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CARBON DIOXIDE EMISSIONS FROM AIR TRAFFIC INTERNAL TO INDUSTRIALISED STATES AND BETWEEN THEM

By the AIR &SPACE ACADEMY –Civil Aeronautics Committee

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Why this study?

In a previous phase of its studies, the Air & Space Academy Foresight Committee projected to 2050 the actual 2010 air traffic and CO_2 emission from aviation worldwide, which showed that the objective of decoupling the emission from traffic was not reached at this horizon.

The present study by the Air & Space Academy Civil Aeronautics Committee, will not change the overall trend, the message of which is not different from all the information published for twenty years on the subject!

Such a repetitive comment seems to demonstrate the failure of the industry to improve aircraft enough to satisfy any decoupling expectation: the objective of this new phase study is to help moving away from this feeling and to open a more productive way forward allowing refining the analysis and its implications, taking on board the political stakes at international and regional levels.

Drawing on a segmentation of the worldwide air traffic, differentiated in the same way as it was considered by the United Nations with respect to CO_2 emissions from fixed installations, this new phase study focuses on projected CO_2 emissions from air traffic internal to the industrialised States and between them.

Aviation has become an unequalled means for developing territories for each State, and, at the same time, its environmental impact has become sometimes severely criticized. The need to mitigate climate change has now been widely agreed all over the world, and is on the agenda of the United Nations! They have not distributed aviation emissions between States, contrary to what they did for emissions from fixed sources: they have entrusted ICAO to take care of mitigating civil air transport emissions.

ICAO in turn, and after lengthy negotiations, did not alter its resolution not to tax international aviation fuel as already specified in the Chicago Convention which rules bilateral air rights

agreements between States, and recommended to include international aviation carbon dioxide into open emissions trading systems.

ICAO now contemplates to limit international aviation CO_2 after 2020 according to modalities to be adopted from 2016 onwards.

Fixed installation emissions so far were managed by the United Nations according to the Kyoto Protocol, adopted to bring down the 2012 world emissions levels of 6 greenhouse gases to their 1990 levels. The Protocol differentiated the reduction goal of the States according to their level of industrialization: it published a list of industrialized States which were requested to reduce the concerned emissions from the fixed installations located in their territories.

Considering that the Chicago Convention prohibits discrimination between operator flags in bilateral air rights, such a differentiation, added to the fact that amongst the 6 greenhouse gases, CO_2 is the only one directly emitted by aircraft, incites to consider aviation emissions according to the origin-destination of each couple of States, depending whether both are industrialized or not: i.e. to isolate amongst the worldwide aviation CO_2 emissions, those internal to Industrialized States and between them, and to forecast their evolution to the 2050 horizon chosen by the Air & Space Academy Foresight Committee.

The goal then is neither to advocate any similarity with fixed source emission already dropped by United Nations, nor to inspire any new regulation, but to report aviation CO_2 variations in a differentiated way because aviation segments have different variations.

Traffic is generally detailed by national flag according to the national authority which manages it when the aim is to quantify particular operated flows, whatever the flag!

The Committee performing the study would neither have the competence nor the right to rank States by industrialization level: it uses the available list established by the Kyoto Protocol at the time, knowing that the existing list is based also on politic position! 38 so-called industrialized States are identified in the Annex 1 of the Protocol: USA, Canada, Japan, Australia, New-Zealand, Russia, Ukraine, Island, Norway, Switzerland, Monaco, Liechtenstein and European Union less Cyprus and Malta[1]. The work then consists in quantifying the variations of the aviation CO_2 emissions from the commercial flights internal or in between these 38 States.

