IMPROVING THE ATM CAPACITY BY FUNCTIONAL DIVISION OF THE TRAFFIC:
THE DUAL AIRSPACE

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IMPROVING THE ATM CAPACITY BY FUNCTIONAL DIVISION OF THE TRAFFIC: THE DUAL AIRSPACE

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Abstract:
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The sharing of responsibilities in the current ATM system is based on a geographical delineation of the European airspace. However, the current paradigm does not present the problem of control task allocation in the most beneficial way, since it is not based on a detailed analysis of the various traffic patterns and their specific characteristics. It would be beneficial to introduce a system which would separate responsibility for managing cruising traffic and climbing/descending airport traffic where traffic is very dense.

As proposed in the Paradigm SHIFT project [1] the paradigm of Dual Airspace aims at increasing the en-route traffic by introducing a functional division of the traffic, based on its nature (i.e. climbing, descending, cruising). The objective would be to cohabite two operational modes of traffic management in the same geographical area for coping with the peaks in demand expected in the future. It’s an innovative proposal for task sharing in ATM. Highways constitute a privileged airspace for innovation, without making a “big-bang” in the current districts.
## REVISIONS

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SUMMARY

All the ATM community highlights the fact that current air traffic management system cannot cope with the challenges of future air transport system. This paper proposes an original air traffic management system which will enable to cope with the peaks in demand expected in the future. It is reasonable to suppose that the increase in demand will result in an increase in en-route traffic over the European core area, which is already congested to the point where it gives rise to numerous regulations.

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1. INTRODUCTION

ICAO forecasts a growth in world travel of 5% by year until 2005. It is not unreasonable to expect that air traffic in Europe may almost double or triple in the 2002/2020 timeframe, as stated in ACARE [Bib 2Bib 2]. Current air traffic management system cannot cope with the challenges of future air transport system [Bib 2Bib 2] [Bib 2Bib 3] [Bib 5] [Bib 8], and a new paradigm for improving the capacity seems to be inevitable.

Basing upon the results of the EUROCONTROL “Super-Sector” project [Bib 7] and on interviews with operational air traffic controllers and ATM experts, an initial analysis shows that en-route air traffic is a mix of climbing, descending and cruising aircrafts. On one hand, each of these categories has different characteristics in terms of density, disruptions, bulk, shape, complexity, and services, which require different resolution approaches. On the other hand, the sharing of tasks and responsibility among ATM actors has always been based on localized, geographical sectors where the control of all traffic categories is unique.

Future concept shall consider the different traffic characteristics and resolution approaches in the design of airspace through a well-defined task sharing between actors of ATM. The aim here is to propose an original air traffic management system which will enable to cope with the peaks in demand expected in the future. It is reasonable to suppose that the increase in demand will result in an increase in en-route traffic over the core area, which is already congested to the point where it gives rise to numerous regulations.

The Concept of Dual Airspace is based on separation of traffic patterns and the creation of two kinds of control units: the Highways and the Districts.
2. TRAFFIC PATTERN ANALYSIS

One of the main points addressed by the analysis of the existing traffic is its non-homogeneity. As presented below, the traffic is a mix of climbing and descending airport traffic and cruising flight. Each of these categories has different characteristics in terms of density, shape, complexity and services.

2.1. TRAFFIC DESCRIPTION

One of the main obstacles to air traffic analysis is that it is easy to speak of a collection of aircraft seen individually, but very difficult to characterize a group of aircraft. The following description makes a distinction between two categories, making it possible to describe traffic.

2.1.1. Climbing and Descending Airport Traffic

This traffic consists of aircraft climbing to their cruising level from their SID (Standard Instrument Departure) exit point and aircraft descending from their cruising level to their STAR (Standard Terminal ARrival) entry point. This denomination combines climbing and descending traffic but, for many reasons, it would seem preferable to separate these flow patterns and their management.

