Performance Insight

The role of ANS in a decarbonising world – Current knowledge and questions for debate

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BACKGROUND

This PRC Performance Insight document, has been prepared by the EUROCONTROL Performance Review Unit (PRU) for the Performance Review Commission (PRC).

The PRC conducts independent measurement, assessment and review of the performance of the Pan-European Air Navigation Services (ANS) system, including its contribution to the efficiency of Pan-European aviation. The PRC strives to identify future improvements and makes recommendations as appropriate.

The PRC maintains open and transparent dialogue with relevant parties, including but not limited to States, Air Navigation Service Providers, Airspace Users, Airports, social dialogue partners, civil-military organisations, international and national organisations, etc. The PRC conducts research into the development of performance measurement. This includes, inter alia, investigating how performance could best be described/measured in the long-term, developing and testing proposals for future indicators and metrics and contributing to future improvements in performance.

The PRC disseminates the results of its analysis to relevant parties, provided that no sensitive data are involved, in order to demonstrate the PRC's commitment to transparency and to promote the application of PRC analysis.

The PRC produces independent ad-hoc studies, either on its own initiative and/or at the request of relevant parties. The PRC's website address is: https://www.eurocontrol.int/air-navigation-services-performance-review

NOTICE

Sustainability is an important political, economic and societal issue and the entire aviation industry has a responsibility to minimise its impact on the environment and climate change.

All industries are increasingly challenged to take action to mitigate their environmental footprint. There is a particular focus on the aviation industry which is frequently highlighted as a negative example in the increasingly vocal political and public discussions.

In addition to the long recovery from the COVID-19 pandemic, decarbonisation of aviation is arguably the greatest challenge facing the air transport industry. Decarbonisation will also be a political and societal priority over the coming years.

The objective of this paper is to provide a collection of facts about the environmental performance of aviation in general and the role of Air Navigation Services (ANS) in particular to identify and formulate relevant questions for future debate.

Although there are other areas such as noise and local air quality where aviation has an impact, the focus in this paper will be on greenhouse gas emissions (GHG) and the impact on climate.

What is the problem?

Aviation climate impact originates from direct or indirect effects from emitting carbon dioxide (CO_2), nitrogen oxides (NOx), particular matter (PM) and water vapour into the atmosphere.

Because of its long residence time in the atmosphere, CO_2 is a global issue irrespective when and where the emissions take place.

Even though notable uncertainties remain, the non-CO_2 effects of aviation could be more relevant than CO_2, according to recent research [1]. Although there are other factors, the radiative forcing effect of non-CO_2 emissions is mainly concerned with the formation of contrails when aircraft fly through ice-supersaturated airspace. Non-CO_2 effects of aviation have a much shorter lifecycle and depend on location and time which makes them much more complex to understand.

It is important to point out that the confidence level is much lower for non-CO_2 effects. Broadly speaking the uncertainty of non-CO_2 effects is eight times higher than for CO_2 [1].

Overall, the overarching goal for CO_2 is to minimize total net emissions from fossil fuels while for non-CO_2 effects the goal is to avoid the formation of contrails as much as possible.

How big is the contribution of aviation?

There is often confusion about the contribution of aviation based on the varying scope of respective reports and studies. It is important to separate and distinguish the sources and references used.

Aviation is estimated to be responsible for around 2-3% of the total anthropogenic CO_2 emissions globally [2].

In Europe (EU27+UK), aviation accounted for 4.3% of total GHG emissions in 2019 (latest year for which EEA data is available) [3].

Between 1990 and 2019, GHG emissions from transport increased while at the same time total GHG emissions decreased by 25%.

Road transport which accounted for 20.6% of total GHG emissions in 2019 (and for 71% of transport GHG emissions) increased by 24% compared to 1990.

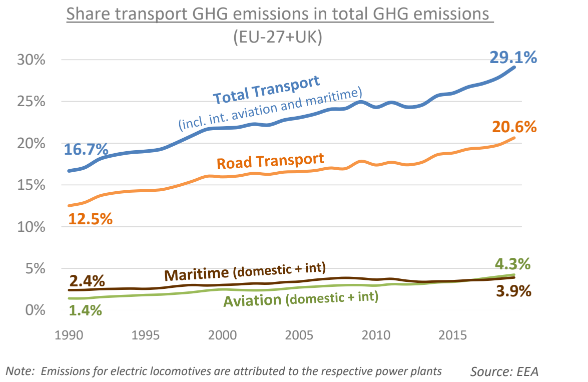


Figure 1: Share of transport in total GHG emissions (1990-2019)

Emissions from aviation increased by +125% compared to 1990 levels. As a result, the relative share of aviation increased from 1.4% in 1990 to 4.3% in 2019 and is expected to continue to grow as other sectors are expected to decarbonise quicker over time.