Preliminary work analysed the data already available, the 2007 IATA flows between the 8 IATA regions of the world, the ICAO 100 largest national traffics in 2011 and 2012 and the 20 years history of the 6 ICAO regional traffics. Based on the data interpolated or extrapolated as required, , the contribution to CO_2 growth due to traffic growth , internal to industrialized States and between them, appears to be less than the contribution to the CO_2 reduction experienced by their renewed fleet, as operated on its network, eventually restructured. Therefore, resulting CO_2 emissions from this part of the world traffic, hereunder designated as "industrialized traffic" for simplicity, would not exceed in 2012 their 1996 level.

[1] Germany, Austria, Belgium, Denmark, Spain, Finland, France, Greece, Ireland, Italia, Luxembourg, Holland, Portugal, United Kingdom, Sweden, Estonia, Latvia, Lithuania, Hungary, Czech Republic, Slovakia, Slovenia, Poland, Bulgaria, Romania and Croatia

Traffics

1996 and 2012 ICAO annual publications provide passengers and freight kilometers traffics of the 6 regions (Europe, North America, Latin America, Africa, Middle East, Asia Pacific), the 100 greatest domestic and international scheduled traffics by national flag, thus identifying traffics to and from Industrialized European States with an uncertainty less than 0,5%, and the worldwide non scheduled international passengers kilometers.

North America is composed of 2 industrialized States among the 38, Canada and USA, Asia-Pacific contains 3 of them, Japan, New Zealand and Australia, whereas most of European States (33)are industrialized States, and the 3 other ICAO regions do not contain any. Domestic traffics are part of intra-regional traffics while international traffic is divided into intra-regional and inter-regional traffics.

Fig 1: ICAO Annual Traffics *(M millions, PK passengers kilometers, TK tons kilometers, i international)*

ICAO 2012	*MTK*	*iMTK*	*MPK*	*iMPK*	*MTK fret*	*iMTK fret*	*MTK poste*	*iMTK poste*
Japan	18858	12106	138059	61361	7036	6096		
North America	175321	70593	1452654	488012	41070	25127		
South-West Pacific	19056	12512	161235	93549	3658	3486		
Industrialized Europe	168223	153172	1361670	1210100	39546	38621		
Asia-Pacific	221602	149770	1632962	906975	71817	63350		
Europe	180515	163625	1466623	1295433	41479	40534		
ICAO scheduled traffic	854831	627917	6762869	4560516	182429	156302	4997	3488
OACI non scheduled traffic				225378				
ICAO 1996	*MTK*	*iMTK*	*MPK*	*iMPK*	*MTK fret*	*iMTK fret*	*MTK poste*	*iMTK poste*
Japan	19242	13699	141634	79081	6802	6040		
North America	114804	40411	970147	286664	23342	13568		
South-West Pacific	10619	7664	88728	59433	2312	2107		
Industrialized Europe	81105	69722	576449	464275	25397	24632		
Asia-Pacific	85546	67716	605967	417045	30606	28339		
Europe	82738	71117	591750	474837	25639	24860		
ICAO scheduled traffic	314680	204870	2411010	1363350	88810	75200	5890	2550
OACI non scheduled traffic				204700				

Annual IATA publications provide passengers and freight kilometers traffics flown by operators of the organization, internal and between 8 regions of which 4 are also ICAO regions. The 4 others compose, 2 by 2, the 2 other ICAO regions: ICAO Asia-Pacific is composed of 2 IATA regions, Asia, containing Industrialized Japan, and South West Pacific, essentially composed of 2 Industrialized States, Australia and New Zealand. Intra-regional traffics distinguish domestic traffics (not accounted since ICAO provides them per State) and international ones. Interregional traffics are trans-oceanic traffics: IATA flows do not cover entirely ICAO traffics. The IATA reporting was changed in 2012 and the number of regions increased from 8 to 9 by the partition of Africa into North and South Africa. The partition leads to 2 flows instead of 1 between Africa and Europe: the data from 8 regions in 2011 were used and the variations from 2011 to 2012 (the 2012 & 2011 cells of the following table, Europe/Africa and Africa/Europe are then used, one with the North flow , the other with the south flow).

