The Energy Dilemma: European Air Transport Growth Between the Devil and the Deep Blue Sea

In many industrial activities, environmental concerns have been a stringent constraint to their development. Far away from these environmental considerations, Air Transport has always thought itself as a "disembodied" activity. Nowadays, the Air Transport Network has to face its "forgotten" environmental responsibilities and therefore adapt its economical strategies in order to fit within the framework of sustainable development. Our intention in this paper is not to be prescriptive, but to describe, at different levels of analysis, organisational, operational and institutional levies that are put in place within the Air Transport network in order to enhance its energy efficiency.

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Air Transport and the energy double bind: "Peak of Oil" and the "Kyoto" agreement:

Defining an Environmentally Sustainable Transport (EST):

During the 1990's, several attempts have been made to define what is meant by "Environmentally Sustainable Transport" (EST). Most of them have been based on the general definition of sustainable development introduced by the Brundtland Commission in 1987 (CMED, 1987). Everybody knows the weakness of Sustainable Development: this "concept" is so broad that it gives no help in determining, selecting and applying a commonly shared framework. In fact, Sustainable development is essentially a matter of conflicting goals (Hueting, 1990). Likewise, defining an Environmentally Sustainable Transport is not an easy task because that means taking into account several dimensions of a complex network activity. But difficulties do not mean impossibility and many institutions have tried to determine the boarder of what an EST could be. This question was the object of the 1996 Vancouver Conference, organised by OECD. This paper provided a preliminary qualitative definition of environmentally sustainable transport (EST), as follows:

"Transportation that does not endanger public health or ecosystems and meets mobility needs consistent with (a) use of renewable resources at below their rates of regeneration and (b) use of non-renewable resources at below the rates of development of renewable substitutes." (OECD, 1996)

Few years later, the European Commission launched a joint expert working group on this subject and gave this extensive definition of what could be a sustainable transport mode:

"A sustainable transport system must contribute to economic and social welfare without depleting natural resources, destroying the environment or harming human health." (CEGTE, 2000)

The common viewpoint of those definitions is that the state of natural goods and services should be viewed from a long term perspective of at least several generations, focusing in particular on irreversible changes, and taking into account indirect effects and complex causal chains. Thus, four specific criteria have been defined to determine an Environmentally Sustainable Transport in regard to its energy consumption. Two relate to resources consumption and two others relate to polluting emissions (See below, Table 1).

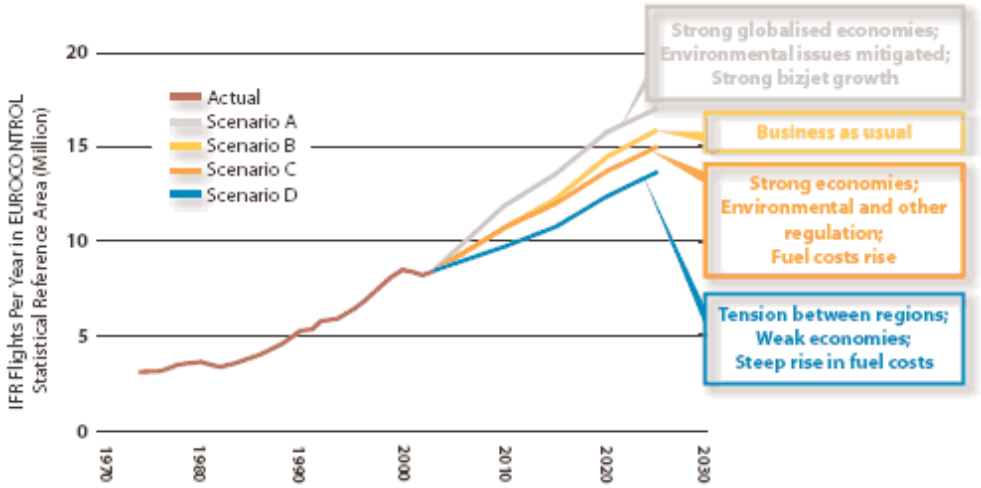
If you take acknowledgment of those different criteria, everyone can guess that Air Transport is not, at this moment, environmentally sustainable (Upham, P., 2003). This view point is not fatalistic, but on the contrary urges the change in the sector.