What are the ambitions and targets?

Recognising the need to address aviation's impact on climate, the International Air Transport Association (IATA), adopted three global goals for civil aviation in 2009 [4]:

(1) Average fuel efficiency improvement of 1.5% per year from 2009 to 2020;

(2) A cap on net aviation CO_2 emissions from 2020 (carbon-neutral growth); and,

(3) A reduction in net aviation CO_2 emissions of 50% by 2050, relative to 2005 levels.

In 2010, the International Civil Aviation Organization (ICAO) adopted a comprehensive agreement to reduce the impact of international aviation emissions on climate change with the following goals [5]:

(1) annual average fuel efficiency improvement rate of 2% up to 2050; and,

(2) Carbon neutral growth of international aviation from 2020 onwards.

Additionally, ICAO agreed in 2017 on a CO_2 efficiency standard for new aircraft [6] which limits the CO_2 emissions form aircraft in relation to their size and weight (applicable to new aircraft as of 2020 and to in production aircraft as of 2028).

The political momentum is clearly there and evidenced by these initiatives. Despite initiatives and the commitment by aviation to these challenging objectives there is a risk to not meet the ambitious targets of the Paris Agreement and the "European Green Deal" for the EU adopted in 2019 [7].

In early 2021, the EU adopted new targets to reduce GHG emissions to at least 55% below 1990 levels by 2030 (previously 40%) with a view to make Europe the first continent with no net GHG emissions by 2050.

For transport, it calls for a 90% reduction in GHG emissions by 2050 compared to 1990 levels, while working towards a zero-pollution ambition.

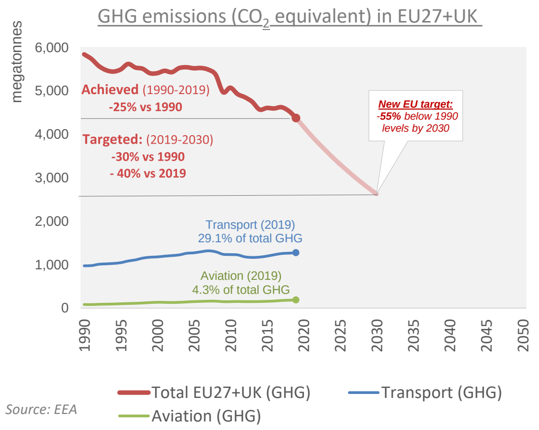


Figure 2: EU GHG emission target

How to get there?

Unfortunately, there is no panacea for reducing aviation's impact on climate. The truth is that it will be extremely challenging to reduce aviation emissions quickly with current available technologies.

All strategies to reduce aviation's impact on climate essentially focus on four pillars:

(1) aircraft technology (airframes and engines),

(2) sustainable aviation fuels (SAF),

(3) market based measures (MBM), and

(4) improved infrastructure and operations (operational efficiency).

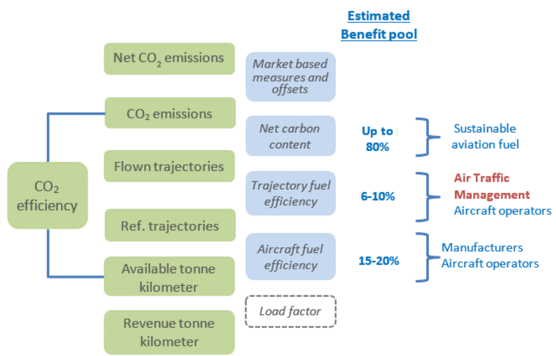
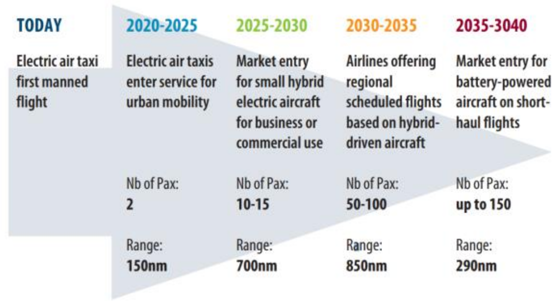


Figure 3: Aviation CO_2 efficiency

Aircraft technology and fleet composition: Fuel efficiency improvements over the past decade were remarkable. The latest generation of aircraft (e.g. A350, B787) burn about 15-20% less fuel than the previous generation they replace.