Fig 2: IATA Annual Flows, passengers and tons kilometers, interregional & intra-regional international in MPK and MTK

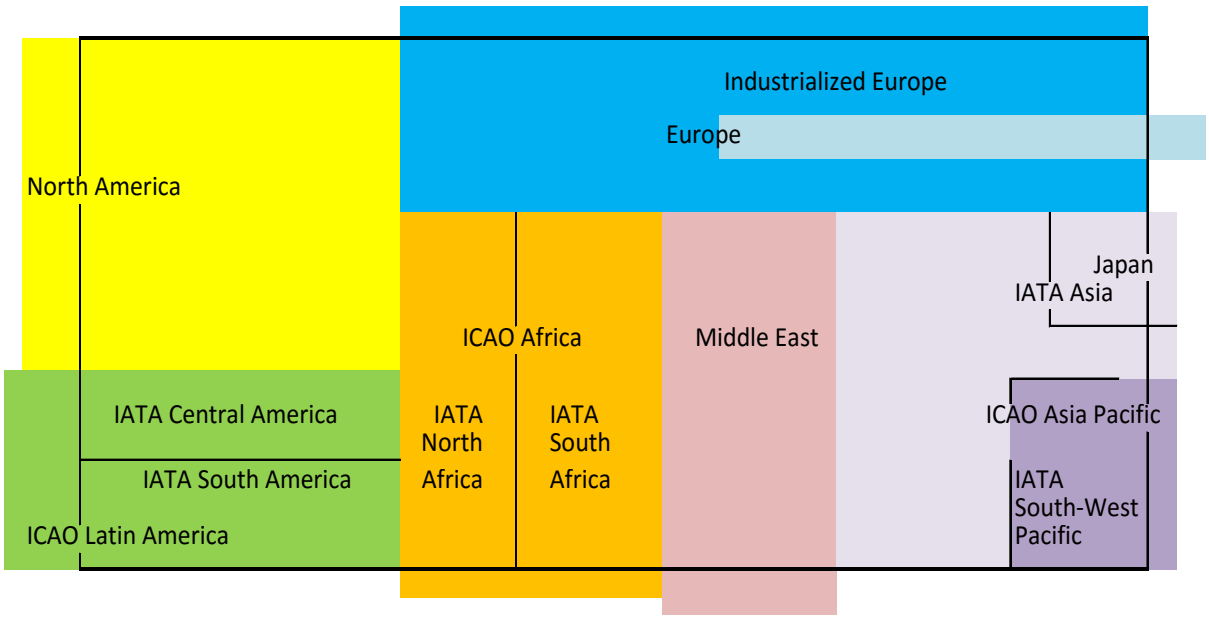
Passengers 2011	North A.	Central A.	South A.	Africa	Europe	M. East	Asia	South-West P.
North A.	17119	79469	60706		456227		226149	66222
Central A.		4079	14102		78882			
South A.			22260		89469			
Africa				16481	80609	34111	16208	3306
Europe				18359	224726	114741	331344	24992
M. East						21339	158252	
Asia							242867	87977
South-West P.								11043
△% 2012/2011								
North A.	2,7	5	7,7		2,7		6,4	5,5
Central A.		4,8	24,3		0,5			
South A.			17,6	6	0			
Africa				14,9	1	17,9	7,9	1,6
Europe				18,6	5,3	12,9	6,2	0
M. East						9,1	10,6	
Asia							11,2	5,5
South-West P.								3,1
Freight 2011	North A.	Central A.	South A.	Africa	Europe	M. East	Asia	South West P.
North A.	39	735	2462		17930		27602	1218
Central A.		1	382		2121			
South A.			454		3462			
Africa				325	4076	1673	514	99
Europe				285	1072	6113	31666	701
M. East						635	6453	
Asia							13168	4096
South-West P.								32
△% 2012/2011								
North A.	4,3	-3,9	-1		-2,2		-5,4	1
Central A.		2,4	-6,6		4,2			
South A.			29,9	-8,3	0			
Africa				6	-3	10	-2,7	-12,4
Europe				12,9	-2,5	15,2	-4,5	0
M. East						14	15,2	
Asia							2,5	2,2
South-West P.								-5
Passengers 1996	North A.	Central A.	South A.	Africa	Europe	M. East	Asia	South-West P.
North A.	18100	24440	24285	4479	216184	4127	124067	20193
Central A.		2264	1233		32767			
South A.			3274	467	21249		3882	
Africa				4270	52683	6328	5032	1403
Europe					106932	27594	140092	23635
M. East						2541	24680	
Asia							88143	50669

