Flying in 2050

AVIATION IN A WORLD UNDER CONSTRAINT

SUMMARY

MARCH 3, 2021

SUPAERO DECARBO

THE SHIFT PROJECT

With the contribution of:

CITOYENS POUR LE CLIMAT

THE SHIFTers PROJECT
THE CARBON TRANSITION THINK TANK
Les Bénévoles

Editorial

Few industries, other than aviation, occupy such a unique place in the energy transition landscape. High-tech industry with negligible climate impact for its advocates, fad of the ultra-wealthy prone to minimise their emissions for its detractors, it generates polarising opinions and sometimes useless oppositions.

The authors of this report support the idea that another voice must be heard beyond these extreme positions.

In May 2020, a first report named “Crisis, climate: preparing aviation’s future” offered a series of carbon-free measures that the government could demand in return for its support to the industry. By targeting immediately actionable measures with significant effects as soon as 2025, this report supported the idea that the recovery of an industry severely impacted by the crisis was not incompatible with the launch of an effective decarbonisation policy. On the contrary: it argued that delaying the energy transition of aviation makes it all the more vulnerable to the threat of climate change.

The nine months that separated us from this publication have been marked by contrasting events. Although Airbus has committed to producing a hydrogen-powered aircraft in 2035, although the public statements made on the decarbonisation of aviation have multiplied, the health crisis has continued, impacting the financial balance of many actors now facing an unprecedented risk of bankruptcy. But in these nine months we have also seen many voices rise, those of engineers, pilots, air traffic controllers, airline employees and aviation users who saw themselves reflected in the speech of the Shift Project’s report. Expressing their interest in the process, highlighting its shortcomings and limitations, led many of them to wish for a deeper analysis.

These are the contributors to this new report: professionals in the industry, eager to confront the distressing but inevitable question of how to act today to keep on flying tomorrow in a world under constraint. If no one disregards the suffering and helplessness created by the COVID-19 crisis, there’s unfortunately much worse threats looming in climate change, depletion of fossil energies and the collapse of biodiversity on human life in general, and on aviation in particular.

All of us who love aviation and those of us who have made it their job, all of us who love technical matters, great discoveries, all this prodigious human intelligence dedicated to fly machines, we affirm that we love even more life, nature and science - that very science which also rigorously describes the aerodynamic and climatic phenomena, this very science we cannot on the one hand enjoy the benefits from and on the other ignore the upheavals it predicts.

We, aeronautical engineers, pilots, air traffic controllers, air companies employees, users or simple aviation lovers, tired of polarizing speeches it suffers from, we sign-up this report with the ambition of creating the conditions for a peaceful debate on its ability to drastically reduce its greenhouse gas emissions, in proportions compatible with a viable world in 2100. We, climate-related aero-lovers, claim that we can be part of the solution rather than the problem, by carrying a transparent, disinterested and scientifically supported speech on what the aviation industry can - but also cannot – do to decarbonise itself.

The editorial board

Read the press release

Editorial committee

Editorial team

N.B. The professional status of some team members drives them to remain anonymous. Moreover, all contributors speak on their own behalf and their words in no way should reflect those of their respective company or association, exceptions made of The Shift Project, the Shifters, Citizens for the Climate and SUPAERO-DECARBO. The representatives of the latter carry an independent voice from the Higher Institute of Aeronautics and Space (ISAE-SUPAERO) which does not engage it in any way.