In combination with the COVID-19 pandemic, airlines announced plans to retire less fuel-efficient aircraft. Still, it will take some time (aircraft lifespan = 20-30 years) until efficiency gains through fleet replacements will fully filter through the entire aircraft fleet. Many of the new generation aircraft will still be operating in 2050 (B737 MAX, B777X, B787, A320Neo, A330Neo, A350) so progress will flatten out.

The manufacturers' environmental challenge is the development of new airframes ("blended wing body") and non-fossil alternative propulsion systems (electric, hydrogen, etc.).



Source: IATA

Figure 4: Alternative propulsion systems

However, the innovation and manufacturing lifecycle in commercial aviation are lengthy so the benefits will only materialise in the longer term. Electrification of aircraft/fleet for commercial passenger/cargo operations might see its introduction in 15-20 years with a gradual replacement of the fleet at that moment in time [8].

With the potential to cut aviation's net CO_2 emissions by up to 80%, Sustainable aviation fuels (SAF) can be a real game changer in the transition away from fossil based fuels.

With a view to the non-CO_2 impact of aviation, SAF is also a potential win-win candidate as the use of SAF not only reduces the net CO_2 emission from aviation but also has the potential for lessening the formation of contrails (thinner and less persistent) because less soot particles are emitted.

However, the SAF production processes are energy and cost intensive: blending SAF with fossil fuels or switching to SAF only helps decarbonising aviation if the production is fully based on renewable sources.

According to IATA, SAF is currently on average between 2 to 4 times more expensive than fossil fuels and production is presently limited to just 0.1% of the total aviation fuel consumed by the industry [9].

European and individual State initiatives will be necessary to create the necessary economic stimulus to promote and commercialise SAF production which will help narrowing the price gap between SAF and fossil fuels and boost production levels and hence the SAF uptake in the aviation sector with a direct impact on net CO_2 emissions.

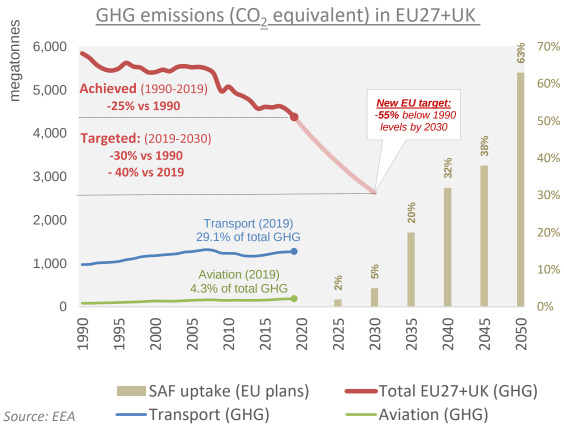


Figure 5: EU GHG emission targets and planned SAF uptake

As part of the ReFuelEU Aviation initiative, the EC is considering applying a SAF blending mandate gradually scaling up the use of SAF for departing flights, with a starting point of 2% in 2025, moving to 5% in 2030, 20% in 2035, 32%in 2040, 38% in 2045 and 63% in 2050 [10].

Hence, medium to longer term, clearly the biggest reductions in CO_2 emissions will be achieved with the transition to SAF – even though the effect of SAF will only become visible from 2030 onwards.

Market based measures (MBM) aim to introduce a price for carbon emissions to incentivise innovative technologies to bring down CO_2 emissions from aviation but also to curb demand. There is a vast portfolio of possible economic measures including, global or regional emission trading schemes, specific taxes on fuel or tickets, or the application or adjustment of charges to incentivise the decarbonisation of aviation.

As international aviation is not part of the Kyoto Protocol, the EU decided to include emissions from aviation in the EU emissions trading system (EU ETS) in 2012, after earlier consideration of taxation. The initial legislation covered all flights in and out of the European Economic Area (EEA), with a cap based on average emissions in 2004-2006.