Volumetric

Climb and descent phases can be considered to relate to aircraft in a radius of less than approximately 150 nautical miles from their airport of departure or destination. Hence, the throughput of such traffic is measured by the number of movements. Of course, this number is identical to the number of runway movements at the airports served. Hence, demand for this type of traffic is limited by runway throughput. Regardless of the trend in demand in the medium term, a surge in this traffic would seem unlikely for TMAs already close to saturation (Paris, Frankfurt, London, etc.). The future situation will therefore probably be similar to that of the current situation of these major airports, where management is satisfactory, albeit apparently not sufficiently efficient. In the case of this traffic, the challenge to capacity will be unlikely to take the form of an insurmountable barrier.

Since throughput corresponds to the number of movements, no synergies are expected from annular segmentation around an airport. The natural allocation of tasks corresponds to angular sectors around the TMA. This type of sectorisation is applied around Paris.

Disruptions

Climbing and descending airport traffic is particularly prone to the disruptions outlined in the previous part. This is an area subject to aeronautical events, like meteorological phenomena intensified both in frequency and size when approaching the ground, and because aircraft are more sensitive to technical malfunctions when they are climbing or descending. Uncertainties are similar in scope, but have greater consequences for the flight dynamics of aircraft moving vertically, particularly when climbing, where the flight domain is critically restricted. From the viewpoint purely of aeronautical disruptions, climbing traffic is subject to very few external disruptions, whereas the descent phase is exposed to the repercussions of disruptions affecting the entire flight.
Configuration

Climbing and descending airport traffic naturally moves in 4D. During climb or descent, vertical and longitudinal positions vary simultaneously, as do velocity and the flight envelope. Unfortunately, no standard profiles exist for these variations, which differ considerably depending on the aircraft (type, engine power and weight) and the air mass status. These variations are particularly sensitive during the climb phase as opposed to the descent phase, for obvious reasons related to the flight mechanics. The consequence of basing the allocation of work on a precise forecasting of these profiles is that the impact of the disruptions on operators’ workload is unmitigated, or even amplified.

Owing to its changing nature, climbing and descending airport traffic is both voluminous and complex. Because of the considerable uncertainties regarding trajectory prediction, each aircraft occupies a large amount of airspace in 3D, which makes conflict resolution all the more difficult in the case of aircraft with reduced maneuverability.

Service

A distinction needs to be made here between climbing and descending aircraft.

Climbing traffic originates from a runway in the area served. Its throughput is not aligned with the separation minima required in this phase. Control is therefore asked to ensure this separation. This is made easier by the fact that traffic diverges towards several airports of destination, and therefore tends naturally to spread out into airspace. The main problems arise from the great diversity in aircraft performance, which brings aircraft closer together, and the 4D nature of traffic, which makes monitoring difficult because of the number of potential configurations. The task of ATC is therefore to provide a separation monitoring service tailored to each aircraft.

Descending traffic converges. It originates from various asynchronous sources, and the task of ATC is to merge it into a single flow with a throughput corresponding to that of the landing runway. In order to achieve this, it makes aircraft perform manoeuvres allowing them to move on the temporal plane - aircraft are actually more manoeuvrable at lower levels, but the problem arises from the density of traffic, which results in available airspace becoming more congested.

2.1.2. Cruising Traffic

This traffic includes all aircraft stabilized at a certain level for a significant period of time. This definition therefore excludes short-haul flights.

Volumetric

Navigation of aircraft at cruising level does not vary in time or space, unlike in the climb and descent phases, which are dependent on spatial and temporal deadlines. It is possible to define a relevant throughput measurement which is not dependent on the allocation of work amongst operators: the quantity of radar plots, produced from the number of aircraft and their flight distance (or flight time). Management activity is therefore dependent on the distance flown and the number of aircraft (quantity of radar plots).
**Disruptions**

The cruising phase is only slightly affected by internal disruptions: the behaviour of high atmospheric levels is less turbulent than that of low levels, and the attitude of aircraft flying in a stable manner is easier to predict. Of course, the disruption factors as a whole may affect the smooth progress of such flights: events are more infrequent but do occur, route prediction is still prone to uncertainty, control may divert aircraft from their route in order to ensure separation, and communications between control and the flight crew are still subject to inertia and uncertainty. However, if control makes an effort not to divert aircraft from their planned route in order to "expedite traffic", it should be possible for the progress of traffic to be close to the planning.

