On the Operational Feasibility of Traffic Synchronisation—preliminary results

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Abstract—One general hypothesis for future Air Traffic Management (ATM) is that traffic in a flow shall be better organised to increase its performance in terms of capacity and delays savings. This hypothesis suggests a shift from current ATM concept, which is non-synchronised, to a synchronised system with constant distance separation between all aircraft evolving in a flow in order to be able to cope with future air traffic demand.

The goal of the research is through experimental approach to achieve objective results of traffic synchronisation through flow capacity increase (i) and potential conflict situation decrease (ii) and hence improvements of safety to support the operational feasibility applied in case of Central European Upper Airspace.

A simple synchronisation model and rule-based algorithm is proposed, taking into account the quantitative indicators followed by preliminary results showing the potential of traffic synchronisation in real.

I. INTRODUCTION

The worldwide growth in air traffic after 2004 is characterised by a tangible increase in daily traffic (4.8% for the whole year) and very high in Central and Eastern Europe (20%). From 2005 onwards, traffic growth in the whole European Civil Aviation Conference (ECAC) area is expected to be approximately 3-4% per year [1], meaning that in 2020 the ATM system shall accommodate about twice as many aircraft as of today. It can be seen that the key driver for change is to identify means by which the additional capacity might be generated to meet the forecast traffic growth while keeping the safety and efficiency at least at today level.

As traffic density is approaching average European levels in many of those areas, managing such high traffic growth presents a challenge. This estimation leads to a serious problem, especially in the core area. As a consequence, either air route network has to be extended to accommodate increased air traffic flows, or traffic in flows shall be better regulated with fewer extensions to current route network.

Several studies have been launched recently in Europe and USA aiming to support the future vision of synchronised ATM system with the ultimate goal to fill the gap between the predictive (taking the case of Europe, by the slot allocation planning performed by Central Flow Management Unit (CFMU)) and the adaptive components (local tactical actions performed by the controllers) of ATM systems [2] [3] [4]. Several organisational changes have been proposed such as Super Sector [5], Shift [6], Multi Sector Planner [7] and Traffic Organization [8]. Some other studies on traffic organization have investigated the potential of flow synchronisation; however they focus mainly on speed control and/or solely on the terminal areas [9] [10].

All above mentioned investigations are based upon the hypotheses that when traffic is synchronised, better efficiency for the overall air traffic management system could be reached thanks to the focus on the management and monitoring of traffic flow instead of individual flights. Airport throughput could also be improved since the flights are organised into the flows in the en-route environment what directly affects the efficiency of an airport.

There have been different definitions of synchronisation and research uses the assumption that traffic synchronisation is the tactical establishment and maintenance of a safe flow of traffic with higher throughput. In other words, coordination between control sectors is a necessity since the distance required to synchronise a given traffic could span across several sectors, given the small sizes of sectors in core European airspace.

Among previous studies, the FAM project at EEC has explicitly considered the same assumption. However, none of the above investigations has seriously considered controllers’ acceptability, and in particular for the task of monitoring aircraft’s speed adjustment and assigning flight level to achieve synchronised flows. That may span over several sectors, and therefore requires collaborative work between controllers. The work presented in this paper is framed within a PhD research that investigates the acceptability of controllers in the collaborative context. The objectives are to experiment a synchronisation model together with an algorithm based on a set of rules to achieve synchronised traffic flow and validate it by testing during fast time simulation. The general unknown in the thesis is to understand the future vision of ATM, particularly the flow management improvements by traffic synchronisation in an
en-route environment.

II. TOWARDS TRAFFIC SYNCHRONISATION

A comparison of US and European en-route environment has found that the controllers’ productivity is unlike. The difference arises in part from the fact that the US controllers can handle more traffic (flight-hours for each hour on duty) when working at their maximum throughput [11]. A fundamental difference is in techniques used to organise the traffic. In US En-route Miles-In-Trail Spacing (MIT) is the most common Air Traffic Flow Management (ATFM) measure defined by the distance between two consecutive aircraft on a given flow. They are used to distribute arrival delays upstream of destination airports and to mitigate local areas of en-route space congestion. They have a significant operational advantage; when flights are formed into in-trail areas of en-route space congestion. They are used to distribute arrival streams, controllers are able to visualise and control spacing at the sector without automatic assistance. MIT are not applied at all in Europe where the aircraft start to be organised once they reach the Terminal Area (TMA).