Ange **BLANCHARD** (*ISAE-SUPAERO student*), Jeanne **BOSC BIERNE** (*ISAE-SUPAERO student*), Angela **BOVO** (*Engineer SUPAERO, Member of SUPAERO-DECARBO collective*), François **CAMILLERI**, (*Aeronautical engineer, Member of Sciences Pole of the Citizens for the Climate collective*), Grégoire **CARPENTIER** (*SUPAERO engineer, Co-founder of the SUPAERO-DECARBO collective*), Olivier **COEURDRAY** (*SUPAERO Engineer, Member of SUPAERO-DECARBO collective*), Maximilien de **POMMEROL** (*ISAE-SUPAERO student*), Olivier **DEL BUCCHIA** (*Engineer SUPAERO, Co-founder of SUPAERO-DECARBO collective*), Xavier **DEVARS** (*Airline Pilot*), Soizic **ESNAULT** (*PhD student in fluid mechanics*), Louis **FIEVET** (*Former aeronautical engineer, Member of SUPAERO-DECARBO collective*), Yohann **GIRARDEAU** (*ISAE-SUPAERO student*), Bich **HA DUONG** (*SUPAERO Engineer, 16-years airline career, Member of SUPAERO-DECARBO collective*), Nicolas **HUBERT** (*Aeronautical engineer, Member of SUPAERO-DECARBO collective*), Clément **JARROSSAY** (*Aeronautical engineer*), Auriane **JOUDIOU** (*ISAE-SUPAERO & Sciences-Po Paris student*), Alix **LAGET** (*Air traffic controller*), Julien **MARCINKOWSKI** (*Aeronautical engineer, Energy and climate trainer*), Florian **NGUYEN** (*Aeronautical and space engineer*), Florent **NOBELEN** (*Aeronautical engineer, Member of SUPAERO-DECARBO collective*), Marie **REBIERE** (*ISAE-SUPAERO student*), Jules **RICHARD** (*Aeronautical engineer, advisor in mobility, Member of SUPAERO-DECARBO collective*), François **ROBERT** (*Aeronautical engineer, Student in Arts and Politics at Sciences Po, Member of SUPAERO-DECARBO collective*), Elisabeth **WOELDGEN** (*Aeronautical engineer*).

Wished to remain anonymous: Guillaume (airline pilot), 6 aeronautical engineers, 1 airline company former board member.

Proofreading / Consulting

Loïc **BONIFACIO** (*ESTACA Engineer*), Sigrid **CLAVIERAS** (*SUPAERO engineer, Union of public transport and railways, Member of SUPAERO-DECARBO collective*), Maxime **EFOUI-HESS** (*SUPAERO Engineer, Member of SUPAERO-DECARBO collective, Project manager at THE SHIFT PROJECT*), Yves **FOUQUART** (*Former Lille University professor, Former member of scientific committee at World Climate Research Council Program and co-editor of IPCC 3rd report*), Nicolas **GOURDAIN** (*Professor at ISAE-SUPAERO, Member of SUPAERO-DECARBO collective*), François **NEGRE** (*Air traffic controller, ATM expert for European Union research*), Nicolas **RAILLARD** (*THE SHIFT PROJECT Project Manager*), Yannick **SALEMAN** (*Employment, Finance and Macroeconomics Project Manager at THE SHIFT PROJECT*), Antoine **THEBAULT**, Léa **FOURCADE** (*Graphic designer*), Édouard **LAFORE** (*Graphic designer*).

Wished to remain anonymous: An aeronautical engineer, a member of the DGAC, a member of the ICAO, a person working in IT solutions for airlines and the travel sector, Manager in Strategy.

Table of contents

1 Context

The airline industry is currently hit by the worst crisis in its history, affecting all actors with never seen before risks of trickle-down bankruptcies, job and know-how losses[1]. In the long run, **climate risks, bundled with the depletion of fossil fuel resources, threaten the entire world economy.** More than ever, anticipation and transformation become a matter of survival in tomorrow's low-carbon world, in the aviation industry as in every other.

In 2018, global civil aviation emitted ~1.1 Gt of CO_2 [2], upstream included, i.e. **~2.56% of global CO_2 emissions** (agriculture, forestry and other land use included) [3]. Despite continuous improvement in aircraft fuel efficiency, **CO_2 emissions increased by 42% between 2005 and 2019** [4] **solely due to air traffic growth.** Taking post-COVID crisis growth projections announced by IATA into consideration [5], keeping those emission levels under control is a concern of utmost importance.

Air transportation also contributes to climate change by rejecting other GHG (Greenhouse Gases). **In 2011, aviation contributed – including all effects on top of CO_2 emissions – to around 3.5% of the net effective radiative forcing; in 2018, the share of the non-CO_2 effects over radiative forcing was twice as high as that of CO_2 alone** [6]. However, there is not yet any consensus on a robust metric to describe the impacts of those non-CO^2 effects on climate, considering they work under significantly different dynamics and time scales. We present the status of current scientific knowledge on non-CO^2 phenomena [7], but on the premise of robust calculations and long-term projections, all quantitative studies focus on CO^2 emissions alone. The assessed climate impact must therefore be considered as a minimum. It is reminded that any technology or strategy to reduce emissions of the air transport industry must consider the whole span of the different phenomena.

Let us recall that, despite its democratisation efforts, air transportation remains the prerogative of a minority of people, among the wealthiest. **Only 10% of the world's population travels by plane every year** [8] **and, in 2018, only 1% of the world's population represented 50% of aviation-related emissions** [9]**.** Reduced to the number of single travellers, these levels of emissions take a whole different scope.