On the other hand, cruising traffic originates from climbing traffic, which is highly sensitive to disruptions.

**Configuration**

The mix of demand is the main obstacle to displaying cruising traffic, and even more so to managing it. This traffic consists of aircraft arriving from and leaving for all points of the compass. Expressed in terms of points of departure and arrival (city pairs), European traffic consists of 28,000 daily flights spread over 9,000 city pairs! However, long-haul flights contribute more to the quantity of radar plots than do medium-haul flights, and 1,500 city pairs account for half of the tracks [Bib 4]. This figure remains consistent and could jeopardize the frequent use of the term flow to designate cruising traffic: one aircraft every half hour is well short of forming a dense flow of flights. Flows do not result naturally from demand structured in the form of city pairs. They appear, of course, when demand is allocated over a network of routes, but attempts to construct a network responding "naturally" to demand have thus far not yielded any genuinely convincing results.

However, it might be very beneficial for control to organize cruising traffic in flows. Management of a flow is mono-dimensional. A flow is not very voluminous and takes up very little airspace, making it possible to envisage breaking down a flow into several corridors which are horizontally and vertically parallel in order to be able to process a higher throughput and have preset solutions making it possible to handle overtaking problems effectively. If flows are few in number, it might even be possible to separate them passively by allocating different flight levels at the crossing section.

**Service**

Within a given flow, aircraft are able to head for a fairly broad spread of destinations. Furthermore, at a given route location, aircraft at cruising level still have on average 500 nautical miles to cover before starting their descent. There would therefore be little point in sequencing them precisely as in the approach phase. The regularity of flows is a useful management tool, but must remain second to punctuality, in line with asynchronous planning. Cruising level is the best time to implement solutions which ensure that the aircraft arrive at the exit point at the scheduled time. The main obstacle to achieving this lies in the fact that cruising traffic is no more than a collection of traffic originating from airports which are totally desynchronized in relation to one another. Consequently, it is impossible to avoid the local formation of traffic bottlenecks. This situation necessitates the availability of a surplus capacity system which is able to go with the flow and handle adverse traffic configurations.
2.2. ACTUAL PROBLEM IN TERMS OF CAPACITY

The problem of congestion of the air navigation system is linked to the local accumulation of traffic (“bottlenecks”).

The quantity of radar plots designating cruising traffic volume is directly linked to fleet size: it constitutes a variable index-linked to the long-term health of air transport, which can reasonably be expected to grow at a sustained rate. This growth will be diluted in European airspace, although there are natural phenomena of local concentration towards the central area, currently already saturated, which lead us to believe that the current management system will be unable to absorb this future demand effectively.

On the other hand, airport movements are limited locally by the maximum capacity of an airport. Failing major changes in runway management or the acceptance by local residents of airport noise and pollution, the future situation will inevitably be fairly close to that seen today in saturated TMAs such as Paris, London or Frankfurt. As regards climbing/descending airport traffic, we will therefore probably be looking at an improvement in the current system, which is working, albeit with difficulty, rather than a major leap forward allowing us to overcome a hypothetical capacity barrier. Climbing/descending airport traffic is in fact protected by the management of the airports themselves: it is more vulnerable to traffic loads, but its management has nothing in common with aeronautical considerations.

But it's not the only reason of this barrier of capacity.

