EVALUATION OF NIGHT ROUTE NETWORK ON FLIGHT EFFICIENCY IN EUROPE

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Received 9 September 2011; accepted 20 September 2011

Abstract: There are many different concepts and definitions for the flight efficiency, where every stakeholder involved in air transport has its own perception on flight efficiency. Flight efficiency concept is based on trade-offs between safety, airspace capacity, fuel consumption, flying distance, time distance, time cost, fuel cost etc. Flight time and flying distance which has impact to fuel burn and operation costs to airspace users are mainly generated by deviations from the optimum trajectories. According to the Performance Review Commission (PRC) Report in 2009 average en-route extension in Europe was 47.6 km, with the year on year improvement of 1.2 km. The PRC Report emphasized that there is constant increase of medium/long haul flights operated by aircraft operators in Europe while short haul flights are decreasing. One of the issues, concerning flight efficiency in Europe, is that aircraft operators are not using night routes sufficient during flight planning process. This paper is presenting flight efficiency for the traffic demand using night route network and not using it at all. Flight inefficiency is expresses by the agreed performance indicators: distance difference (NM), duration difference (min), fuel combustion difference (kg) and CO_2 emission (t) environmental indicator.

Key words: flight efficiency, night route network, flight efficiency indicators, System for Traffic Assignment and Analysis at a Macroscopic Level.

1. Introduction

Flight efficiency as a generic term involves trade-offs between the elements with significant importance to the aviation community, from Air Traffic Control, airline operators to the end consumers. One of most significant flight efficiency trade-off is safety vs. capacity. Capacity values should be higher in order to satisfy the growing demand but shouldn't affect and reduce the acceptable levels of safety in Europe. There will be 16.9 million movements in Europe in 2030, 1.8 times more than in 2009. The range of the forecast scenarios is between 13.1 and 20.9 million flights in 2030, 1.4-2.2 times the traffic in 2009 (Fig. 1). The growth will average 1.6%-3.9% annually; it will be faster in the early years, stronger in Eastern Europe and for arrivals/departures to/from outside Europe, than for intra-European flights. With the growing traffic demand airspace is becoming congested, resulting with greater number of delayed flights. As airspace has a limited capacity and with the growing traffic demands it is not always possible to offer direct routing to all planned flights (Steiner et al., 2008). One of the problems refers to the congestion of international routes of the

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Euro-zone and the efficiency of conventional air traffic control systems in following the future traffic increase (Steiner et al., 2010). This paper elaborates the possibility for the airline operators to use night and direct routes for flight planning in order to optimise the trade-off between airline operators wishes (direct routing) and ATC constraints (Route Availability Document).

2. Flight Efficiency Observations

Airline operators would have significant savings on a yearly basis from making possible to plan their flights on more direct routes and saving miles in flight length reducing flown distance. According to the EUROCONTROL PRC Report additional one mile of flight costs the airline operator between 4 and 16 € (depending on the aircraft type) (EUROCONTROL, 2004). In 2009 in Europe the average en-route extension was 47.6 km per flight (32.3 km is attributable to the efficiency of en-route network and 15.3 km to the interfaces with Terminal Area). IATA's fuel action plan target is US$1.5 billion in savings from greater route efficiency and optimised operational procedures. IATA, CANSO and EUROCONTROL have developed Flight Efficiency Plan (Fuel and emission savings) in order to identify solutions and develop operational improvements in short term period. Flight Efficiency Plan has five action points: (1) Enhancement of the European en-route airspace design, (2) Improving airspace utilisation and route network availability, (3) Efficient TMA design and utilisation, (4) Optimising airport operations, (5) Improving awareness performance. This paper is presenting improvements that are in alignment with the Flight Efficiency Plan Action Point 2.