South-West P.								5656
Freight 1996	North A.	Central A.	South A.	Africa	Europe	M. East	Asia	South-West P.
North A.	410	294	1079	86	12317	1367	12058	768
Central A.		24	12		1221			
South A.			79	9	1415		16	
Africa				110	2589	197	166	51
Europe					1318	1782	14622	815
M. East						158	1305	
Asia							5359	2221
South-West P.								213

Each of the ICAO regional traffics is hereunder represented by a colored rectangle (schematically located more or less where continents are), and the IATA flows between 2 regions are globally contained inside the black lines parting the ICAO rectangles. The areas in this view only provide a qualitative presentation, as the traffic scale has not been taken in account accurately.

On the basis of almost balanced bilateral operations, traffics of flags operating IATA international flows are about proportional to those published by ICAO: they constitute the very major part of them. Then it is legitimate to extrapolate IATA productions to ICAO productions, for passengers as well as for freight.

Fig 3: ICAO Regional Flags & IATA Interregional & Intraregional Flows



The part of the international IATA flows to and from Europe, corresponding to those to and from European Industrialized States should be isolated, proportionally to traffics compared with the European traffic, ~93% in 2012. With the same approach, those to and from Japan included into those to and from Asia, are identified proportionally to the Japan traffic compared with the Asian traffic, ~9% in 2012: such assumption is the most uncertain in terms of computed result, but the effect on total traffic should be very minor.

The flows internal and between 4 industrialized Regions, North America, South-West Pacific, Japan and Industrialized Europe, are thus quantified in 1996 and 2012: the 2012 values have to be projected to 2050 as closely as possible to what the Air and Space Academy Foresight Committee did for their worldwide data projection.

The part of the industrialized traffic in the world traffic, passengers and freight expressed in tons kilometers, is almost halved, from 60% en 1996, to 32 in 2012. And the 2012 Industrialized traffic is 1,44 times the 1996 similar traffic.

Fig 4: "Industrialized States" Annual Flows (MTK)

2012		North A.	Industrialized E.	Japan	South-West P.
	North A.	106513	42768	2738	3780
	Industrialized E.	30413	49320	3302	1406
	Japan	2288	3615	10878	547
	South-West P.	4104	2147	680	7587
Total	272086				

1996		North A.	Industrialized E.	Japan	South-West P.
	North A.	77241	23511	3855	1582
	Industrialized E.	20127	28353	4428	1775
	Japan	3174	4424	10077	920
	South-West P.	1735	2220	1177	3839
Total	188439				

The extrapolation factors used for North America and Europe in such extrapolation from 2010 to 2050, have obviously to be applied to flows internal to North America and Industrialized Europe and between these 2 regions, corrected to take in account the 2 years less from 2012 to 2050!

In addition, the worldwide extrapolation did not consider the geographic disparity of prices: the present work will not either. The same applies to average distances flown intra- or inter-regionally during the period concerned. The 2050 to 2012 factors of the worldwide extrapolation for which the GDP ratios are the closest, are then applied to flows concerning Japan, Australia and New Zealand, correcting them proportionally to these ratios. The largest uncertainties bear on minor parts of the traffic only.