The air navigation service requires a complex management system where responsibilities are shared by a large number of sub-systems. The sharing of responsibilities is currently based on a geographical delineation in European airspace. This method provides clarity, and ensures that two aircraft likely to enter into conflict are managed by a single and identified control authority, provided that the convergence points are sufficiently far away from sector boundaries. Sectorisation is therefore an exercise designed to share the workload between the various operators harmoniously.

The problem of sectorisation is algorithmically complex, since the evaluation of the workload requires a simulation of traffic progress, and the sectorisation of airspace in itself implies a coordination task. Furthermore, sectorisation and network are closely linked, and benefit from being considered together, which makes the task much more difficult. The development of effective airspace design tools represents one of the potential ways in which the capacity of the navigation system might be enhanced. However, data suggests that the current paradigm does not present the problem of task allocation in the most beneficial way, since it is not based on a detailed analysis of the various traffic patterns and their specific characteristics. The congestion of the current en-route system would seem to be caused more by the fact that it mixes cruising traffic and climbing/descending airport traffic than by the intrinsic problems in managing traffic stabilized at a given level, which nevertheless accounts for 60% of radar tracks.
3. PROPOSITION: THE FUNCTIONAL DIVISION OF TRAFFIC

3.1. PRINCIPLE

The traffic complexity in the "core area" requires defining a specific mode of operation by separating the various types of flight, i.e. climbs, descents and over-flights, in which the traffic is segregated into flow-based traffic and district-based traffic.

The aim is to relieve pressure on the main traffic axes forming part of the core area's interlinked network by setting in place highways independent of that network. In other words, the Dual Airspace concept proposes to create two independent sub-systems, within a high-density area, based on a functional division of traffic.

The highways will span the continent, and they will be reserved for steady aircraft in level flight. Traffic management on highways will be flow-based, with closure conflicts but no convergence conflicts. In the core area, the theory is that there will be a limited number of highways along the main east-west and north-south axes. The highway system is not organized with a view to connecting airports directly. As demonstrated in the TOSCA project phase III [Bib 1] a city pair (large TMA to large TMA) oriented tubes option generate with only 35% of the traffic on ECAC area a blocked airspace unable to support the 65% of the remaining traffic. The highway approach brings together flows corresponding to many city pairs. Highway intersections generate no routes convergence since they are managed through different level allocations. The highway constitutes a privileged airspace with tremendous potential for innovation. The aircraft which make use of it are stable at a given level; they all move in a predictable manner, in the same direction and the same way. An aircraft flight path, then, is no longer three-dimensional but mono-dimensional. The possible benefits of this situation are threefold and complementary:

- simplified traffic, making it possible to assimilate a larger number of aircraft;
- simplified ATC, through the use of a limited system of elementary instructions: change in speed and change of route (digital airspace);
- simplified displays, replacing the map backgrounds with synoptic tables.

The district-based traffic will be specific to local traffic in order to cope with the local constraints of traffic and airspace. These districts use tried-and-tested traffic control methods similar to those used today. Regional airspace should turn to its advantage the isolation of a significant proportion of cruising traffic:

- direct decrease in the volume of traffic;
- increase in the reliability of predictions;
- functional specialization of districts (climb or descent);
- increase in airspace availability.

An example of dual airspace horizontal view is given in Figure 1.
3.2. ORGANIZATION OF AN HIGHWAY

Introducing this system of airspace organization respects air safety, since it guarantees that aircraft located in two different sub-airspaces will never come into conflict. Cross-over points between the two systems are clearly identified and governed by clear and explicit rules. Introducing this system of airspace organization respects air safety, since it guarantees that aircraft located in two different sub-airspaces will never come into conflict.

3.2.1. Horizontal Organization

Horizontally, the highway system may be described as a small number of ribbons (from one to six), each of which is a few dozen nautical miles across. Every ribbon contains two parallel clusters of flights, each cluster devoted to traffic traveling in the same direction. The division of each cluster into routes makes it possible to increase the capacity offered, and opens up new perspectives with regard to ATC.