There are numerous interpretations of flight efficiency. The most common is that flight

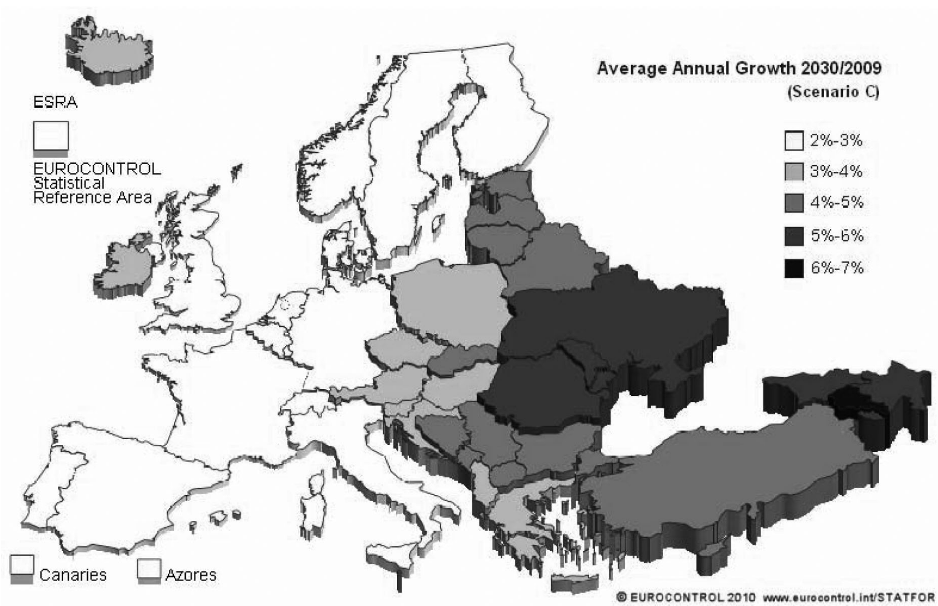

Fig. 1.
Average Annual Growth

efficiency is defined as the difference between the actual flight path length and direct flight path length connecting the entry and exit points of the flights for the selected centre, presented as additional mileage, flight time, fuel burn and costs to operators (Fig. 2). According to EUROCONTROL flight efficiency has horizontal (distance) and vertical (altitude) component. Calculation in this paper takes into account horizontal and vertical flight profile.

In order to contribute to the Air Traffic Management improvements, set of flight efficiency indicators have been developed (EUROCONTROL, 2002). Flight efficiency indicators measure efficiency of the actual routes and flows in terms of distance, fuel burn, flight duration, cost to the airlines and environment. The first flight efficiency indicator evaluated in this paper is Route Efficiency indicator, and it represents the measure of route extension of the actual route flown. Duration is obtained by subtracting the begin time to the end time of each flight. Duration indicator presents the time difference between actual flights time duration (no night route network segments) with more direct flight time duration (using night route network segments). Fuel Burn indicator is presented as additional fuel burn difference between when the airline operators are not using night route network and when there is the option to use night route network.

3. Improvements in Flight Efficiency

Comprehensive harmonisation programs should solve the problem of European airspace congestion and fragmentation, by contributing to the effective increase in capacity and air transport efficiency. The vast majority of the improvements considered in the context of the EUROCONTROL ARN Version-7 contribute to the deployment of the Flight Efficiency Plan

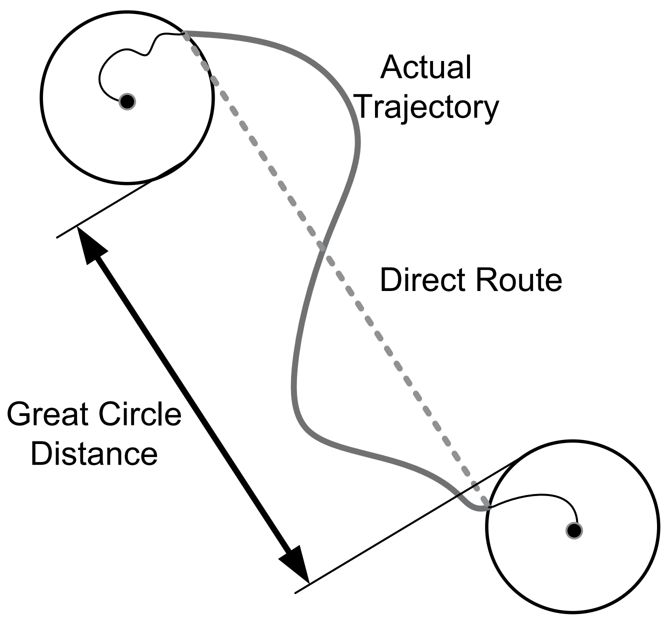

Fig. 2.
Route Reference Methodology Used for the Flight Efficiency Calculation

(EUROCONTROL, 2010). The objective of ARN Version-7 is to provide Aircraft Operators with their preferred trajectories selected from within the route network, whilst ensuring that the capacity and safety targets defined by the sectorization are met. The ARN Version-7 delivers more route choices to the operators when planning a flight. This involves improved access to the existing route network and the creation of new routes, including predefined direct routes available subject to time limitations or ASM conditions.