In conclusion, the ATFM system in US tends to work towards better utilization of airspace capacity. This in turn has an impact on controllers’ workload. Because peak-time flows are more predictable in the short term, and more regular, controllers in the US are able to handle a larger number of flights simultaneously, contributing to a greater productive efficiency [11].

MIT measures are taken as an example of traffic flow and safety enhancement. Improvement of safety in European environment through removing potential conflict situations and increasing the airspace throughput as a result of traffic synchronisation is not only desired but needed.

A. Synchronisation model - simplified

Simplified synchronisation model has been proposed to investigate the benefits of traffic synchronisation with respect to different ATM system actors (airlines, providers, efficiency of airspace use itself) and above all for better utilization of existing route network with respect to other actors of the ATM system. The simple form consists of three levels: the top is the goal of the research, the second level is the criteria by which the indicators will be evaluated, and the third level consists of the measurable indicators themselves (Figure 1).

For deeper analysis, measurable indicators characterising the traffic distribution after synchronisation process have been defined with respect to limiting factors: aircraft performance envelope, number of conflict situations, workload of the controllers and costs of the over-flown time.

Currently, the traffic is distributed on the flight levels mainly with respect to airliners preferences (fuel consumption, optimum speed). This approach leads to increase of the controllers’ workload, since one flight level accommodates aircraft with several different speeds and each of those flights require inevitable communication between pilot and controller, manoeuvres to be done. However, if the expectation for the year 2020 is to accommodate twice as many aircraft as today, one must search for trade-off.

With traffic synchronisation this irregularity of speed distribution on target flight level will be removed with direct impact on speed diversity on neighbouring flight levels. The traffic on neighbouring flight levels will be released from the aircraft following the synchronised flows; hence also here lower speed diversity can be expected. The controllers' workload will be reduced; especially the required communication with the aircraft, since they will control the whole flow instead of individual flights.

Four values are used for regularity assessment [12]:

\[ \text{Variance of speed distribution over 1FL} = \text{the measure of its statistical dispersion, indicating how far from the expected value its values are. Where the average (or mean) is a measure of the centre of a group of numbers, the variance is the measure of the spread:} \]

\[ s_x^2 = \frac{\sum_{i=1}^{n} x_i^2 - nx_m^2}{n} \]

(1)

\[ \text{Coefficient of variance}^2 \] is calculated for the speed distribution on selected flight levels. With this parameter the consequences of synchronisation on the surrounded traffic are examined:

\[ V_x = \frac{s_x}{x_m} \]

(2)

\[ \text{Standard deviation of speed over 1FL}^3 \] is a measure of the degree of dispersion of the data from the mean value. It this case it is used as an indicator how balanced the traffic load is. Through the aircraft shifts into other FL, when an adjustment in speed is not applicable, the traffic distribution

\[ s_{x_a}^2 \text{[-] - variance, } s_{x_m}^2 \text{[-] actual capacity of the interval } i, \text{ } n \text{[-]} \text{ number of the intervals, } x_m \text{[-]} \text{ average value in the whole sample } m \]

\[ s_{x_a} \text{[-]} \text{ coefficient of variance, } s_{x_m} \text{[-]} \text{ standard deviation, } x_m \text{[-]} \text{ average value in the sample } m \]

\[ s_{x_a}^2 \text{[-]} \text{ standard deviation, } s_{x_m}^2 \text{[-]} \text{ variance} \]
Bunching index\(^4\) is used as a factor describing the grade of regularity in time on FL. A bunching index of 0 would describe an absolute regular flow. It is calculated by the sum of the square differences of the actual, to the theoretical capacity (of one aircraft) in each interval:

\[
S_x := \sqrt{\sum_{j=1}^{n} (c_j - l_j)^2}
\]

\(B\). Transition time

To achieve traffic synchronisation, a given traffic shall be transformed from a non-synchronised state to an ordered traffic. The flow isolates a part of the traffic on particular flight level selected according to predefined rules. The aircraft falling into the target speed will be instructed to keep or adjust its speed to join the synchronised flow, failing which it has to be rerouted to another flight level. This happens under the consideration of the aircraft performance limitations.

It is not only about increasing the route throughput. The impact of route length to ensure that synchronisation is beneficial plays a role as well. The transition time \((T_t)\) differs for each flight and depends on traffic density and the availability of the target flight level. The question is:

How much time is needed to transform non-synchronised traffic into a synchronised one?

Does the transit phase encompass one or more sectors?

This transformation is necessary for the traffic inbound from non-synchronised areas, and requires in-depth analysis of its feasibility.