Fig 5: 2012 to 2050 Extrapolation Factors

	North A.	Industrialized E.	Japan	South-West P.
North A.	**1,755**	**1,284**	0,939	1,748
Industrialized E.	**1,284**	**0,941**	0,8386	1,280
Japan	0,939	0,8386	0,7476	0,936
South-West P.	1,748	1,280	0,936	1,742

Fig 6: 2050 Industrialized States Flows of Traffic (MTK)

	North A.	Industrialized E.	Japan	South-West P.
North A.	186881	54927	2571	6608
Industrialized E.	39059	46393	2769	1799
Japan	2149	3032	8132	512
South-West P.	7175	2748	637	13218
Total 378611				

2050 industrialized traffic represents **1,39** times the 2012 corresponding traffic.

CO_2 Emission

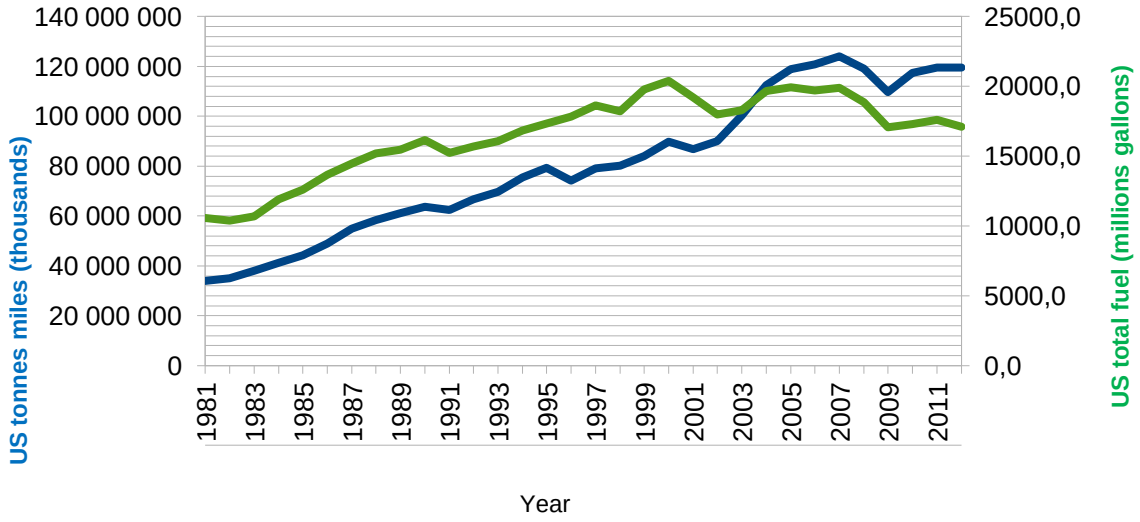
Specific emissions, i.e. CO_2 tons per carried ton kilometer, must be known in order to infer CO_2 emissions from traffic. The work of the Foresight Committee estimated a worldwide improvement such that the 2050 figure was ~65% of 2012: this improvement (due to the fleet renewal, the fleet operation and the optimization of the network) has been applied to the traffic internal to the 38 considered Industrialized States and between them: this assumption is acceptable as long as the fleet operating the industrialized traffic is composed similarly to the world fleet is. With this assumption, the 2050 industrialized traffic CO_2 emissions are less than in 2012: they reach 90%[2], combining the industrialized traffic variation with the variation of specific emissions.