The ARN Version-7 contains, at this stage, approximately 400 (four hundred) packages of airspace proposals scheduled for implementation between 2011 and 2014. These proposals include more than 1500 route changes and more than 40 re-sectorisation projects. They were or will be implemented as follows:

- approx. 200 proposals for the Summer season 2011
- approx. 115 proposals for the Summer season 2012
- approx. 100 proposals for the Summer season 2013
- approx. 30 proposals for the Summer season 2014

As from the full implementation of ARN Version-7 in 2014, flying distances would be reduced by approximately 12 million NMs, this representing the equivalent of 72000 tons of fuel saved, or reduced emissions of 240000 tons, or 60 million Euros. The European ATS route network will become only 2.9% longer than the great circle distances (from TMA entry to TMA exit points) from an airspace design point of view (Fig. 3).

The implementation of ARN Version-7 has the potential to significantly improve flight efficiency if all projects are fully implemented. Between autumn 2010 – end of 2014, flight efficiency is expected to improve by at least 10%. The

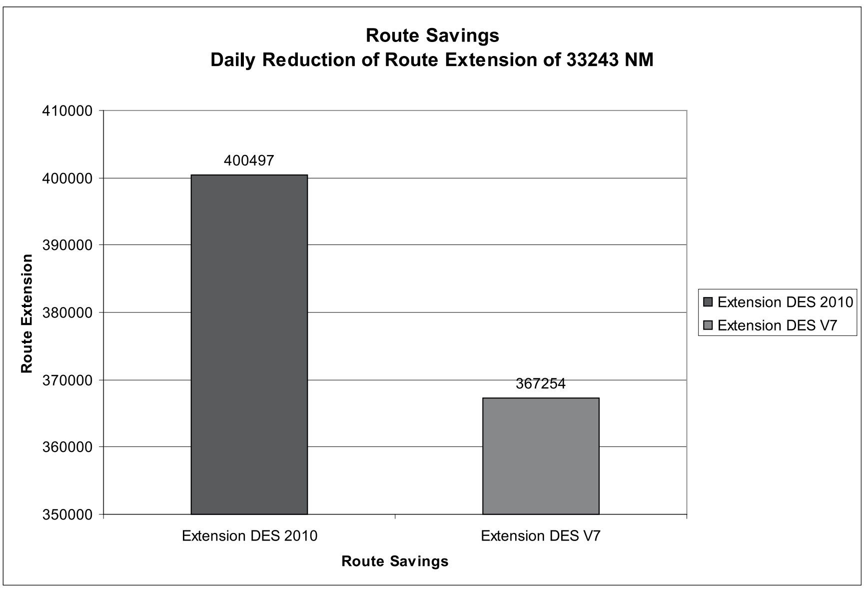

Fig. 3.
European Route Network Savings

route extension due to airspace design (if all flights would have used the route network without any route restrictions and with all CDRs permanently available) is expected to decrease from 3.13% in September 2010 to 2.90% by the end of 2014. The graphs above and below present the expected evolution of flight efficiency indicators between autumn 2010 – end 2014 in terms of extension compared to the great circle and net savings (Fig. 4).

ARN Version-7 between 400 proposals for improvement until 2014 contains number of night route proposals for implementation and the map below is showing the layer of new night/direct ATS route segments that will be added to the European ATS Route Network through the ARN Version 7 (Fig. 5).

4. Evaluation of Night and Direct Route Impact on Flight Efficiency

The evaluation of Night Route Network segments impact on the flight efficiency in Europe is analysed with tool System for Traffic Assignment and Analysis at a Macroscopic Level (SAAM) developed by EUROCONTROL. The main feature of the SAAM tool is the Assignment process that uses the combinatorial search algorithm that performs optimisation finding shortest distance between city pair from flight plan. SAAM tool examines traffic demand pattern as a set of four dimensional (4D) planned flight trajectories from entry to exit point in the area of interest.