The synchronisation process starts once the aircraft crosses the border of the airspace block. The controllers use current practices to smoothen the flow in order to deliver more organised traffic into the next sector. If this is not feasible within the boundaries of the first sector, the second sector follows the same procedures to achieve flow-wide improvement and so forth. The coordination and traffic organisation to achieve synchronised flow is the task of the controllers.

In order to simplify the investigation, other issues such as non-nominal weather conditions or military traffic are initially disregarded.

\(C\). Airspace

If en-route ATM is required to deliver traffic for the airports in a particular sequence at specific times, then it must have the ability to speed up or slow down aircraft. This will influence aircraft operating levels and, in consequence, flight efficiency. Conversely, organising and sequencing of traffic by speed and flight levels raise questions as to the optimum level of integration which is feasible and the most beneficial.

The Central European Upper Airspace\(^5\) (Figures 3) is chosen for this research because of the characteristics of its traffic: high growth and high percentage of over-flown traffic.

The chosen airspace offers high potential for performance improvement with synchronised ATM concept.

\(D\). Route network

Flow consists of aircraft with a common part of the flight path or part of it spreading on more than one flight level. Adjusting the flow of traffic into given airspace, along a given route or bound for a given aerodrome, so as to ensure the most effective utilization of the airspace is very complex.

To simplify this complexity an assumption has been made where each synchronised flow has its own speed & flight level; the flow speed fixes the speed of the flight.

\(5\) The activities of CEATS are centred towards improving the operation in this area, where Air Traffic Services are currently provided by different Area Control Centres in Vienna, Budapest, Bratislava, Ljubljana, Zagreb, and Padua, and to be replaced by a unique common control centre in

\(^4\)\(b\) [-] – Bunching index, \(n\) [-] – number of aircraft, \(c_j\) [-] – theoretical capacity of aircraft, \(l_j\) [-] – actual load
The discovery of ‘interesting flows’ depends on both daily traffic distribution and frequency of the aircraft arrivals to CEATS Airspace Block. The initial investigations showed 2 main flows. These two routes carry the heaviest amount of traffic between Western and Eastern Europe; therefore they were selected for further investigation.

Aircraft performance envelopes play a major role in the ability of the aircraft to reach target flight level assigned to the aircraft regarding the speed it flies.

III. PRELIMINARY RESULTS

A. Traffic analysis

The first step towards well-organised traffic flows is to have sound knowledge of traffic distribution taking into account above mentioned limiting factors whereupon the analysis of the traffic distribution has been made. Since CEATS is not under the operation yet the modelling approach uses the data obtained with the last model based simulation (FTS4) as baselines for comparative study [13]. One 24-hours traffic sample (June 28, 2002) is used during the course of this study, increased of 36% (as estimated for the start of CUAC’s initial operations). This simulation was performed with the Reorganized ATC Mathematical Simulator (RAMS Plus TM) - a fast-time simulation tool commonly used at CEATS Research, Development and Simulation Centre (CRDS).

In this sample more than 7 000 flights are considered of which 5241 are in upper airspace (above FL285). In order to make a comparison, adequate aircraft performance data are necessary, especially true air speed during the cruising phase of flight. Those data were obtained from the aircraft performance summary tables for BADA 3.6 document [14]. For each aircraft type, the performance table specify the true air speed, rate of climb/descent and fuel consumption for each phase of the flight. In the course of the study the cruising, plus cruising and descending aircraft are examined. Moreover those aircraft which have only a small offset of their entry or exit flight level to the cruising flight level were also added to the traffic sample6. This was done under the assumption that in this case still most of the cruising phase of flight is performed within the CEATS boundaries. To understand the traffic behaviour some additional measurements have been made including: over-flown time (mean value per sector); average speed versus % of traffic; aircraft types versus speed; speed versus FL.

The initial investigation shows that 54.42% of the traffic uses the speed 0.8M; flight level FL370 is highly preferred by 17.78% of the overall traffic. These speed and flight level have high potential to be assigned to the inbound traffic for synchronisation purposes. Nevertheless, presented analysis shows only the traffic distribution on the level basis. It doesn’t mean that all the routes on particular flight level are used by the same amount of traffic. Another step is to look deeper and analyse with the same approach the traffic distribution on selected two main route segments

B. Rule-based algorithm

To perform the synchronisation a rule-based algorithm with four steps was manually developed according to which aircraft are organised into synchronised flows (Figure 6). At first, two FL’s are selected to be synchronised depending on the aircraft preferences. Second step is to select speed range also based on current aircraft preferences on selected FL. Next step is to test whether the cruising speed of the aircraft can be adjusted. Depending on the result, either the aircraft has to adjust the speed or it has to change the FL. This happens under the consideration of the aircraft performance limitations.