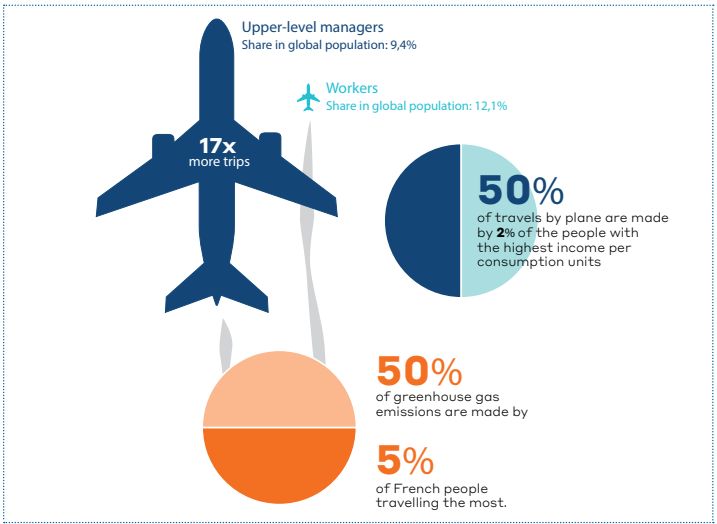


Chart #1 - An over-representation of the upper socio-professional category in air transportation [10]

2 Key objectives of the report

1. To offer the **definition and the establishment of a carbon budget** for air transportation
2. To assess the measures of decarbonisation proposed by the sector through a **scenario analysis**
3. **To proof-test our two decarbonisation scenarios** against the carbon budget, in order to draw proper conclusions
4. To list the decarbonisation actions that can be rapidly implemented nationwide
5. To integrate the impacts on jobs in the sector

We have taken a holistic approach that covers the technological, energetical and organisational prerequisites as well as the impacts on usages, jobs, and infrastructures. Aspects related to the consumption of non-energy resources and to the transition funding are well identified, but their estimation will be subject to a further study (see full report). The Methodological Note accompanying this study will be published in spring of 2021.

1. See full report §5.8 and appendix 3
2. Quantity of CO_2 alone in 2018 (without taking into account other Greenhouse Gases) of 905 $MtCO_2$ (excluding upstream) taken from the "June 2020" table in IATA, Airline Industry Economic Performance – June 2020 – Data Tables. Other sources provide different values but of the same order of magnitude, which is sufficient for our study here: 918 Mt according to the ICCT, 905 Mt according to the EESI, or 918 Mt according to ICAO.
3. 42.1 $GtCO_2$ emitted worldwide in 2018 according to Global Carbon Project https://www.globalcarbonproject.org/carbonbudget/archive/2019/GCP_CarbonBudget_2019.pdf
4. See Calculation note, source ATAG for 2005 and IATA for 2019
5. https://www.iata.org/contentassets/e938e150c0f547449c1093239597cc18/pax-forecast-infographic-2020-final.pdf
6. The contribution of global aviation to anthropogenic climate forcing for 2000 to 2018, par Lee et al., Atmospheric Environment, 2020, 117834, ISSN 1352-2310, https://doi.org/10.1016/j.atmosenv.2020.117834 (http://www.sciencedirect.com/science/article/pii/S1352231020305689)
7. See full report §5.7
8. Le Monde https://www.lemonde.fr/idees/article/2011/11/01/7-milliards-en-avion_1596821_3232.html
9. The Guardian, 1% of people cause half of global aviation emissions – study, 2020.
10. DGAC survey 2015-2016 https://www.ecologique-solidaire.gouv.fr/sites/default/files/ENPA_2015_2016.pdf + government survey 2008: https://www.statistiques.developpement-durable.gouv.fr/enquete-nationale-transports-et-deplacements-entd-2008

3 Our baseline proposal: establishing a carbon budget for air transportation

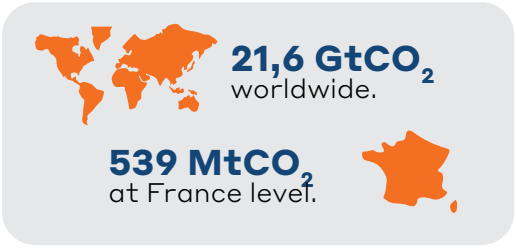
«To contain the global temperature rise within + 2°C compared to pre-industrial levels with a 67% probability rate» is a climate target in line with the Paris Agreement and commonly referred to in scientific publications. **In line with this objective, the IPCC estimates a global carbon budget of 1,170 $GtCO_2$** [11] reduced to 844 $GtCO_2$ for the 2018 – 2050 timeframe.