In order to evaluate the direct impact of Night Route Network on flight efficiency in Europe following scenarios were created:

1. **No-Night Scenario** – only ATS route network was made possible for flight planning, (night route network excluded),
2. **Night Scenario** – ATS route network and night route network is made possible for flight planning,
3. **Delta Scenario** – comparison between No Night and Night Scenario.

The objective of this paper is to identify the flight efficiency benefit pool for airline operators by using more direct routes (night route network segments). Scenario development model explains the methodology used for night route network flight efficiency simulation (Fig. 6).

ECAC area was selected for evaluation of night routes network impact on flight efficiency. One day traffic sample was selected – 30/09/2010. Traffic sample represents current traffic - Model 1 - and it represents flight plan as filled by airline operators and corrected by EUROCONTROL Central Flow Management Unit (CFMU). This traffic sample represents the flights that are taking into account RAD restrictions but not CFMU regulation and it is not the real picture of the current traffic flown on that day. This traffic sample can be observed as planned flights for the selected period.

Route network was selected from AIRAC 1012 effective from 18th of November 2010 and it corresponds to the period of traffic sample used (Fig. 7).

Following parameters were used for making scenarios:

- **Rules:** RAD, South Jet Stream Atlantic Wind, SID, STAR, Flight Level Constrains (These rules overcome default rule for shortest route between city pairs, and assign flights on other path.)
- **Night route network availability:** from 22:00 – 05:00.