Three scenarios of rule-based algorithm are considered:
1. Speed adjustment in FL +/-0.02M;
2. Speed adjustment in FL +/-0.01M;
3. Speed adjustment in FL +/-0.02M, change FL of aircraft falling into predefined speed range in neighbouring FL into FL selected for synchronisation

The limitations are set to minus two flight levels and plus one FL for climbing.

C. Preliminary results on the route CHIEM-ZAG

Scenarios are compared resulting from different values for the control variable Speed in the algorithm. In order to assess

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6 E.g.: Flight DLH2888: Entry = 250, Cruise = 370; Exit = 0
ZAG; TONDO-BEGLA) contain 302 aircraft entering at CHIEM and flying via BEGLA to ZAG and 184 aircraft using the segment TONDO – BEGLA. In CEATS environment Reduced Vertical Separation Minima (RVSM) will be applied between FL290 and FL410 and the traffic must be split into odd and even flight levels. Both selected segments are uni-directional. The current traffic distribution on the segment CHIEM-ZAG is illustrated in Figure 5 (the most preferred FL370 accommodates 122 aircraft; and 50.82% of the traffic on this FL prefers the speed 0.8M) and Figure 6 depicts the situation after applying the algorithm.

After the traffic analyses next step was to calculate quantitative indicators for each above mentioned scenario in order to find the most beneficial one. All scenarios show 100% regularity in speed distribution over target FL’s and the variance of speed in these FL’s is zero. All the other indicators have been compared and preliminary conclusions drawn (Figure 7).

For example for the scenario 1 on the en-route segment CHIEM-ZAG (speed adjustment of +/-0.02M) two flight levels have been selected: FL 370 and FL350. FL 370 initially accommodates 122 and FL350 68 aircraft. The target speed 0.8M for synchronising the flow on FL370 is currently preferred by 50.82% and speed 0.78M on FL350 represents 70.59% of the traffic. All those aircraft that didn’t fall into target speed range have been rerouted to adjacent flight levels.

After the synchronisation, 60 aircraft remained on FL350 and 112 aircraft on FL370 (Figure 8) meaning that only 8 (FL350) and 10 (FL370) aircraft have been rerouted since all the other aircraft could adjust their speed.

Likewise, in scenario 2 (speed adjustment of +/-0.01M) two flight levels have been selected: FL 370 with speed 0.8M and FL 350 with speed 0.78M. After synchronization 68 aircraft remained on FL370 in comparison with double increase of the traffic on FL350 (103) (Figure 9). This modification of the algorithm has caused increase of the vertical movements in order to build the synchronized flow. From the Figure 9 it is visible how the traffic distribution on the flight levels has changed compared to basic scenario and scenario 1.

Scenario 3 is modification of scenario 1 with additional rule. In this case the aircraft on neighbouring FL’s falling into the selected speed range have been rerouted to target
flight level to join the flow. From the Figure 10 it is evident that in scenario 3, FL350 accommodates much larger number of aircraft (127) what is in contrary with FL350 with less traffic (72) than in scenario 1 or scenario 2.

a) Regularity

When prioritizing the aircraft speed adjustment on target flight level the best results can be seen in both:

<table>
<thead>
<tr>
<th>Name / Current values (ORG)</th>
<th>Scenario 1</th>
<th>Scenario 2</th>
<th>Scenario 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade of synchronization</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>Variance of speeds in FL1 / FL2</td>
<td>0/0</td>
<td>0/0</td>
<td>0/0</td>
</tr>
<tr>
<td>Selected speed</td>
<td>0.78M/0.8M</td>
<td>0.78M/0.8M</td>
<td>0.78M/0.8M</td>
</tr>
<tr>
<td>Speed change +/- 0.02M</td>
<td>5/48</td>
<td>0/0</td>
<td>0/0</td>
</tr>
<tr>
<td>Speed change +/- 0.01M</td>
<td>8/1</td>
<td>7/1</td>
<td>7/1</td>
</tr>
<tr>
<td>Standard deviation of load in FL (ORG 42.029)</td>
<td>39.138</td>
<td>37.267</td>
<td>43.644</td>
</tr>
<tr>
<td>Variance of speeds in affected FL’s (330: 0.000641/390: 0.000494)</td>
<td>330: 0.000716</td>
<td>330: 0.000716</td>
<td>330: 0.000964</td>
</tr>
<tr>
<td>(390: 0.000746)</td>
<td>390: 0.000731</td>
<td>390: 0.000848</td>
<td></td>
</tr>
<tr>
<td>Bunching index</td>
<td>350: 1.1</td>
<td>350: 1.06</td>
<td>350: 1.14</td>
</tr>
<tr>
<td>(390: 0.72/ 370:1.22 /350: 1.19)</td>
<td>370: 1.15</td>
<td>370: 1.22</td>
<td>370: 0.97</td>
</tr>
</tbody>
</table>