While the airline industry has set itself the ambitious goal of reducing its emissions by 50% in 2050 compared to 2005 [12], it, however, has not defined a carbon budget. On the other hand, the national carbon accountings exclude international transport, of which the aerial. It is therefore not possible to guarantee the compatibility between the various paths considered by the industry and the global climate target defined by the IPCC.

It is on the basis of this observation that the framework proposal of the study has been formulated, consisting essentially in **defining a carbon budget and a GHG reduction path for air transportation, both national and international, taking into account its impact on climate change as a whole (non-CO_2 effects excluded).**

Thus, **we have defined a carbon budget for international aviation**, i.e. the total amount of GHG that the industry can emit by 2050 to remain within the objective of containing global warming within +2°C by the year 2100. The carbon budget allocated to international aviation could be defined by the ICAO and trickled-down into the Low-Carbon National Strategy [13] as well as in the next revision of contributions at national level (CDN) [14]. In this study, the aviation carbon budget is defined **in proportion of industry emissions in 2018, i.e. respectively 21.6 $GtCO_2$ worldwide and 536 $MtCO_2$ at level of France [15], over the 2018 – 2050 timeframe.**

In this study, **carbon budgets*** of air transportation are defined **in proportion of industry emissions in 2018**, which are, respectively:



4 Decarbonising through technology

Starting from this baseline proposal, we have studied two possible paths for reducing climate impacts of air transportation, paths that are compatible with the objectives of the Paris Agreement.

For this, we have established **two decarbonisation scenarios – through technology – of the aviation industry**, named «**MAVERICK**» and «**ICEMAN**» [16].

- The «MAVERICK» scenario makes very optimistic assumptions on the potential for decarbonisation by technology, but which implies that choices largely in favour of the air transportation industry are made, as well as significant and immediate investments, and which presents a high level of risk in regards to its implementation within short deadlines.

In this scenario, **the worldwide fleet is renewed in 15 years** (compared to an estimated current average of 25 years as per ICAO data [17]), the **production of alternative fuels is at its maximum** (beyond all current projections) [16] and **it is primarily intended for air transportation**.

- The «ICEMAN» scenario considers reasonably optimistic assumptions about the potential for decarbonisation by technology, more spread over time and thus offering more flexibility for its implementation.

In this scenario, the previous scenario is **delayed by 5 years, worldwide fleet is renewed in 25 years** and the air transportation benefits from no more than **50% of the global production of alternative fuels.**

For each scenario, we assessed the carbon impact up to 2050 using a model that takes into account the characteristics of the fleets and their renewal, the gradual incorporation of alternative fuels and the emissions linked to their manufacture. Thus, these scenarios take into account the availability of energy resources.

We assume that air traffic returns to its 2019 level in 2024, and that it then grows by 4% per year until 2050 (2019 – 2039 projection, IATA).

The scenarios are summarised in the table below:

11. See full report §4.2.3, sourced from IPCC SR15, chapter 2
12. ATAG target presented in the ICAO "2019 Environmental Report" (p174)
13. SNBC: https://www.ecologique-solidaire.gouv.fr/strategie-nationale-bas-carbone-snbc
14. See detail of proposal 0 in §6 of the full report
15. See full report §5.9.3
16. See full report §8.1
17. https://www.icao.int/environmental-protection/Documents/ICAO-ENV-Report2019-F1-WEB%20(1).pdf p.279

	MAVERICK	ICEMAN
Energy efficiency gains, both for ground and in-flight operations	The gain in energy efficiency is a reasonable assumption	
Industrial roadmap for new planes' market launches	Aggressive roadmap, detailed by aircraft type, including: • Optimistic technological gains • Launch of short/medium haul hydrogen-powered planes in 2035 • Launch of long-haul plane 100% alternative fuels compatible in 2035	5-year lag from the Maverick scenario
Fleets' renewal rate	Every 15 years	Every 25 years
Alternative fuels priority allocation to air transport (abundant production in both scenarios)	100% of alternative fuels production dedicated to air transportation	50% of alternative fuels production dedicated to air transportation

Reasonable assumptions **Optimistic assumptions** **Very optimistic assumptions**

Conclusions

We have proof-tested these two scenarios against the previously established carbon budget.