Regarding the 1996-2012 period, the European Union never acknowledged any decrease of the EU flags aviation CO_2 emissions: the reporting by its operators gives indications but they are altered by the consolidation which occurred. World operators such as AF then AF/KL, BA or LH reported each year the improvement of their world specific emissions. As far as they are concerned, the published US flag CO_2 specific emissions, show a clear reduction of the same order of magnitude as the ones from European world operators (see next graph): 2012 CO_2 emissions are equal to 1995 ones, although the traffic was 1,6 times greater [see http://www.rita.dot.gov/bts/sites/rita.dot.gov.bts/files/subject areas/airline information/index.html - *Consumption:* http://www.transtats.bts.gov/fuel.asp - *1981-1995 Statistics:* http://www.rita.dot.gov/bts/sites/rita.dot.gov.bts/files/subject areas/airline information/air carrier_traffic_statistics/air traffic/annual/1981_present.html -*1996 to 2012:* http://apps.bts.gov/xml/air_traffic/src/index.xml#CustomizeTable]

Then the most relevant data for the improvement of the specific emissions of the industrialized fleet in the 1996- 2012 period, are those published by USA for their own fleet, considering in addition that North American flag produces more than half of the industrialized traffic. Emission variation internal to the 38 States and between them, has therefore been computed using the improvement of the CO_2 specific emissions from the US fleet during the same period of time, those of 2012 representing 59,5% of 1996 ones.

[2] 1,39*0,65=0.90

Fig 7: US Traffic and fuel consumption from 1981 to 2012



Between 1996 and 2012, multiple crises of the air transport industry and many mergings or bankruptcies modified the ratios of freight or of medium haul traffic in the total traffic, freight and passengers, or medium and long haul, then also modified the specific consumption of the operations: its variation may be assessed. During that time, the proportion of the medium haul traffic in the US traffic decreased by 2 more percents than the corresponding ratio in the industrialized traffic, and the proportion of the freight in the US traffic increased by 4 more percents than the same ratio in the industrialized traffic. These 2 variations reduce the improvement of the CO_2 specific emissions of the industrialized traffic compared to the US one. The freight specific consumption is, aircraft type by aircraft type, the 2/3 of the passenger one and those of the medium haul fleet is about the 3/2 of the contemporary long haul fleet. The improvement of the industrialized fleet is therefore reduced by 1,8 points compared to the improvement of the US fleet, 1,3 for the freight impact and 0,5 for the medium haul impact. The 2012 specific consumption of the industrialized traffic is then 61,3% of what it was in 1996.

From 1996 to 2012, CO_2 emissions of the industrialized traffic decreased from 100 to 88%[3] (product of the industrialized traffic variation : factor 1,44 - see above - by the variation of the specific consumption: 0.613), thus decoupled from the traffic growth! In fact the curbing takes place slightly earlier: it is not indispensable to clarify the accurate date, particularly when taking in account the fact that the achieved 2013 and 2014 environmental productivity will have still placed the decoupling origin at a more remote date, during the first half of the nineties. 2050 industrialized traffic CO_2 will then be 80%[4] of what it was in 1996 (combining the variation observed between 1996 and 2012, 88%, with the variation observed between 2012 and 2050, 90%, see above), a smaller level than it was in the middle of the 1990s decade!

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[3] 0,613*1.44=0,88

[4] 0.88*0.90=0.80

The next 2 figures hereunder show the results of traffic and CO_2 emission variations, expressed as proportions of the 1996 levels. The worldwide data of the Air and Space Academy Foresight Committee are added in the same graph.