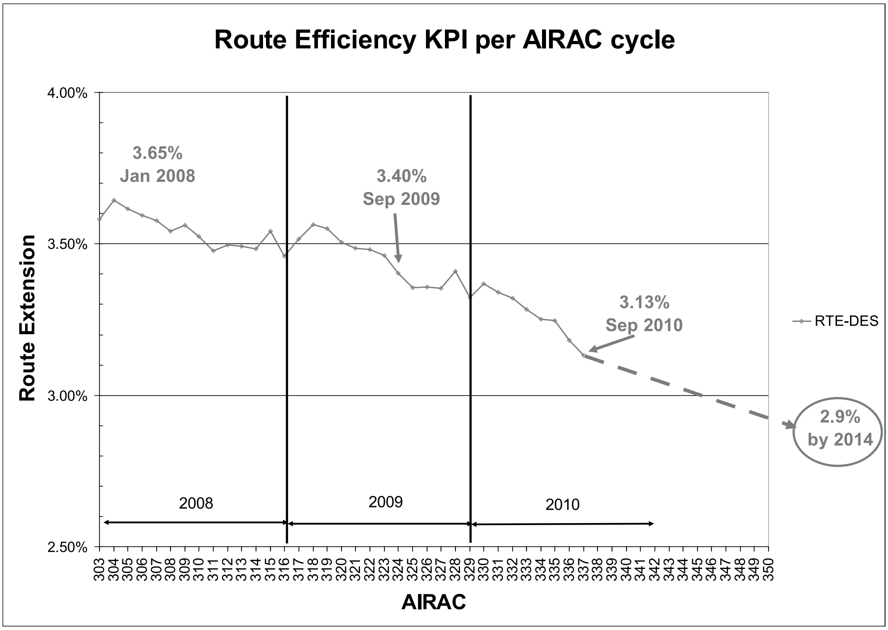

Fig. 4.
Route Efficiency in Europe

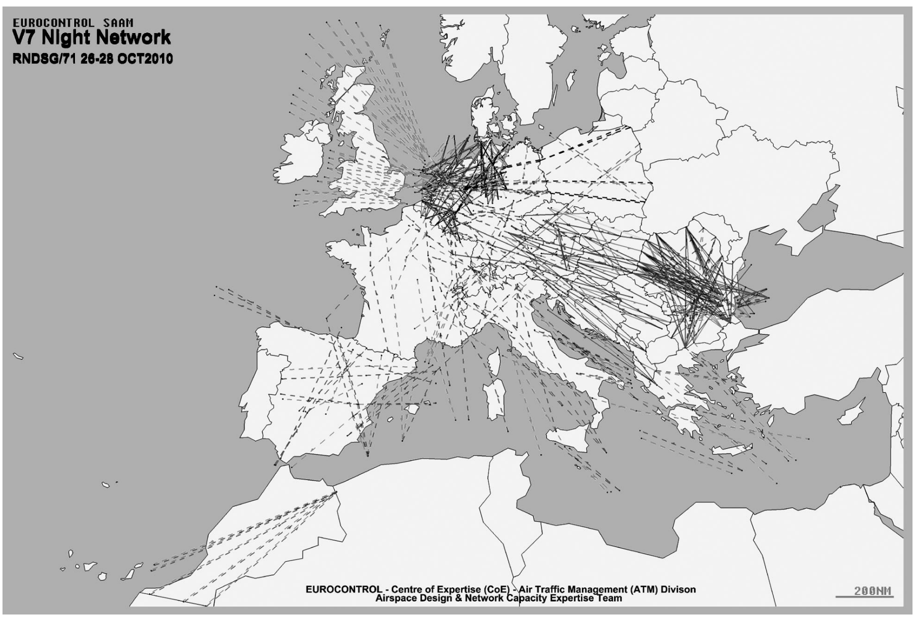

Fig. 5.
European Night Network

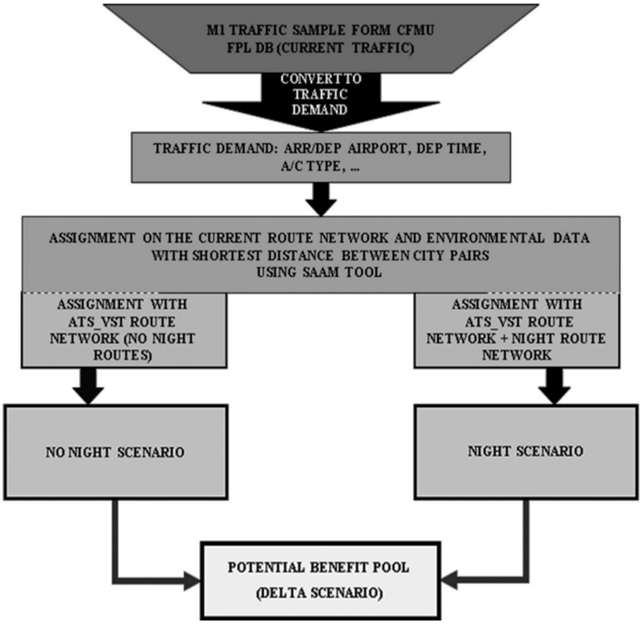

Fig. 6.
Methodology for Night Route Network Flight Efficiency Benefit Pool

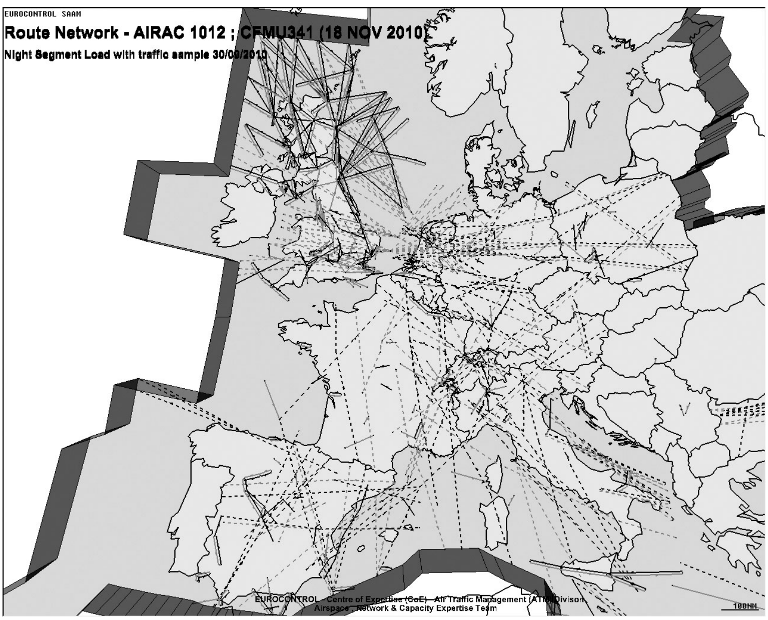

Fig. 7.
Selected Simulation Area and Night Route Network Segments

No-Night Scenario represents the scenario where night route network are offered for planning without the night route network structure. In this scenario for the referent period of one day (30/09/2010) there were 31280 flights across Europe with overall flight distance of 24748965.6 NM. Night Scenario represents the possibility for operators to plan their flight on more direct night route network segments. When applying night route network and with ATS route network into the simulation run the flight distance of 31280 flights was 24744527.3 NM.

