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Single European Sky and its impacts on CO_2 emissions

submitted by

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Abstract

Aviation has been subject to comprehensive changes over the last decades. Passenger numbers and freight volumes have boomed and are expected to further increase over the next years. Adverse impacts are correlated to growth rates and will further increase in a business-as-usual scenario for the airline industry. A focus in the external effects debate is the discussion on CO_2. One solution which has especially been communicated by the airline industry is the implementation of a Single European Sky. The paper examines the potential of a Single European Sky for emission reduction. Therefore, actual routes have been compared with shortest distances on selected corridors within Europe. It comes out that significant reductions in trip length can be achieved leading to savings in fuel consumption and cost reductions for the airlines. In an environment with a high degree in competition, lower costs will be forwarded to the customer. Lower prices attract more people and more flights will be operated leading to an overall increase in emissions. An emission trading system (ETS) can be seen as more effective to reduce external effects. ETS allows caps of total emissions and covers the total economy leading to a better allocation of resources.

Introduction

In the last decades aviation has been subject to comprehensive changes influenced by political decisions (liberalisation, deregulation and privatisation of the industry), economic growth and lower production costs (tendency of lower costs per seat km). These tendencies are expected to continue within the nearby future. Megatrends for these tendencies can be outlined by:

(1) strongly growing demand in air passenger and freight transport, growth is expected to rise by around 5 % per year (IATA, 2007),

(2) changes in business models of airlines (e.g. from national flag carrier to a point-to-point airline including low cost offers),

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(3) tremendous enhancement in airport capacity especially in Asia (e.g. U.A.E., Qatar, China),

(4) expansion of local airports and the efforts of regions to convert former military airports into civil airports (e.g. Black-Forrest airport),

(5) development in airplane design – introduction of Airbus A 380 and Boeing Dreamliner, with promises to reduce the costs per seat km significantly and

(6) increasing cooperation in terms of alliances (e.g. Star Alliance, One World) which lead to capacity constraints at major European airports (e.g. London Heathrow, Frankfurt).

The airline industry will increase supply of seats and flexibility for passengers to ease travelling by air. This will lead to more flights within the network. Negative effects will arise and be strengthened. The results can effect the industry directly, e.g. congestions at airports, or indirectly in case of external effects. A focus in the external effects debate is the discussion on noise, CO_2 and NO_x. According to recent studies the external effects per 1.000 passenger kilometres are around 52.5 EUR (UIC, 2004), which is very high compared to rail transportation (22.9 EUR). The challenging task for the future will be to decouple emissions from passenger growth as well as from economic growth.

The airline industry defines the creation of a Single European Sky as a milestone in reducing environmental emissions. Reductions should come from shortening holdings (aircrafts flying in a fixed pattern awaiting permission to land), improving flight corridors and more efficient routings. In the following we will concentrate on the latter.

The remainder of the paper is as follows: In a first step, the European air traffic control system is examined. Afterwards, current flight routes of selected intra European corridors are analysed and compared with direct linear distances. Reduction potentials are derived from the comparison (direct beeline vs. flown route). Finally, suggestions for airlines and politics are made.

European air traffic control policy

The European air traffic control network has been developed over time. Each sovereign nation uses its own mechanisms and set up its own agency for traffic control. Since the beginning of the 20th century aircrafts especially in Europe were flown in different countries that it became apparent to have at least accepted standards. In 1919, the International Commission for Air Navigation (ICAN) was created to develop "General rules for air traffic" which were applied in most countries where aircrafts operated (Arndt, 2004). Despite further attempts to unify the network, especially since the 1960s more than 25 civil air traffic control agencies exist in Europe including 58 control centres which use 22 different operating systems (Lufthansa, 2006). Figure 1 displays the current situation in the European air traffic control system.