Fig 8: Worldwide & Industrialized States Air traffic Variations

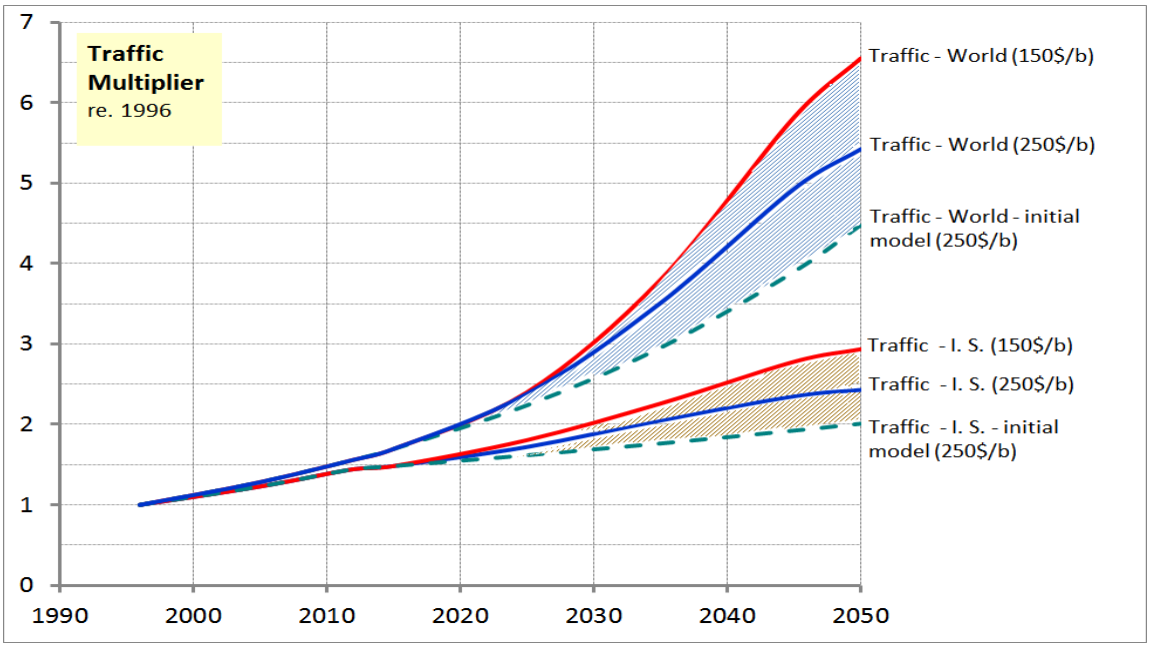
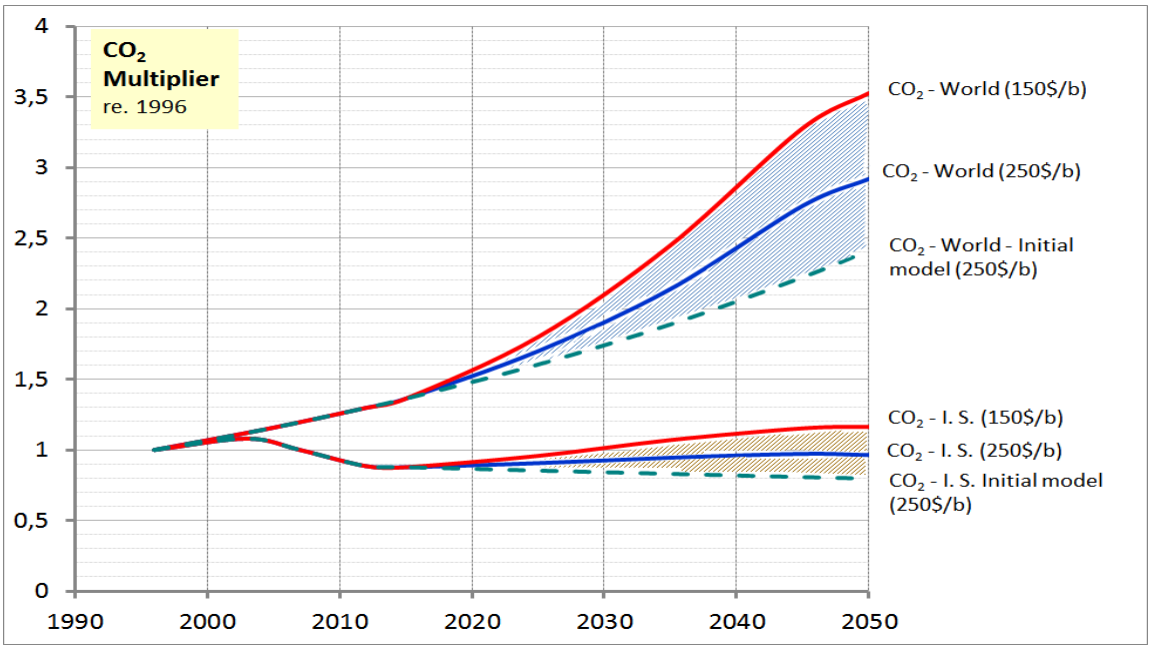


Fig 9: Worldwide & Industrialized States CO_2 Variations



If this result had been anticipated, it could have avoided to the European Union to try unsuccessfully to include international aviation into its Emission Trading System.