Even though the two scenarios «MAVERICK» and «ICEMAN» allow to significantly bend the curve of GHG emissions, **none of them is compatible with the carbon budget assuming 4% year-on-year traffic growth.** Beyond the uncertainties surrounding the achievement of technological targets within the industry, the rate of adoption of innovations in the planes fleet is too slow in the light of climate emergency.

In summary, our work shows that **no realistic scenario can contribute to achieving the goal without reducing traffic growth.**

Holding the carbon budget

To stay within the **above-defined** carbon budget frame, there are theoretically three options left:

- **Bet on even more technical improvement and faster than in the «MAVERICK» scenario:** this is a very risky bet, this scenario is already at a very high limit of what can be expected from technical progress and is already generating considerable energy externalities.

- **Increase the carbon budget of the air transportation industry:** this first requires defining such a budget at international level, steering it and managing inter-industry strong arbitrations to the detriment of other sectors, the overall budget not being negotiable since physically determined. To date, however, there is no international governance supporting such discussions. Moreover, the aviation industry is already in fierce competition with other industries for the access to low carbon resources and to the financing of its development programmes.

- **Lower the traffic hypothesis:** it is essential to integrate this element into decarbonisation trajectories in order to establish a relevant sobriety policy and to anticipate the consequences on employment in the air transportation sector.

Therefore, to remain within the frame of the carbon budget defined above, we must lower the growth rate from 2025 to +2.52% in the "MAVERICK" scenario, and to -0.8% in the "ICEMAN" scenario. If these changes were to be not effective in 2025 and the traffic continued its year-on-year growth of 4%, the effort to be provided subsequently would inevitably be more important. Chart #2 shows the evolution of sobriety effort to be made in order to stay within the carbon budget, depending on the year in which traffic would not increase any longer by 4% per year, whether this would be «spontaneous» or further to an international consensus on growth limitation.

The situation requires both tactical choices to master short-term emissions within the carbon budget, and strategic choices to sustain long-term emissions of the air transportation industry beyond 2050.

Considering a constant carbon budget, the longer we wait, the more consequences on traffic – therefore on the financial health of the aviation industry – will be important.

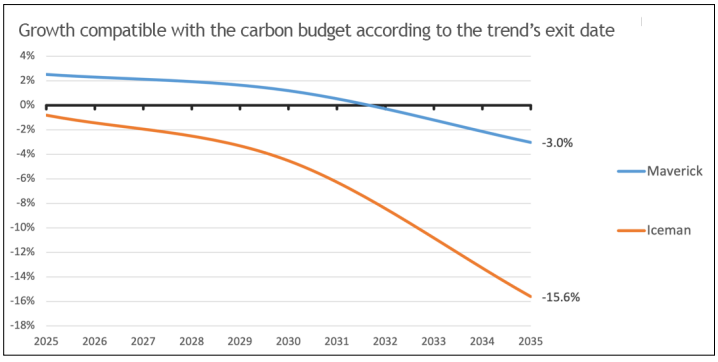


Chart #2 – Evolution of traffic growth compatible with the carbon budget depending on the year in which the trajectory falls off the trend

5 Focus on France: which decarbonisation measures to quickly implement nationwide?

The “MAVERICK” and “ICEMAN” scenarios have been applied at the level of France.

Broken down to the perimeter of emissions in France, the one measured by the DGAC [18], the hypotheses of the “MAVERICK” and «ICEMAN» scenarios differ from the World perimeter on three structuring aspects: the production of bio-fuel, the distribution of the emissions between long-haul vs. short and medium-haul flights [19] and the possible short-term actions, presented below.

A. Run short-term operational efficiency actions

Four emission reduction areas, deployable by 2025, were studied: **decarbonising ground operations, replacing small-capacity turbo-jet engines with turbo-propellers, limiting fuel tankering and reducing flights’ cost index to a minimum.** [20] [21]

But their impact is limited. By 2050, they will only contribute to 4% of the required reduction effort [22]. As shown in the worldwide scenario study, a fixed carbon budget requires finding other short-term reduction measures.

Thus, to meet the envelope of the predefined carbon budget, usage sobriety is required.

B. Run short-term sobriety actions

The reduction in air traffic can be suffered, as it is currently the case, or **proactively anticipated allowing air transport to be sustainable in the long term by controlling its GHG emissions.** Usage sobriety can come from a reduction in offer or in demand.