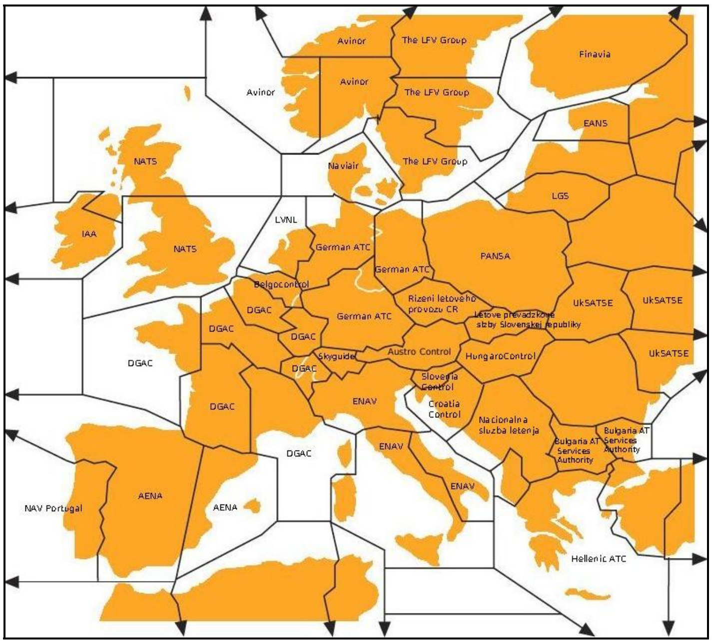

Figure 1: Air traffic control zones in Europe (Source: own composition based on Lufthansa, 2006)

Comparing the air traffic control systems of the US with the current European system shows the European complexity. Both regions have around the same air space but many more providers exist in the European air control market. Table 1 summarises key factors for both regions.

Table 1: Comparison between selected air traffic control information in Europe and the US (Lufthansa, 2006 and Eurocontrol, 2004)

	Europe	**USA**
Air space (million square km)	10.5	9.8
Air navigation service providers (civil and military)	47	1
Control centres	58	21
Operating systems	22	1
Programming languages	30	1
Flights (in million)	9	18
Cost of traffic control per flight (in euro)	742	386

To overcome the semi-optimal situation in Europe the idea of a single sky emerged in the 1960s when Eurocontrol, the European Organisation for the Safety of Air Navigation, has been founded. Its major objective is the creating of a single upper sky which enables the efficient use of airspace that is based on actual flight patterns. Nowadays, air traffic boundaries are strongly related to national borders which results in detours, holding patterns and additional kerosene consumption (see Figure 1).

CO_2 emission reduction potentials through optimising flight routes

Calculating CO_2 emission reductions due to optimizing flight routes are quite ambitious as a lot of different factors influence the kerosene consumption of flight routes. To derive a calculation assumptions are necessary. In a nutshell we assume that aircrafts consume a constant amount of kerosene per km between origin and destination. Under this assumption a comparison of flight routes is focused on differences between the current route and an ideal route which can be used in a Single European Sky. As those routes are still hypothetic we assume that flight routes are the bee-line between origin and destination airport (optimistic approach). Nevertheless, in real terms even with a Single European Sky flight routs are expected to be about 2 to 10 % longer than the bee-line caused by weather conditions and capacity constrains within the network. Thus, our calculation is an upper estimate of the CO_2 reduction potential as actual flight routes are compared with the shortest possible distance between two airports.

In particular our approach implies the following assumptions: we do not consider regional airflows despite they have a big impact on kerosene consumption of aircrafts. Besides, we neglect capacities constrains of flight routes and assume that all aircrafts could fly at the same altitude. Departures and landings can always be accomplished in the direction of the bee-line to destination. Furthermore, we neglect no-fly zones.

In the following we present six exemplary European flight routes which are mapped in Figures 2 to 4. We analysed these flight routes according to their frequency (Madrid-Barcelona, Frankfurt-Berlin) and according to the number of possible ATC crossings to become a broader view on the maximum efficiency gains (e.g. Paris-Warsaw, London-Rome and Munich-Helsinki). The actual data have been provided by Eurocontrol. For identifying the flight routes we analysed around 6,200 different flights in August 2007 and transferred them to the corresponding maps (see Figures 2 to 4).