Resource depletion and gaseous emissions, the double bind of Air Transport

For our study, the unsustainable pathway of Air Transport can be summarized by two main energy related constraints. The first one could be called

Resources consumption	Polluting emissions
Renewable resources shall be used efficiently and their use shall not be permitted to exceed their long-term rates of natural regeneration.	Releases of hazardous or polluting substances to the environment shall not exceed its assimilative capacity; concentrations shall be kept below established critical levels necessary for the protection of human health and the environment.
Non-renewable resources shall be used efficiently and their use limited to levels which can be offset by substitution by renewable resources or other forms of capital (Hartwick rule').	Irreversible adverse effects of human activities on ecosystems and on biogeochemical and hydrological cycles shall be avoided.

Table 1: *Specific criteria for Environmentally Sustainable Transport [source: OECD, 2001]*



Scheme 1: *Growth scenari of European Air Transport*
Source: Statfor, EUROCONTROL Long-Term Forecast of Flights (2004 - 2025)

"Peak of Oil" and underline the risk attributed to technological dependence of Air Transport. As a matter of fact, at least for the near and medium term, the type of energy required by this industry is likely to be kerosene derived from oil. Today's engine technologies are highly dependent on resources that are very cheap to extract but really scarce when viewed over the very long time horizon. That kind of non renewable resource has no real substitute, and in a sense, at this moment condition, Air Transport contributes actively to its own dusk. Nordhaus (1973) explain this "locked in" syndrom by the fact that our industrial system seeks to gain short term "royalties" thanks to scarce "low-cost" resource. The problem of such dependence is that it could generate high risk of surprise: "The feature of this path is that the run up of prices can be a big surprise." The programmed energy crisis within the next decades, with supply of conventional oil unable to keep up with demand, will cause that surprise . In this way, the end of cheap oil could cause the disappearance of technologically "locked" activities such as Air Transport.

The second constraint refers to Kyoto protocol. This Multilateral Environmental Agreement (MEA) is well known and was build up by the United Nations Framework on Climate Change (UNFCC). This framework urges the change to fight against Climate Change and sets out basics principles, commitments and institutional and procedural mechanism for its implementation. Under this instrument, developed countries are to attain a reduction in Greenhouse gazes of at least 5% of combined emissions levels during 1990 in the period between 2008-2012. In the European Union, the direct greenhouse gas (GHG) emissions from aviation correspond to only 3 % of total GHG emissions but grow faster than any other transport modes Moreover, the Intergovernmental Panel on Climate Change estimated that aviations total impact is about 2 to 4 times higher than the effect of its past CO2 emissions alone (IPCC, 1999). According to previsions, if growth continues at this rate (4.3 % per year), European Air Transport emissions could reach, by 2012, 150 % of the 1990 level and will represent 8% of total European CO2 emissions by the year 2025 (Bleijenberg, 1995). On a global scale, these emissions could grow to a proportion of 4-15 % by 2050, with 6-7 % generally held as the most likely range . (Somerville, H., 2003).

Steady growth, core of the energy dilemma

In that perspective, one could say that steady growth is the driving force causing the human economy to approach the physical limits of the biosphere (Daly, 1974, 1990). Eurocontrol's Report "Challenge to growth" estimates that the European Air Transport will continue its growth (See Figure 1): the theoretical long term evolution of traffic demand for 2025 shows growth factor between 1.7 to 2.5 the 2003 flight demand (Eurocontrol, 2004), that means 14.5 to 21.1 millions IFR flights (compare to 8.5 millions IFR Flights in 2003). As a matter of fact, Air Transport follows this trend seeing that economical liberalization and the development of a leisure class has pulled strongly its growth. And there is little doubt that growth in aviation will continue. Commonly, it is said that it will be about 5 % per year for the next decade, with lower growth in Europe than in some other part of the world (especially Asia and Middle East). Whatever the forecast, growth in aviation implies growth in fuel consumption and gazeous emissions.