Obviously, the decrease of the industrialized CO_2 depends upon the projection made for the 2050 GDPs for which the Civil Aviation Committee has applied the same methodology previously followed

by the Foresight Committee (same GDPs for the results derived from the initial traffic modelling, shown with a dotted line, but updated GDPs for the other results). Nevertheless the decoupling is very likely because it would still be observed even if the industrialized traffic growth was 37% greater than projected (based on the initial traffic modeling). And there is no reason why the moderate traffic growth combined with the specific emission improvement which causes the decoupling would not prolong it after 2050.

Conclusions

United Nations did not implement GHG compensation mechanism, except those between 2 States when the Kyoto Protocol was enforced, for the fixed installations of their territories: these mechanisms only targeted reductions obtained by investments of an industrialized State in another State (Clean Development Mechanism or Joint Implementation), excluding any other means or perimeter.

ICAO already recommended including international aviation emission into open emission trading systems possibly organized by States between their different emitting sectors (2004 General Assembly). The Organization also contemplates the use by aviation of bio-fuels, the fabrication of which would not compete with food agriculture: the bio-fuel buyers would compensate the part of their CO_2 emissions resulting from their combustion, so as to balance if necessary the quantity of CO_2 absorbed during the fuel production by their vendors. We are not distinguishing here the use of bio-fuel from other compensation means.

If ICAO specified in the future any limit for international aviation CO_2 without recommending also worldwide regulatory compensation mechanisms available to international air transport operators, its Member States would be obliged to reduce the mobility of its citizens! Such a constraint has very little chance to lead to a world consensus. The most credible assumption is that beside the limit, means of compensation will be organized as the Foresight Committee has already anticipated.

Yet the industrialized States sustain only frail economic growth and weak demography which limit the air mobility demand in these regions and between them: the improvement made by the renewal of their fleets then is enough to decouple the CO_2 emissions from the corresponding mature traffic.

The report does not aim at closing one's eyes to the global trend, neither at trying to reject the resulting guiltiness on some States rather than on others. The principle of differentiated responsibility introduced for fixed installation emission as well as the decision by the U.N. not to allocate air transport emission to states, would in any case exonerate them.

It allows to assume that, as some industrializing states become in turn industrialised, the likely natural evolution of factors and effects should tend to moderate their air traffic and CO_2 emission growth beyond 2050, similarly to industrialized States to-day, therefore with an overall moderating effect worldwide in the long run. Consequently, the measures to be taken in order to control aviation CO_2 emissions could therefore be contemplated within an evolutionary frame, anticipating the extinction of carbon compensation system with the progressive decoupling from traffic, and avoiding to sustain any penalising system, disregarding in particular any discriminatory measure not respecting the spirit of international agreements.

It should be kept in mind that the growth of the air transport operated by the flags of the industrialized States comes essentially from the bilaterally operated links between them and the other industrializing States around the world.

Bilateral agreements have historically preserved to local flags the access to a vital market that world operators, benefitting of larger investment or skill, would have, otherwise, , confiscated at that time. To-day also, in return, these very agreements bring to world operator of industrialized State flags, access to a demand which shall have to be satisfied in spite of the existing competition biased by social charges for the benefit of their staff or of the suppliers' staff on their feeders network. The bilateral agreements protected equitable access in the past, they should keep maintaining this equal balance to-day and in future.