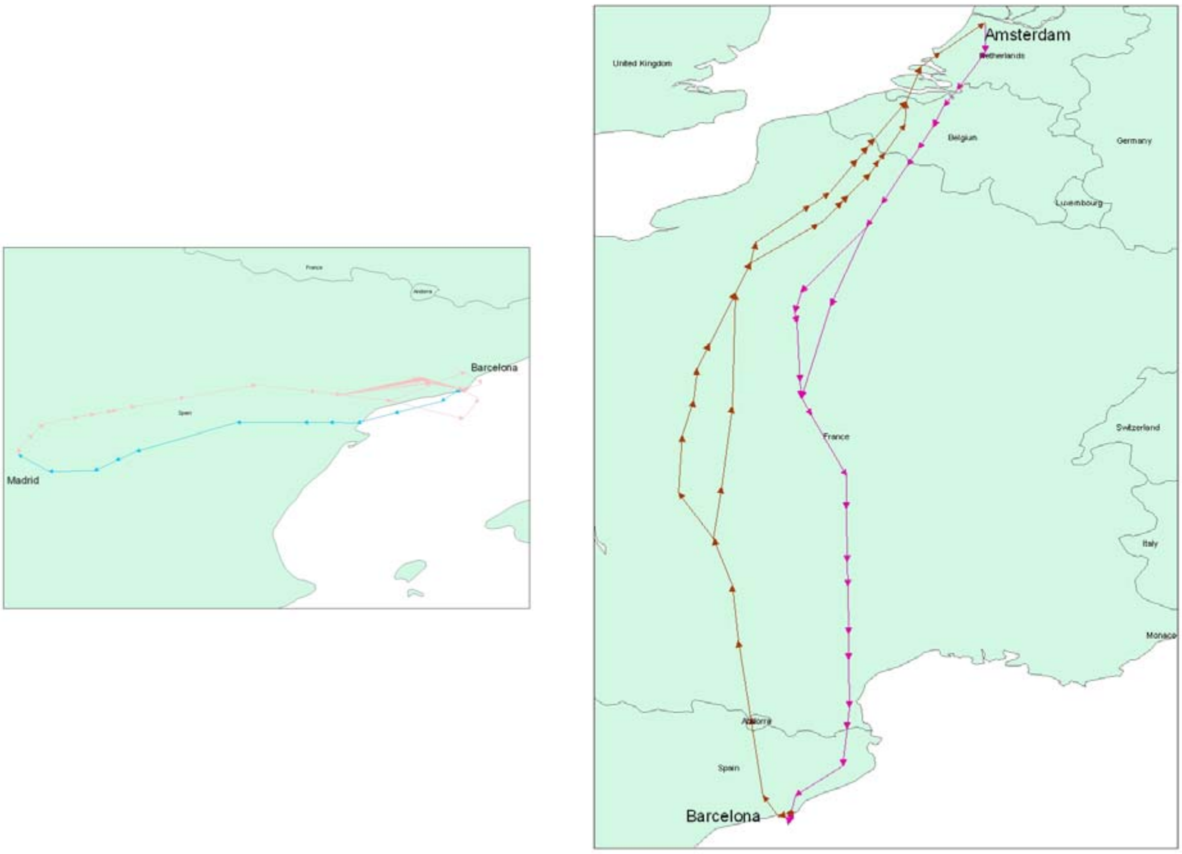

Figure 2: Flight routes Amsterdam-Barcelona and Madrid-Barcelona (Source: own mapping based on data from Eurocontrol – August 2007)

The most frequent intra European flown relation is Madrid-Barcelona (Eurostat, 2007). Even though it is a very short distance in a single country, origin and destination lay in two different ATC zones. It can be assumed that deviations from the shortest possible route of such short relations are caused by other reasons than different ATC (e.g. winds, capacities). Thus, we regard this route as a paradigm (business-as-usual) route. It is not surprising that the actual routes appear to be very straight when comparing with the other relation, such as Barcelona-Amsterdam, where about five different ATC zones are overflown and where especially the outbound flights are far from the direct line (see **Fehler! Verweisquelle konnte nicht gefunden werden.**).