Nobody really knows how much time oil will be so easily extracted (Porter,1995) and everybody agreed to say that Kyoto protocol is only the first step to stabilize GHG concentrations in atmosphere. In many European countries, reduction objectives discussed were about a cut in emissions of 60 to 80 % their 1990 levels (that is the Factor 4 objectives). For instance, Britain objectives try to achieve a 60% cut in emissions (DTI, 2003). For that, the UK royal Commission concluded that "aviation policy must not simply respond to current growth patterns. A primary aim of policy must be to seek to limit aviation's contribution to global warming. This will require significant constraints on the growth of air traffic" . It will be necessary in the next decade to not only de-couple environmental degradation from continued economic growth, but to ensure that

pressures on the environment are at a level compatible with environmentally sustainable development.

Decoupling Air Transport growth from its environmental impacts

The Strategic Research Agenda for an Environmentally Sustainable Transport System

First of all, if we look upon technological option to solve our dilemma, we have got to take into account the work leaded by the European Community Institutions. As a matter of fact, Environmental Efficiency of the European Sky is structured by a Strategic Research Agenda (SRA) which sets out fundamental challenges for the future of aviation (2020). The technical content of the SRA is driven by five challenges: Quality and Affordability, Safety, Efficiency, Security and Environment. The trust of this strategic research is that technology developments can do much to address environmental effects and the following inter-related research goals have been established for the aerospace industry by the Advisory Council for Aeronautical Research in Europe (ACARE):

Concerning environment, the Advisory Council for Aeronautical Research in Europe (ACARE) sets out four generic goals that must be attained for the year 2020:

- to reduce fuel consumption and CO2 emissions by 50%;
- to reduce perceived external noise by 50%;
- to reduce NOx by 80%;
- to make substantial progress in reducing the environmental impact of the manufacture, maintenance and disposal of aircraft and related products.

The main target we are focused on is the objectives of reducing fuel consumption and CO2 emissions of 50%. This reduction has been allocated between the airframe, engine and air traffic management as shown on table 2.

Airlines environmental strategy

Reducing aircraft fuel consumption remains a key business objective for airlines and aircraft manufacturers. Fuel price is the main incentive to reduce its consumption. It is a growing cost for airlines; with the recent rise in fuel prices, it can represent up to 25 % of their cost structure (especially for Low Cost airlines). Even if airlines can use futures commodities to cover this rise, the price of jet fuel is a stringent constraint to enhance energy efficiency. Even if aircraft fuel efficiency has improved by some 70% over the last 40 years, it is now expected to increase only at a rate of around 1-2%. More and more airlines have fixed objectives in that direction. For instance, Air France seeks to limit the growth in CO2 emissions to the half of the traffic growth in PKT and for that need to maximize its fuel efficiency. Fuel efficiency objectives have been fixed by almost all Legacy Carrier, at different level and different timeframe, as shown on table 3.

Airlines	Fuel efficiency objectives	Period	liters per 100 passenger kilometers
Air France-KLM	NA	NA	3.5
British Airways	+ 30%	1990-2010	3.8
Lufthansa	+ 38%	1991-2012	4.29
Japan Airline	+ 20%	1990-2010	N.A.

Table 3: *Energy efficiency objectives of Legacy Carriers [Sources: environmental report 2004-2005]*

Airlines have many means to attain those environmental objectives. They can be summarized in three main categories listed in table 4(on next page).