The subdivision into districts enables effective traffic management between airports, and at highway entry and exit points. Districts contain enough airspace to allow complete climbs and descents to be monitored without the need for coordination. This requires approximately 150 nautical miles.

3.2.2. Vertical Organization

It is the vertical organization of the airspace which allows the two systems to coexist independently. The vertical airspace is subdivided into sections assigned alternately to one or other of the two sub-systems. Each system is thus sealed, without presenting an insuperable obstacle to the other. Aircraft are thus forced to remain stable at an authorized level all along the highways, where the systems overlap but never interpenetrate.
As shown Figure 2 an highway could be represented by three ribbons at three different flight level, each composed by two parallel clusters, themselves divided in two parallel routes.

### 3.3. EXPLOITATION

#### 3.3.1. Highway System

The aircraft which make use of it are stable at a given level; they all move in a predictable manner, in the same direction and the same way. An aircraft flight path, then, is no longer three-dimensional but one-dimensional. The possible benefits of this situation as stated before, are a large simplification of traffic and its control.

The management of a highway is continuous over its entire length, and is not affected by national borders in any way. Aircraft flight paths are thus managed coherently in the long term, in order to achieve ambitious objectives in terms of punctuality.

This concept offers the ability to support further technology improvement like ASAS or automation and is totally open to smooth transition.

**Disruption management**

The airspace organizational structure described above is helpful in those cases, fortunately frequent, where aircraft do not experience any particular difficulty in flying thought the different airspaces. Furthermore, additional mechanisms make it possible to deal with unforeseeable factors.

**External disruption**

At sub-system level (District or Highway), this may be of three types:

- Aircraft supposed to enter the sub-system but not showing up. That does not cause any particular difficulty.
- Aircraft not supposed to enter the sub-system, but showing up. Examples include the case of a single aircraft having to leave the highway, or a major failure of the highway system. In both cases, scenarios can be established in order to deal safely with such events.
- Failure of an aircraft to be punctual. To be prepared for this eventuality, the highway system has a capacity reserve, enabling it to absorb traffic which is not punctual (and which can create a local load peak). It then adapts the speed of the aircraft to absorb this failure and deliver punctual traffic at the exit point.

**Internal events**

A distinction may be made between events which disrupt a limited number of aircraft, such as a failure affecting an aircraft or an airport, and events which require modification of the airspace itself. Bouts of turbulence, for example, require the closure of one or more vertical sections, while stormy weather can force the highway to divert to one side. Traffic in the affected sections is then moved towards an aeronautically stable section. A protocol for coordination between the two sub-systems is called for, and its terms will be stipulated in the interests of guaranteeing safety.

In order to be resilient to weather condition, potential distortion of these highways could be imagined.

On one side, the highway could deforms its structure sliding down its flight level from 2000ft (Figure 3).

![Figure 3: Sliding](image)

On the other side, the highway deforms its structure by opening an airlock of climb and descent between two highway’s flight levels non adjoining but separated by 2000ft or 3000ft. (Figure 4).
3.3.2. District

The control of regional airspace is based on tried-and-tested methods. Its purpose is to take aircraft between airports and highway access points efficiently.

Regional airspace is divided into autonomous districts for purposes of controlling operations. Each district is an independent tactical unit and organizes control methods at local level: teams, procedures, tools and flight paths, depending on the specific traffic configuration.

3.3.3. Transitions connections

Points of entry from a district onto the highway and exits off the highway into a district need to be strictly codified. These transitions take place in clearly identified areas. Aircraft changing from one system to another apply a double-bayonet procedure (Figure 5). The system which the flight is leaving initiates the movement, which is completed with the agreement of the system receiving the flight. The regional airspace system supervises lateral movements while the highway system supervises vertical movements, which maintains opacity between the systems.
This concept to be efficient and safe need a clear responsibility sharing. The two sub-systems proposed above should cohabitate but be totally independent from the operational point of view. There is no possibility of intrusion, the transition will be made via airlocks, the systems overlap but never interpenetrate. And the impact of disruptions should be solved by the adaptation of the highway as presented Figure 3 and Figure 4.
4. MODELING: THE VERTICAL APPROACH

To evaluate the feasibility and efficiency of such airspace sharing, the first modeling investigation to perform is to determinate the best shape of an highway and its impact on district.