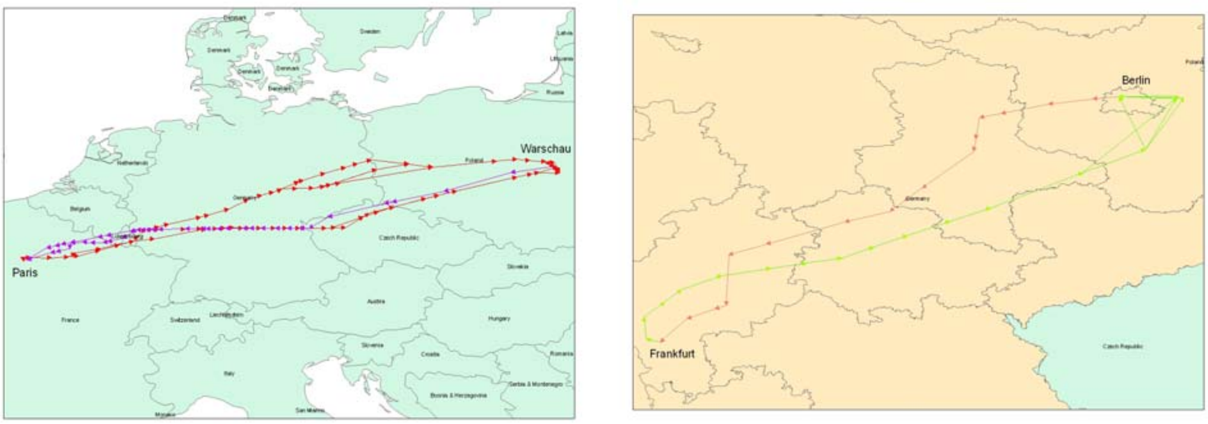

Figure 3: Flight routes Paris-Warsaw and Frankfurt-Berlin (Source: own mapping based on data from Eurocontrol – August 2007)

Looking at an east-west relation – here the Paris-Warsaw link – flights seem to be more straight even though they cross about five different ATC zones (see **Fehler! Verweisquelle konnte nicht gefunden werden.**). Considering the most frequent intra German relation from Frankfurt to Berlin (which crosses one ATC zone), the routes are far from direct connections (not caused by different ATC zones but rather to congestions or landing restrictions).

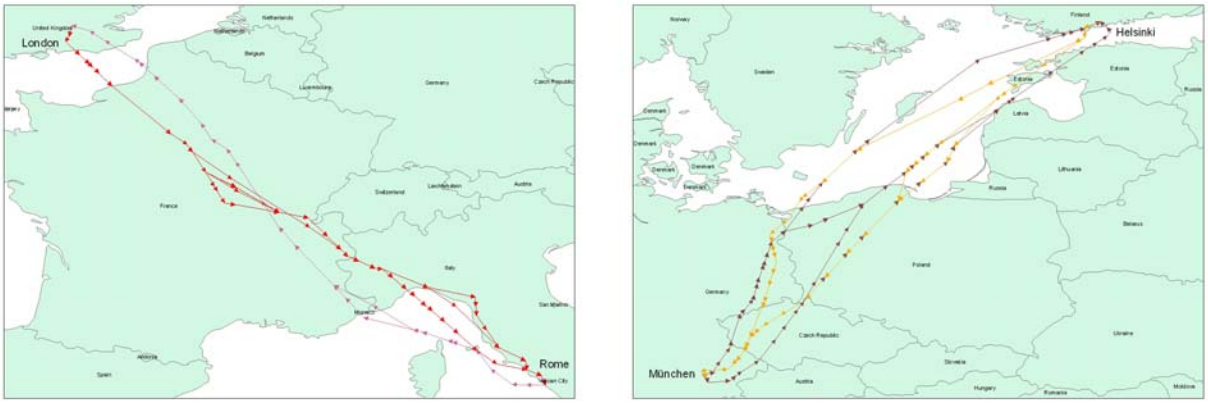

Figure 4: Flight routes London-Rome and Munich-Helsinki (Source: own mapping based on data from Eurocontrol – August 2007)

On European diagonal routes the flights are quite straight even though they cross between four and six different ATC zones. Considering the corridor London to Rome and Munich to Helsinki the flights are relatively straight, but with a large number of different routes (see **Fehler! Verweisquelle konnte nicht gefunden werden.**).