The total difference between No-Night and Night Scenario represents the flight inefficiency if night route network segments and direct routes are n ot offered for planning (Table 1.).

Table 1
Night Route Network Flight Efficiency

Night Network Flight Efficiency 30/09/2010			
Indicators	**No-Night**	**Night**	**Delta NoNight -Night**
Distance (nm)	24748965.60	24744527.30	4438.30
Fuel Burn (t)	272238.62	272189.80	48.82
Duration (min)	3535566.51	3534932.47	634.04
CO_2 Emission (t)	860274.04	860119.77	154.28

Distance indicator represents the comparison between the distances flown when the operators are using ATS routes without night route network segments offered for planning, with the distance flown when night route network segments are offered for planning. The methodology used for the fuel burn, duration and CO2 calculation is based on the ICAO ALLPIRG 4 and ICAO ALLPIRG 5 referent documents, where:

- Average fuel burn per nautical mile of flight is equal to 11 kg of fuel,
- Average cruising speed is 7 NM/min,
- CO_2 emission is equal to fuel consumption multiplied with 3.16.

Under the assumption that 30/09/2010 traffic sample represents average daily traffic sample in a period of a year 2010, use of night route network would resulted in a substantial savings of flight distance by 1619979.5 NM, average fuel burn by 17819.8 t, and CO_2 emissions by 56310.49 t in 2010.

Table 2
Represented Air Carriers

Carrier	**Number of Flights**
TCX - Thomas Cook	27
TOM - Thomsonfly	25
BCS - EuroTrans	25
AFR - Air France	22
BER - Air Berlin	21
DLH - Lufthansa	17
BAW - British Airways	15
TAY - TNT Airways	13
JAF - Jetairfly	11
CFG - Condor	11
GWI - Germanwings	10

When making the analysis of night route network impact on flight efficiency it is interesting to observe the carriers and their nature of business. In Table 2 there are fifteen most represented air carriers that would use night network structure if it would be offered for flight planning. First two most represented carriers operate worldwide charter flights, while EuroTrans is cargo airline that operates under the DHL group's express services in Europe. It is obvious that the cargo and non-scheduled (charter) carriers are using night routes more than other carriers (business, military, scheduled, low-cost). According to this

Table 3
Airport Night Arrivals and Departure

Airport	Arrival	Airport	Departure
De Gaulle	33	Leipzig/Halle	25
London Heathrow	26	Köln-Bonn	24
Frankfurt	25	Mallorca	24
Brussels National	23	Dalaman	17
Köln-Bonn	20	London Heathrow	16
Schiphol	20	Liege	13
London Gatwick	19	Frankfurt	12
Manchester	14	Tel Aviv	11
Mallorca	13	Rodos	9
Derby-East Midlands	10	Singapore Changi	8