Therefore, **how can the offer of air transport be adapted to encourage sobriety and complementarity with less emitting modes of transport?**

Four areas of adaptation of the transport offer, deployable in the short term, are studied: **increasing density in the cabins, removing air transport offer when a rail transport alternative of less than 4h30 travel time exists, limiting air traffic for business purposes, and rethinking the “frequent flyer / miles” system** [23] [21].

The implementation of such proposals raises the question of **the usages of air transport, the business model and the marketing positioning of historical airlines.** Again, it is essential that **the legislation supporting those measures does not disadvantage national actors** to the benefit of their competitors. If those measures can be implemented quickly, independently from a technological leap or an industrial programme, they must be part of a long-term transnational policy.

Those sobriety measures have a significant effect on the cumulative emissions curve (-10%) due to their very short-term application (between 2021 and 2025). Thus associated with the technical measures, they would allow to push back the consumption date of the carbon budget by about a year.

In any case, however, the level of sobriety provided by those measures does not allow to remain within the budget.

C. Go further in sobriety

To remain within France›s carbon budget, the growth rate from 2025 must not exceed +0.71% in the «MAVERICK» scenario, and -1.75% in the «ICEMAN» scenario [24]**.** This option is not easy to achieve. The lower the anticipation, the more painful it will become (see Chart #5 in the world scenario of the full report) and it should ideally align with societal choices as to the place and role we want for air transport.

Four areas of reflexion have been identified and seem to be deployable without delay, **across the entire scope of long-haul transport** [25]:

1. **Informing and raising awareness** of stakeholders and the general public, in particular through developing the **educational sources on climate imperatives** for the industry, by regulating the **calculating method of non-CO_2 effects**, by developing an **official trip-related carbon footprint calculator** for any type of transportation or still by reinforcing, through regulatory means, **compulsory posting by transport service providers of the quantity of greenhouse gases** emitted for all trips.

2. **Encouraging travellers** to reduce their number of trips, starting with the business-related ones, for example **via tax-relief mechanisms, or subsidies for the establishment of remote collaboration tools or co-working environments** in medium and low-density geographical areas.

18. DGAC, Gas emissions report 2019: https://www.ecologie.gouv.fr/sites/default/files/bilan_emissions_gazeuses_2019.pdf
19. See deviation analysis in full report, §8.2.3
20. See full report §7.2.1
21. The national areas of studies were taken from the Shift Project report «CRISIS (S), CLIMATE: PREPARING FOR THE FUTURE OF AVIATION» published on 05/27/2020 https://theshiftproject.org/article/climat-preparer-avenir-aviation-propositions-shift-contreparties/
22. See full report §7.2.1.5
23. See full report §7.3
24. See full report §7.4.1
25. See full report §7.4

3. **Engaging aviation customers in prioritizing usages**, for example through extending to the long-hauling offer the proposals D1 and D3 of the Citizen's Convention for the Climate [26], but also by **creating a citizens' initiative of air transport users** responsible for ensuring that sobriety policies are effectively aligned with citizens' expectations. Priority will be given to systems allowing designated people to receive sufficient training, as this is the case for example in citizens' conferences.

4. **Regulating usage**, whether by **restricting activity** (limitation of airport slots, supervision of subsidies, moratoriums on the construction of new infrastructures), by **restricting demand** (modification of the price signal, allocation of travelling rights) or through **taxation**. The tax approach, particularly unpopular, is frequently debated in the field of social justice. In the perspective of fair distribution of efforts and long-haul access equity, a **progressive tax indexed upon trips' frequency and travel distance** is an interesting idea.

These last measures must be **considered on a large scale, at least within the European Union, on the global scope of long-haul transport**, in order to ensure the reduction of overall emissions from the industry and the fair treatment between companies governed by different legislations.