The paper at hand compares the real distance of a flight with its shortest possible flight route. The real distances are taken from the Eurocontrol database for August 2007. For each connection GIS data have been available which allow a reconstruction of the concrete flight corridor. Shortest distances between the airports under consideration are gained from GoogleEarth and have been verified by GIS software. Under the afore mentioned assumptions distance savings for a special link can be calculated. Table 2 summarises the findings and displays the average savings for each direction. It can be outlined that general savings can be achieved for each single relation by implementing a Single European Sky. The level of saving is dependent on the relation itself, the total distance and the number of overflown ATC zones.

Table 2: Savings in distance on selected flight connections within Europe due to the implementation of a Single European Sky

Origin	**Destination**	**Savings in distance (in %)**
Frankfurt (FRA)	Berlin-Tegel (TXL)	14
Berlin-Tegel (TXL)	Frankfurt (FRA)	12
Munich (MUC)	Helsinki (HEL)	5
Helsinki (HEL)	Munich (MUC)	8
London-Heathrow (LHR)	Rome-Fiumicino (FCO)	9

Rome-Fiumicino (FCO)	London-Heathrow (LHR)	6
Amsterdam (AMS)	Barcelona (BCN)	8
Barcelona (BCN)	Amsterdam (AMS)	9
Warsaw (WAW)	Paris-Charles de Gaulle (CDG)	5
Paris-Charles de Gaulle (CDG)	Warsaw (WAW)	9
Barcelona (BCN)	Madrid (MAD)	7
Madrid (MAD)	Barcelona (BCN)	13
Lisbon (LIS)	Bucharest (BBU)	4
Bucharest (BBU)	Lisbon (LIS)	5

Conclusion

As shown above, the introduction of the Single European Sky will lead to significant reductions in trip length within Europe and therefore to direct savings of fuel consumption. Due to optimized flight routes and optimized technology up to 0.6 Mega tonnes CO_{2e} reductions are possible (BDI, 2007). Furthermore, it can be expected, that holdings can be reduced, because of optimised coordination between flight control, airports and airline. From an economic perspective of the airlines both effects are very valuable. Production costs per seat kilometre will decrease and reliability will increase.

No clear conclusions can be drawn from an environmental perspective. In a surrounding with a high degree in competition, lower costs will be (partly) forwarded to the customer. And lower prices attract more people, so airlines will use the planes for more flights, without burning less fuel in total. There might be scenarios, in which these lower costs in production will lead to an increase in flights, which overcompensate the savings of the SES by many times.

Estimations made by Deutsche Lufthansa AG (2006) and other airlines show fuel savings between 8 and 12 percent for European flights. The results seem to be reasonable, in case of introducing the SES. From an economic point of view the introduction of the SES should be supported. Nevertheless, it cannot be assumed that emissions will be reduced in a long term view.

It can be suggested to introduce an emission trading system (ETS) on a European / global basis in addition to the SES to reduce external effects by CO_2, NO_x, etc. In comparison to the SES the ETS allows caps of total emissions. And, a sophistic ETS does not only include the airline industry, it covers the total economy and leads to a better allocation of resources. On November 13, 2007 the European Parliament agreed on a Directive launched by the European Commission to include the air sector in the ETS by 2011. The Directive plans to incorporate intra European flights as well as flights to other continents in the system. The proposal will now be discussed by the European Council of Ministers which has a voice in this decision and seems to be very disagreed on ETS.

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