The modeling part of this document is a first investigation based on a vertical analyze of the traffic over Europe (ECAC area).

4.1. BASIS OF THE MODEL

Highways describe ribbons at continental scale. This will allows to split traffic description, taking into account the vertical distribution independently of the horizontal and time-based distribution. The vertical observations raise mean of all European airspace and all the day.

This model is stochastic, rather based on the means of interaction between highways and traffic than unusual situation.

4.1.1. Observables

According with the analysis done in Paradigm Shift operational concept document [Bib 6], traffic is divided into two distinct problematic:

- Traffic during climbing and descending phases, so called airport service.
- Traffic steady at flight level, so called cruising traffic.
- This study proposes the use of two distinct metric to quantify the work of the Air Navigation Services associated with this demand:
  - Airport services are evaluated in number of movements (taking off and landing) on ECAC airports.
  - Cruising traffic is evaluated by counting flight time spent under the responsibility of ECAC control center.

4.1.2. Data

Data are extracted from ALL_FT files, under TACT 10 format, coming from the CFMU archive. Each file contains a day of traffic over the ECAC area. A rapid extraction, done with a Pearl script permits to know:

- if the flight is landing or taking off from an ECAC airports,
- the time spent under the responsibility of an ACC in ECAC area,
- the requested flight level expressed by the airlines for each flight and corresponding to the vertical position of the traffic demand.
4.1.3. Flight level repartition

Figure 6 shows the repartition of number of flights and their duration by flight level.

![Figure 6: Flight level repartition](image)

Figure 7 shows the repartition function of these two measure, corresponding to a cumulated histogram.

![Figure 7: Cumulated repartition by flight level](image)
The gap between these two graphs is the heart of the Dual Airspace concept. Even if airports services are composed by many flights linking closest airports, duration of these flights is quite small but their management raise some difficulty due to the controller workload associated to vertical evolution. On the other hand, cruising flights (medium and long haul flights) take a great part in duration of flights for quite simple trajectory to manage.

4.2. INTERACTION BETWEEN HIGHWAYS AND TRAFFIC

The main goals of this study is to evaluate:

- highways attraction on traffic,
- inconvenience leading by highways,
- listing all the possible configurations of flight level reserved to highways.

4.2.1. Highways vertical attraction

The attraction made by the highways on traffic is quite complex: the vertical dimension should be segregated from horizontal dimension.

The model should not evaluate effective attraction of some configuration, but only its relative attraction vis-à-vis overall configurations. A simple way to present the attraction of an unique flight level highway configuration is to consider highway capturing only a part of this traffic, depending exclusively on the relative vertical position of the traffic compared to the highway. For the benchmarking, the reference taken by the model is 100% of the traffic captured by the highway when this traffic flight at the same level than the level reserved to the highway:

The vertical attraction rules employed is define in Table 1.

<table>
<thead>
<tr>
<th>Vertical traffic position relative to the highway</th>
<th>Part of the traffic caught by the highway</th>
</tr>
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<tr>
<td>More than 2000ft above the highway</td>
<td>0 %</td>
</tr>
<tr>
<td>2000ft above the highway</td>
<td>20 %</td>
</tr>
<tr>
<td>1000ft above the highway</td>
<td>40 %</td>
</tr>
<tr>
<td>0ft same level than the highway</td>
<td>100 %</td>
</tr>
<tr>
<td>1000ft below the highway</td>
<td>10 %</td>
</tr>
<tr>
<td>2000ft below the highway</td>
<td>0 %</td>
</tr>
</tbody>
</table>

This parameters values called kernel are specified according to the different discussions around flight level preference and aircraft envelope. This value could be enhanced by integrating information related to the aircraft economical performance according to flight level. Within this framework, it’s possible to adapt these ratio in order too better reflect the airline choices.
For the description of the vertical attraction of an highway composed by several flight levels, the most attractive highway level is considering for each cruising flight. The attraction should be seen as a multiplicative kernel. The competitiveness of a configuration is the result of the product of its kernel and the traffic mean vertical density.