b) Workload

In case of workload the initial investigation was concentrated on the number of vertical movements that could lead to increase of controller’s workload and potential conflict situations (Table 2). Prioritizing this criterion scenario 1 could be used for synchronising the traffic in real time.

<table>
<thead>
<tr>
<th>Vertical movements</th>
<th>Scenario 1</th>
<th>Scenario 2</th>
<th>Scenario 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>FL change +/- 2</td>
<td>0/6</td>
<td>0/6</td>
<td>0/6</td>
</tr>
<tr>
<td>FL change +/- 1</td>
<td>5/48</td>
<td>10/56</td>
<td>33/59</td>
</tr>
<tr>
<td>Total</td>
<td>59</td>
<td>72</td>
<td>98</td>
</tr>
</tbody>
</table>

c) Costs

Because of speed changes, there is also an impact on flight time costs considering the change of the over-flown time through the airspace. Due to the fact, that after the synchronisation only one speed per one flight level will be used, the over flight time can be defined precisely. It can be accurately calculated with simple formula and results of both over flight times (current situation and after the synchronisation) compared:

\[ t = \frac{S}{V_{TAS}} \]  

This can be appreciated by the airlines since they will be eventually able to optimise (modify) strategically integrated times in the flight planes when crossing given airspace.

Table 3 depicts the difference in flight time a reference flight\(^8\), out of the used traffic sample, from CEATS entry at CHIEM, to its destination at Milas Bodrum, Turkey (LTFE) (954 NM).

However, through the moderate speed adjustment allowed, over maximum +/- 0.02 M, only little changes in flight times are caused. Thereby only a little influence on the flight time costs can be expected.

For the moment no deeper investigation of the synchronisation influence on the flight times is planned.

\(^7\) \(V_{TAS} \) [kt] - true air speed, \(t \) [min] – flight time, \(s \) [NM] – flight distance  
\(^8\) Flight AMM0549 from London Gatwick, Great Britain to Milas Bodrum, Turkey
As the highest priority is to synchronise the inbound traffic with the lowest number of aircraft shifts it is suggested to apply scenario 1 in both route segments.

<table>
<thead>
<tr>
<th>FL</th>
<th>initial TAS [M]</th>
<th>initial TAS [kt]</th>
<th>sync. TAS [M]</th>
<th>sync. TAS [kt]</th>
<th>initial flight time</th>
<th>sync. flight time</th>
<th>time difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>390</td>
<td>0.78</td>
<td>446.350</td>
<td>0.8</td>
<td>457.795</td>
<td>0:52:39</td>
<td>0:51:20</td>
<td>0:01:19</td>
</tr>
</tbody>
</table>

Reference flight: CHIEM - LTFE

<table>
<thead>
<tr>
<th>FL</th>
<th>initial TAS [M]</th>
<th>initial TAS [kt]</th>
<th>sync. TAS [M]</th>
<th>sync. TAS [kt]</th>
<th>initial flight time</th>
<th>sync. flight time</th>
<th>time difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>390</td>
<td>0.78</td>
<td>446.350</td>
<td>0.8</td>
<td>457.795</td>
<td>2:08:14</td>
<td>2:05:02</td>
<td>0:03:12</td>
</tr>
</tbody>
</table>

Table 3. Differences in flight time through acceleration over +0.02 M

Table 4. Degree of synchronisation

<table>
<thead>
<tr>
<th>Change of the degree of synchronisation [%]</th>
<th>CHIEM - JULIE</th>
<th>TONDO – BEGLA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scenario 1</td>
<td>20.27</td>
<td>20.8</td>
</tr>
<tr>
<td>Scenario 2</td>
<td>20.01</td>
<td>-7.49</td>
</tr>
<tr>
<td>Scenario 3</td>
<td>27.74</td>
<td></td>
</tr>
</tbody>
</table>