Air Transport Management and Air Navigation Service Provider

Usually Air Traffic Management (ATM) issues were mainly about safety. During the 90s, came interrogations about capacity and delays. Nowadays, bit by bit, ATM has to enlarge its role and manage broader issues, such as environment. The first environmental concern was noise, because it was the more stringent environmental externalities, blocking the development of airport infrastructure and mobilising State organisation and resident associations.

The reduction of air traffic-related effects of aviation on the environment has been defined as one of the major strategic objectives of ATM 2000+ : This environmental strategy is aiming "to work with ICAO and its Member States to obtain improvements in ATM, in particular the accelerated implementation of CNS/ATM concepts, procedures and systems which help to mitigate the impact of aviation on the environment." Furthermore, at their sixth meeting on the Air Traffic System in Europe, the ECAC Ministers of Transport reaffirmed their commitment "to develop air traffic services so as to maintain safe, cost-effective and environmentally sustainable Air Transport".

Responding to this demand, an environmental policy and strategy has been adopted within Eurocontrol in 2001. It is aiming at studying policy options to limit or reduce GHG from civil aviation, promote the harmonization and integration of environmental recommendations, develop and implement the use of new ATM concepts, procedures and systems that "while enhancing safety, capacity and flight efficiencies, will bring environmental benefits, including improved environmental assessment

Contributors	Specific contributions to fuel consumption reduction	Means investigated
Airframe	20-25%	Aerodynamics, weight reduction, new aircraft concept
Engines	15-20%	Increased thermal efficiency, increased propulsive efficiency
Air Traffic Management	5-10%	In flight delays, Route inefficiencies and taxiing times reduction

Table 2: *Allocation of the overall targets in fuel reductions [Source: ACARE, 2002]*

methodologies and inventories."

Enhanced airspace management could increase customer satisfaction (by reducing delays), while minimizing the fuel consumption (and therefore, the total amount of gaseous emissions). In that perspective, ATM can contribute to a better environmental balance at a negative cost for all the other stakeholders. One problem lies in the fact that minimizing delays goes mainly by increasing the capacity of the overall network, and one can estimate that it will, in fact, increase the total number of flights per year. Other specific problems come with trade-off issues between different externalities. Methodologies are being built up in order to solve them. Noise and fuel saving objectives may be - and actually are often - in conflict: for instance, remote runways, located for noise protection purposes, can result in lengthy taxi times. Here, the competing objectives put Air Navigation Service Provider in a significant dilemma and requires a sensible and sustainable trade-off between those different environmental externalities.

Flight Operational procedures	Use of Ground Power Units (GPUs) for aircraft parked at airports
	Expanded use of fuel economy reclearance method
	Continuous use of flight simulators in place of aircraft in flight crew training
	Use of improved cruise performance monitoring system, Optimal control of aircraft centre of gravity
	Selection of optimal flight altitude, flight speed and flight route, (with CNS/ATM)
	Determination of the optimum fuel load in the flight planning phase
Airline Network Optimization	Increase load factor by optimization of Airlines network (Hub and combined network)
	Constant fleet renewal
Others	Simplification of logistics (local purchase of cabin service goods and cargo fittings)
	Fuel-saving in aircraft maintenance work through efficient engine testing
	Reduction of volume and weight of goods loaded (weight reduction of cabin service goods, and optimal quantity of potable water)

Table 4: *Means summary for increasing fuel efficiency of airlines (IATA, 2005)*

Airports operators

In a general way, airports are already aware of many environmental issues. Environmental local impacts and their public perceptions already constrain growth at many airports in Europe (Upham, 2003). These environmental limits are inherent to environmental capacity of an airport. Airports Council International (ACI) has dealt with the environmental problems and has published a Policy Handbook with a proposed specific and detailed policy regarding airports and the environment. The overall recommendation for implementation of an environmental management system reads as follows:

"Airports should adopt an environmental management system to enable a systematic approach to the management of environmental issues associated with their operation, development". (Source: ACI)

That type of environmental management is based on detailed objectives, standards and practices for noise, emissions, air quality, etc… Nevertheless, Climate Change and GHG emissions seem to be more subsidiary concerns for those kinds of actors, mainly engaged in local issues. Emissions which airports are directly responsible for are few, that implies industrial and tertiary activities (power generator for electricity, heating and air conditioning) and ground handling activities. Implementation of energy efficiency measures are, for those reasons, relatively limited compare to the other group.