6 Impacts on jobs in France

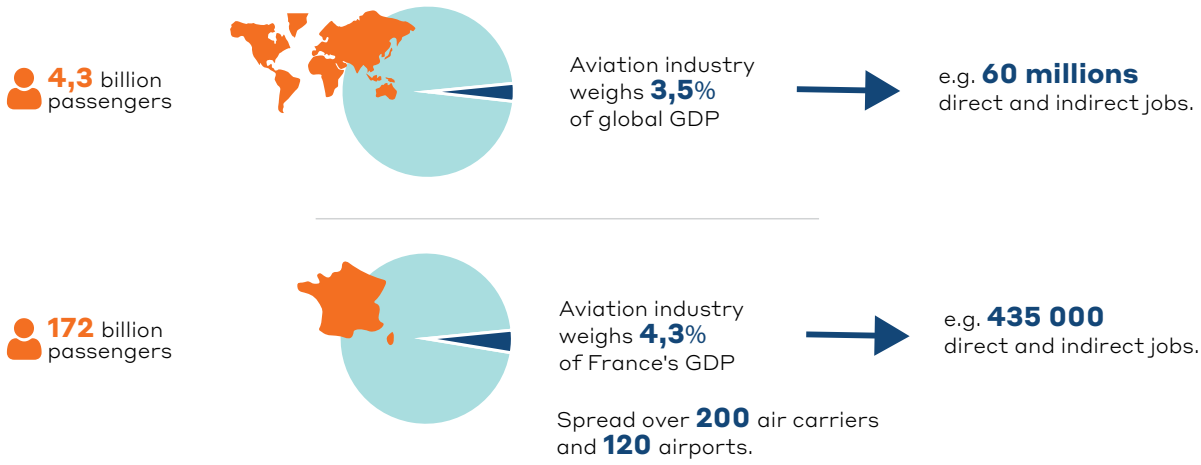
The aviation sector accounts for **3.5% of global GDP** with over **60 million direct and indirect jobs**. In France, civil aviation accounts for **4.3% of GDP** (2018 figure), of which more than half is for aircraft manufacturing.

Air transport activity in France brings together around **200 air carriers** and totals **85,000 direct jobs**, 60% of which are in the Ile-de-France region. On the industry side, French aeronautics posted a positive export balance of **31 billion Euros for around 350,000 direct and indirect jobs.**

Staying within the global carbon budget envelope requires **adjusting the traffic growth rate**, regardless of the industrial scenario: annual growth of **+2.52% for the "MAVERICK" scenario and -0.8% for the "ICEMAN" scenario**. All these projections are conditioned by moderate traffic growth from 2025 onwards, whether decided (via an international consensus) or suffered (for example as a result of COVID-19). **Delaying this moderation, letting air traffic to pick up again after 2024, allows in the short term to avoid further workforce reductions, but all the more condemns long-term employment.**

The «**ICEMAN**» scenario, obviously far from being desirable, nevertheless remains the most likely option in our framework of analysis. Subject to a moderation of effective growth from 2025, **global traffic projected for 2050 is reduced by 19% compared to 2019, and aircraft production by 55%**. How to best anticipate the consequences?

The employment situation in the aviation sector (in 2018 in the world and in France)



26. https://propositions.conventioncitoyennepourleclimat.fr/pdf/ccc-rapport-final.pdf p.235 and 247

Air transportation sector in France

In July 2020, Air France announced that it wanted to **cut 16% of its workforce by 2022**, half of these positions corresponding to unreplaced departures. This difficult decision is consistent with a hope of resumption of traffic in 2024 but it doesn't address the issue of long-term employment.

40% of the workforce is employed in support functions whose transfer to other sectors of activity poses few problems a priori. For the rest, **the most represented job category is that of commercial aircrew which accounts for 22% of jobs in the sector** [27]. The cabin crew members carry out a safety and first aid mission on the one hand, and of customer relations on the other. This population is multilingual, adaptable, accustomed to travel, and trained in first aid, **all valuable skills in a low-carbon society: local tourism, personal assistance, rail transport for example**. However, the rail transportation lead must be approached with caution, since the development of the train is notably conditioned by the **financing of infrastructure renewal**, therefore by the **sustainable political will** to support a mode of transport long neglected apart from high-speed trains. On the other hand, the transfer of the majority of jobs will not be possible without training support, therefore without planning.

Aircraft industry

Most of our scenarios involve a **traffic limitation, therefore a reduction in the size of the fleets** with the socio-economic impacts already observed in the context of the health crisis. For the aircraft industry, **this risk is amplified by the market structure**. Going from an equipment market (mostly) to a renewal market is in theory beneficial for decarbonisation since the diffusion of technical progress is then accelerated. Provided, however, that the companies that will survive the health crisis have enough cash to renew their fleets more frequently. This seems to be impossible without regulatory initiatives or additional financial support. And even so, in most scenarios this is unfortunately not enough to avoid job loss in 2050.

Given this, **the diversification of the industrial base would make it possible to compensate for the short-term decline in jobs while increasing the resilience of the sector and the local economies in which it is implemented, and ultimately limit the risks of a «Detroit syndrome** [28]**»** which today concerns the Toulouse region.