### 4.2.2. Hindrance Caused by the Highway

The inconvenience leading by the highways on the cruising traffic concern only the traffic flying on one of the level occupied by the highway. And vice-versa each flight flying through the highways is confronted with its avoidance. The aircraft could cross below or above the considered flight level, and could resume navigation to RFL after passing.

The hindrance caused by the highways is the scalar product of traffic vertical density and the binary vector, representing the highway flight level used.

Finally, the level of hindrance caused by the highway to the airport traffic is computed as:

\[
H_v = 1 - V(l_0)
\]

Where:

- \( l_0 < l_1 < \ldots < l_n \) are the flight levels dedicated to the highway system,
- \( V \) is the distribution function of vertical flights per movement, i.e. \( V(x) \) is the proportion of flights cruising at a flight level \( < x \),
- \( 1-V(x) \) is the proportion of flights cruising at level \( x \) or above.

Thus \( 1-V(l_0) \) is the proportion of flights which potentially have to cross the highway in order to reach their cruise level.

### 4.2.3. Comparison of the Different Setup

Based on the attraction of the highways and the kernel configuration, a competition on flight level configuration is computed. The result (see Figure 8) give a “top 50” graph starting by the most captured flights configuration. The upper graph of Figure 8 with red sticks represents the attraction on the traffic, the second one shows the inconvenience due to the highways on climbing and descending traffic (purple sticks) and on cruising flights (green sticks). The graph below represents the different flight levels organizations evaluated (flight level occupied by highways).

For example, on Figure 8:

- organization no. 1 allocates to the highways the flight level 320, 340 & 360. It attracts 42 % of cruising traffic, disturbs 40 % of evolutive traffic and 30 % of cruising traffic,
- organization no. 3 allocates to the highways the flight level 330, 350 et 360. Highway attracts 40 % of cruising traffic, disturbs 34 % of evolutive traffic and 31 % of cruising flights.
Figure 8: 3FL structure organization
After running this model, two FL configurations have been chosen for the Dual Airspace experiment:

- Configuration A, in which the Highway comprises three independent flight levels (370, 330 and 310);
- Configuration B, in which the Highway comprises three flight levels, one of which, 370, is independent, while the other two, 330 and 320, are contiguous.

The chosen levels are a trade-off between Highway attraction and disturbance. We would like to evaluate the impact of such Highway in an en-route sector.

The difference between Configuration A and Configuration B lies in the vertical height of the contiguous flight levels. In Configuration A, the flight levels are independent; this means that there are 1000-ft no-go zones which must be avoided by traffic in the sector crossed. In Configuration B, it has been decided to study the impact of a 2000-ft-high no-go zone.
5. CONCLUSION

This first modeling phase is centered on a global vertical approach on highways organization. All these results are encouraging to go further in the evaluation of the Dual Airspace Concept.

Modeling studies are currently in progress, in order to analyze the horizontal position of the highway: the inconvenience leading by the highways on airport traffic service is of course dependant on the geographical position of these highways compared to the airport.

The last modeling step will be to mix the horizontal and vertical approach to find the best possible configuration of highways in term of capacity and efficiency.

A human centered evaluation on the relevance and the validity of the concept in the frame of safety, capacity and efficiency issues is planned. Experiments, in order to measure the influence of a suggested Highway in a classic sectorization will be done in terms of human acceptability, workload, safety criteria, capacity and efficiency.