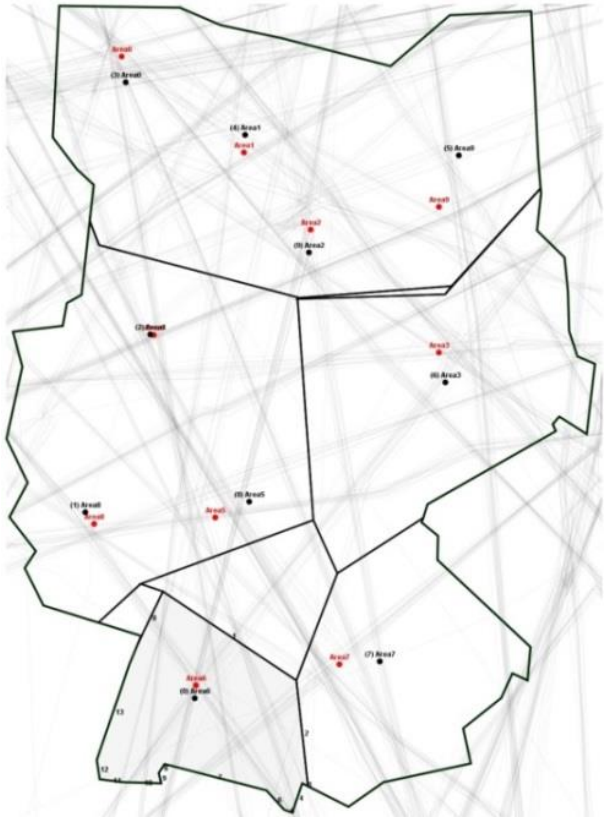
Controller	Main Type	Sub Type	Task-Name	Time [s]	Per x Seconds	Group
Radar	Sector_Entry	CHANGE_SECTOR_IN_CRUISE_FROM_SAME_ACC	Initial Call	11		Radio Telephony
			Initial Monitoring	14	-	Monitoring
			Receipt Flight Strip	3	-	Coordination
		CHANGE_SECTOR_IN_CRUISE_FROM_DIFF_ACC	Initial Call	15	-	Radio Telephony
			Initial Monitoring	14	-	Monitoring
			Receipt Flight Strip	3	-	Coordination
	Conflict	CONFLICT_TYPE_1	Conflict Detection	17	-	Conflict Search
			Conflict Resolution	60	-	Conflict Resolution
	Recurring-Monitoring	RECURRING_MONITORING	Monitoring	5	120	Monitoring

Conflict Types



German Upper Airspaces

task load



Dynamic Airspace Sectorization

three step approach (Maastricht/Amsterdam airspace - EDYYDUTA)

traffic sample

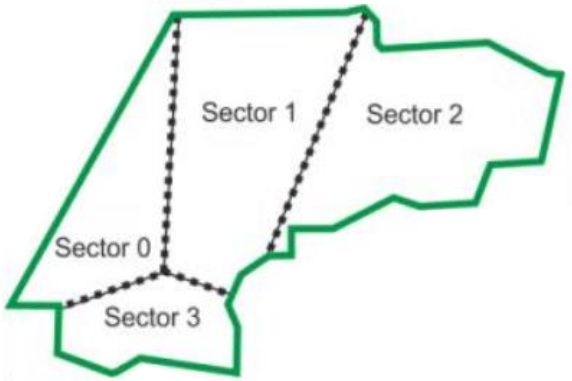
Dynamic Airspace Sectorization

continuous change of EDYYDUTA

Change of air traffic flows over the day

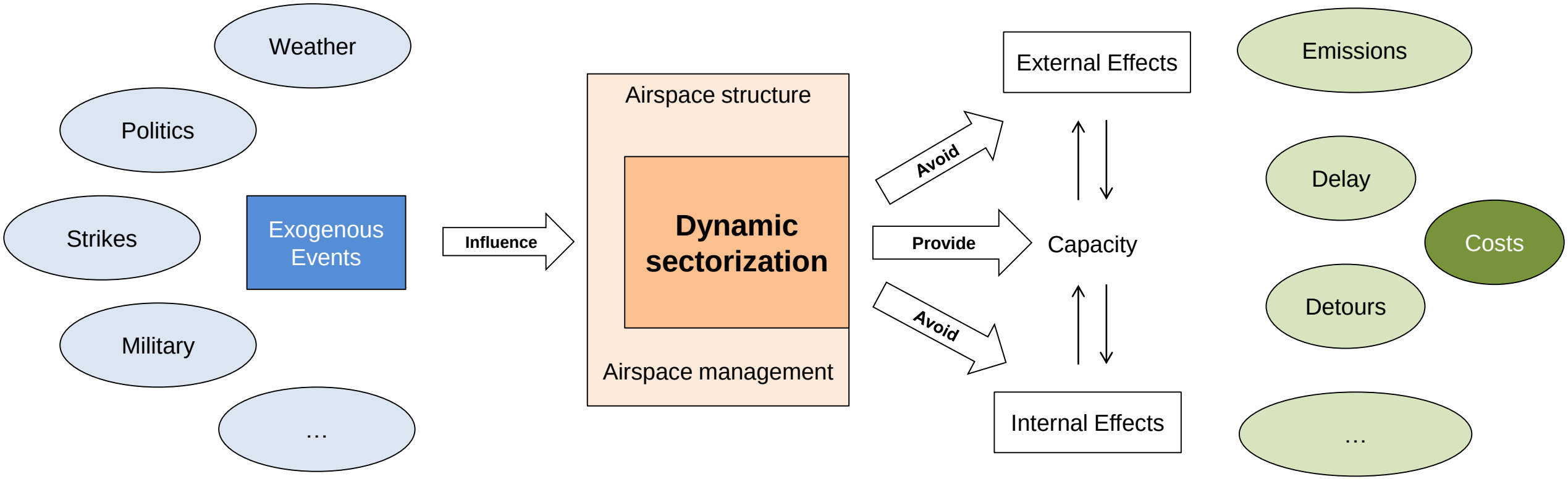
Stepwise adaptation of sectors

Consideration of controller expectations



Volatility – Causes and Effects

contribution of dynamic sectorization



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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Deutsches Zentrum für Luft- und Raumfahrt e.V. (DLR)
German Aerospace Center

Institute of Flight Guidance
Department of Air Transportation

Dr. Michael Schultz
michael.schultz@dlr.de

Thomas Standfuß
thomas.standfuss@dlr.de