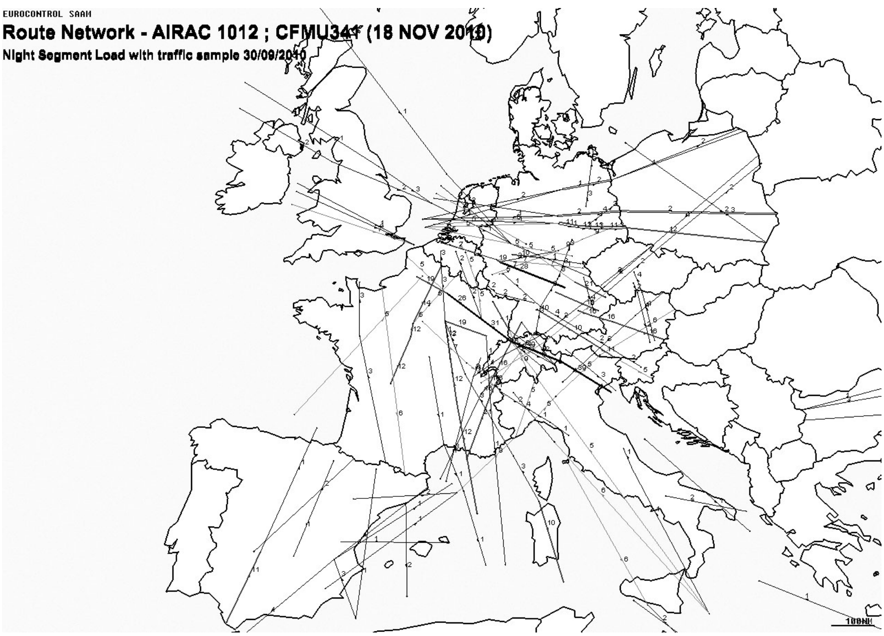

Fig. 8.
Night Segment Load

one day analysis busiest airport in Europe during the night is Koln-Bonn Airport. According to the EUROCONTROL Report Koln-Bonn Airport has 61.6 movements between 00:00 and 04:59. In the Dependent on the Dark Report there are two different categories of airports that operate during the night. First one are the usually busiest European airports (Paris, Frankfurt, Heathrow) that have cargo operations as a part of their usual business, while other categories of airports are the ones that are specialised in cargo operations(Liege). In Europe there are also typical night airports such as Liege or East Midlands with an average capacity at night of 12 movements per hour (Table 3). Figure 8 displays night segment load with segment SUXAN-HOC most loaded segment - 40 flights during night segment availability (22:00 – 05:00).

5. Conclusion

Aim of this paper is to evaluate the possibility for airline operators to plan their flight on night and direct routes among all ATS routes. The SAAM methodology used for this analysis gives reliable data about the night route network influence on airline operators flight planning and flight efficiency. It can be seen from this paper that ARN 7 proposals – introduction of night routes would bring significant benefits to European flight efficiency. The night route network development and utilisation is a part of the Flight Efficiency Plan Action point 1 (Enhancement of the European en-route airspace design). This paper is presenting evidence for improvements and benefits that are in alignment with the Flight Efficiency Plan Action Point. Next step for improvement will be extension of the night segment utilisation and final step will be 24H utilisation.

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PROCENA UTICAJA MREŽE NOĆNIH RUTA NA EFIKASNOST LETA U EVROPI

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Sažetak: Postoje različiti pojmovi i definicije efikasnosti leta, pri čemu sve zainteresovane strane u sistemu vazdušnog saobraćaja imaju sopstvenu percepciju efikasnosti leta vazduhoplova. Koncept efikasnosti leta bazira se na postojećim odnosima između bezbednosti, kapaciteta vazdušnog prostora, potrošnje goriva, doleta, trajanja leta, troškova goriva i sl. Vreme leta i dolet, koji imaju direktan uticaj na potrošnju goriva i operativne troškove korisnika vazdušnog prostora, uglavnom se generišu odstupanjem od optimalne putanje leta. Prema rezultatima EUROCONTROL-ove komisije, 2009. godine, prosečna dužina leta na ruti u Evropi iznosila je 47,6 km, sa godišnjim povećanjem od 1,2 km. U rezultatima je naglašen stalan porast letova srednjeg/dugog doleta u Evropi, dok su letovi kratkog doleta u padu. Jedan od problema efikasnosti leta u Evropi je nedovoljna iskorišćenost noćnih ruta pri planiranju leta vazduhoplova. U radu je izvršeno poređenje efikasnosti leta u odnosu na potražnju saobraćaja sa i bez korišćenja noćnih ruta. Neefikasnost leta opisana je utvrđenim indikatorima: razlikom u dužini doleta (NM), razlikom u vremenu trajanja leta (min), razlikom u potrošnji goriva (t) i emisijom CO_2 (t).

Ključne reči: efikasnost leta, mreža noćnih ruta, indikatori efikasnosti leta, sistem za određivanje i ispitivanje saobraćaja na makroskopskom nivou.