Conclusion

For a considerable part of its history, the Air Transport network has functioned on a "cowboy economy" model, in the sense that there has been no important natural resources constraint on growth. This era is now at its dusk and we have to adapt to a "spaceship economy" model where great attention must be paid to the sources of life and to the "dumps" where our waste and emissions are piled. Natural goods that have traditionally been treated as free goods (air, water, soil, quiet, natural beauty…) must now be treated with the same care as other economical goods. The Air Transport "society" could acts in three ways to that challenge the "energy dilemma", which are in fact signals that resource use and pollution emissions have grown beyond their sustainable limit:

The first way is to disguise or deny the signal, claiming the need to save jobs and develop economies. These responses are no more justifiable because the urge is to find sustainable pathway that can gather environmental preservation as well as economic development. This position is still used by many government and business association but their rationales do not refer to sustainability as a whole but only to its economical bottom line.

A second way to respond is to alleviate the pressure from limits by technical or economic fixes without changing their underlying causes (we cans speak here of "weak sustainability"). We have shown that this response is the most commonly shared in the industry sector, where actors claim for more research to enable more efficient use of resources. These measures are urgently needed and most of them will surely ease pressure. But for how long? Will technologies can be

the only response? And do they do anything about the underlying causes of the pressures? Unfortunately, in our case, economic growth outpaces technology and the best hope from engine and airframe technologies will probably be about 1% fuel efficiency per annum, every year for the next 15 years. Likewise ATM could give another 1% plus improvement. The gap between economic growth and environmental progress cannot be close only by technological operations (European Parliament, 1998).

The last way to respond is to acknowledge that the sociotechnical system of Air Transport as currently structured is unmanageable, has overshot its limits and is headed for collapse, and therefore, to change the structure of the system (this is the "strong sustainability" scope). This response is often used by environmentalist to urge the change in the Air Transport network, like the French Green politician Yves Cochet that wrote recently in a book called "Oil Apocalypse" that commercial civil aviation could disappear in the next two decade of this century because of the peak of oil and the related rise in cost of energy .

Finally, with seek of sustainable Air Transport, the sector tries to overcome the apparent conflict between environmental preservation and unrestrained economic growth. Although some countries have shyly tried to adopt policies that seek to curb the growth rate in aviation, nowhere are national or European policies seeking to reduce this activity. Striking a balance between the most optimistic scenarios and the more pessimistic actors demands to think up structural change of the system by multiple ways. Many measures that have to be implemented need strong cooperations between all the "subnetwork" composing the Air Transport seamless web (manufacturers, airports, air transport management and control, airlines). A coordinated action plan needs to be put in place with collaborative decision taken in order to maximize benefits of each measure (such as the Joint Initiative Technology "Clean Sky"). Unfortunately, because of insufficient support tools on making the complete business case for energy efficiency of the network, because of non costed externalities or uncertainties in future energy price, enhancement of environmental efficiency is still under optimised. Therefore, from our point of view, Institutions have a leading role to play in order to implement coherent and transversal regulation mode within the network, and therefore put in place some norms, standards and other market based instrument that could allow optimization by integration of externalities generated by the Air Transport activities. Moreover, the sinuous path to achieve the "sustainability utopia" need to elaborate compromise in a collaborative way, implying not only institutions and industrial economic actors, but far beyond with the participation of citizens, resident, trade unions, university and even more stakeholders in a large political debate about the issue we have just discussed here.

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