A new story is to be written. This could take the form of an **Industrial Alliance for the Climate, an ad-hoc entity in charge of reallocating the production capacities currently underutilised to produce the equipment needed for the energy transition**. Without calling into question the industrial programmes launched by major contractors to decarbonise aviation through technological means, this Alliance could play the role of **an alternative contractor to the subcontracting chain**, thus relieving companies that would like to join it from the risks of diversification. The Alliance would also enable **the pooling of underutilised industrial resources in order to pool the costs of transformation towards a more competitive and adaptable industry**.

By putting aeronautical know-how at the service of the fight against climate change, the Alliance would position itself as a leading manufacturing player for the decarbonisation of France (or even better, of Europe) and would participate in the industrial (re) localisation effort..

7 Conclusion

Limiting our GHG emissions and adapting our societies to the consequences of climate change are top priorities. The scientific consensus embodied by the IPCC makes the carbon budget a key metric for evaluating the transformation effort and leeway associated with a climate objective. **Defining a sector-specific carbon budget is therefore a political choice, prior to the development of GHG reduction paths**. In its absence, we have adopted the neutral hypothesis of a «2°C» carbon budget in proportion to emissions from the aviation sector in 2018.

Our work shows that **no realistic path can lead to the goal without reducing traffic growth**. Respecting the carbon budget requires combining two levers: the **progress of low-carbon technologies** and **the adjustment of air traffic** to the rhythm of their deployments.

While our findings certainly contrast with the optimism of pre-COVID growth forecasts, **they point the way to a sustainable preservation of the sector, compatible with climate objectives**, while limiting the impact on employment. But this scenario is all the less likely as the sector is slow to commit to the «2°C» trajectory described in this report.

Air transport is part of our modernity; it has made us dream, grow and open ourselves to others. For this dream to remain alive in the face of climate change threats, it is essential to stay away from Manichaeism and share a lucid analysis of the situation. The ambition of this work is to have laid the foundations for such an analysis and, beyond that, to have invited a thorough democratic reflection on the place of air transportation in a low-carbon world.

27. FNAM, Branch report, 2019. https://www.fnam.fr/presse/publications
28. Towards a major economic crisis in Toulouse and its area. Toulouse; the Detroit syndrome? By local representatives of Copernicus, Attac, the Université Populaire de Toulouse et des Amis du Monde Diplomatique, April 22nd 2020. Toulouse wants to avoid the "Detroit syndrome", Matthieu Jublin, Alternatives économiques, June 17th 2020.

Contacts

Press contact: Ilana Toledano, *The Shift Project*
ilana.toledano@theshiftproject.org

Olivier Del Bucchia, co-author of the report
olivier@goliveprojet.com

Gregoire Carpentier, co-author of the report
gregoire.carpentier@gmail.com

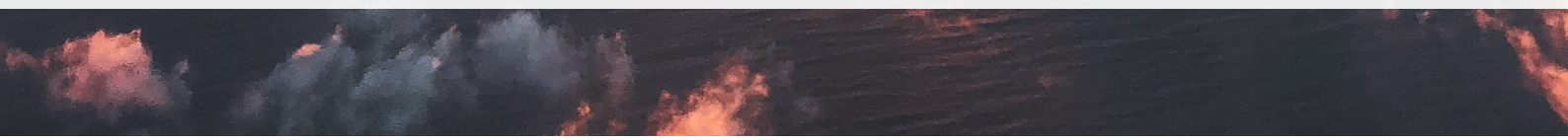
About The Shift Project

The Shift Project is a think tank that works for an economy freed from carbon constraints. A non-profit organisation, recognised of general interest and guided by the requirement of scientific rigor, our mission is to enlighten and influence the debate on the energy transition in Europe. **www.theshiftproject.org**

About SUPAERO DECARBO

SUPAERO-DECARBO is a collective of more than 100 current and former students of ISAE SUPAERO (one of the great schools that trains future engineers and decision-makers in aeronautics and space), more than half of whom are working in the aviation industry or air transport.

The SUPAERO-DECARBO aims to propose, support, accelerate and contribute to any initiative allowing to increase the level of awareness and knowledge on climate change and to imagine the world of tomorrow, in connection with school and industry.



SUPAERO DECARBO

THE SHIFT PROJECT

With the contribution of:

CITOYENS POUR LE CLIMAT

THE SHIFTers PROJECT Les Bénévoles