In this study, the variances of speeds on the FLs of the two discussed routes are assessed in order to describe the degree of synchronisation ($\Delta G_s$). In the case of a complete synchronisation to one target speed, the value of the variance for these FLs is zero. But adjacent FLs must be considered as well, as they are also affected by synchronisation. During the synchronisation process, aircraft which can not adjust to the target speed are sent to adjacent FLs. This might increase the number of speeds found in these FLs, thus decreasing their regularity. This is a contrary effect to the absolute regularity created on the target FLs. $\Delta G_s$ is reduced. As the variance has no maximum, no absolute value can be calculated. Thus, changes in the degree of synchronisation of the routes are used and are expressed as a relative value ($\Delta G_s$) (Table 4):

$$\Delta G_s = \frac{MQW_2}{MQW_0}$$ (8)

$$MQW = \frac{\sum_{i=1}^{p} \sum_{j=1}^{n}(x_{ij} - x_{m,i})^2}{(n-p)}$$ (9)

IV. FUTURE WORK

To build synchronised flow, inter-sector coordination is needed and may induce an increase of the controllers’ workload in comparison with the maintenance of already organised flow. The hypothesis lies upon the acceptability of controllers involving in this coordination task.

Experimentation is to set up to empirically validate the hypothesis. Currently in fast-time model simulations the measurement of workload is derived from the mathematical calculation of the total working times recorded for each ATC task category (Flight data management, Co-ordinations, Conflict search, Routine R/T, Radar). This main categorization in CEATS studies and each category consists of ATC task set. These tasks are assigned to defined actors, i.e. planning and/or executive controller.

Presently, the task list in use consists of 15 tasks with given duration times. To reduce the discrepancy in workload calculated by fast-time simulations and real-time simulations, another set of tasks has been designed [15]. This task list contains 31 tasks with new time durations and the actors who resolve the tasks. The results obtained using a different task list showed the significant influence of task list and/or task duration on workload calculation.

The plan is to use both tasks lists in the synchronised fast-time simulation (SFTS) and to observe which gives more beneficial results and supports the synchronisation proposal more effectively.

To consider the impacts of synchronisation, several measures will be examined and comparison between FTS4 and SFTS will be made. These measures include:

Conflicts. The number of conflicts (vertical, horizontal) will be considered.

Workload. Both task lists will be recorded and workload will be measured.

Sector Capacity. Number of the aircraft in a sector during certain period of time will be considered.

Over-flown time (sector, FAB).

V. CONCLUSION

The expectation from moving towards synchronous ATM is to provide extra-capacity and improve safety.
These synchronous system moves from conflict-based control methods to a time-based control methods, from detection and resolution of the conflicts to a time-based traffic organisation, to move from sector control unit to a flow control.

This study is framed within a PhD research that investigates the acceptability of controllers in the collaborative context, and in particular for the task of monitoring aircraft’s speed adjustment and assigning flight level to achieve synchronised flows.

Traffic flow synchronisation can be used to smooth the traffic operations in high density areas with mainly long-hauls flights. Safety level might improve as a result of traffic flow synchronisation through removing potential conflict situations.

When assessing operational feasibility of traffic synchronisation three areas have been discussed: criteria, operational conditions (rule-based algorithm) and indicators. Some of the criteria that can influence the efficiency of synchronisation in the en-route domain in comparison with current system were discussed. Improvements in utilization of current route network have largely been focused on proposal of the model with respect to these criteria and limiting factors. By drawing up the preliminary results from a synchronisation feasibility investigation, it has been shown how the rule-based algorithm being assess exercises an influence on the results and the relative importance of each factor considered. Furthermore, the application of different indicators to evaluate performance can result in different priorities for model or data improvement.

This paper presented an example of the sensitivity of the results due to algorithm modification under specific conditions. The evaluation showed the importance of the criterion ‘workload’ for the solution choice and in particular the vertical movements of the aircraft.

An important consideration is the ability to validate the model by comparing calculated values with available values under actual conditions (in this case, last updated data from FTS4).

Additional measurement could be done considering the needs of airlines, the extra costs they have to pay (e.g. fuel consumptions) in the synchronisation process. And as well for the future to consider the time (minimum and maximum) the aircraft should be on the cruising level to become part of the synchronised flow.

**KEYWORDS**

Traffic flow synchronisation, human factors, en-route speed control, task sharing, future concept.

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