Following resistance from non EU States and to support the development of a global scheme by ICAO, the EU-ETS has been amended to cover only flights within the European Economic Area (EEA) at least until 2023 (i.e. intercontinental flights are exempt).

In 2016, ICAO adopted the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) as the first global market-based measure to limit and offset emissions from international aviation. Domestic CO_2 emissions from aviation will be addressed under the Paris Agreement.

The CORSIA emissions baseline is the average of 2019-2020 emissions from international air traffic. The impact of the dramatic traffic reduction because of the COVID-19 pandemic on the CORSIA baseline remains to be seen. According to IATA, COVID-19 could lower the baseline to a level equivalent to the emissions from international aviation in 2014 bringing it closer to the EU ETS baseline which was considered as more constraining as it was set when emissions were lower.

CORSIA requires monitoring of fuel consumption on international flights as of 2019. By 2027, CORSIA will be mandatory for all international flights between States not exempted from the scheme. To compensate for CO_2 emissions growth above 2020 levels in international aviation airlines will have to buy emission units from green projects to compensate excess CO_2 levels.

The EU ETS and CORSIA schemes encourage airlines to reduce CO_2 emissions. The EU ETS is a “cap and trade” scheme and CORSIA is an “offsetting” scheme implying that emissions can grow as long as they are compensated by offsets. This offsetting mechanism may reduce CO_2 emissions elsewhere rather than directly in the sector, but does count towards net reductions for aviation. It is however not foreseen that the money from the offsetting process will be used to support the costly transition to SAF which would directly reduce aviation’s net CO_2 emissions.

So what can ANS contribute?

With benefits from aircraft technology and SAF only taking real effect beyond 2030, ATM can help reducing emissions by addressing operational inefficiencies in the ATM system already in the short to medium term. For every tonne of fuel saved, an equivalent amount of 3.15t of CO_2 can be avoided.

ATM deploys a number of projects and initiatives aimed at improving operational efficiency, including performance based navigation (PBN), free route airspace (FRA), Flexible Use of Airspace (FUA), continuous climb and descent operations (CCO/CDO), and other SESAR solutions. These initiatives are supported by a communications, navigation and surveillance (CNS) infrastructure which can be seen as the foundation of aviation operational performance. ATM is further involved in the improvement of ground movement efficiency with projects such as Airport Collaborative Decision Making (A-CDM).

But what is the potential contribution of ANS if all those initiatives are taken into account? There are many different studies aimed at quantifying fuel and flight efficiency. In political discussions, ATM is frequently mentioned to be able to improve fuel efficiency by 10% or more.

In reality, it is often not clear what is meant by this percentage (i.e. what corresponds to 100%), what geographical scope or flight phases were considered and how the results need to be interpreted. While those studies provide useful and valuable insights, the differences in scope and methodologies make direct comparisons often difficult if not impossible. Moreover, many studies rely on aircraft performance models to determine the estimated fuel burn and emissions based on the available trajectories which adds another layer of complexity to the calculations.

Previous PRC work [11] has estimated that the benefit pool that can be influenced by ANS is approximately 6-8% of the total gate-to-gate fuel burn (emissions) in the European Civil Aviation Conference (ECAC) area[1].

A recent study focusing only on flights within the EUROCONTROL area (long haul flights excluded) estimated the average fuel inefficiency from take-off to landing between 8.6% and 11.2% [12].

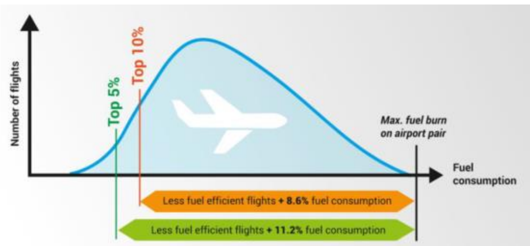


Figure 6: Illustration of the distribution of fuel consumption

Most studies apply similar methodologies which compute efficiency gains compared to a theoretical reference which in reality cannot be achieved at system level. A certain level of "inefficiency" is in fact necessary (separation minima, adverse weather, avoidance of 'Danger Areas' and temporarily segregated areas) or even desirable (trade-offs).

There is clearly scope for further improvement in ANS operational performance. However, it is important to stress that the often-quoted benefit pools cannot be fully recovered nor can the inefficiencies be entirely attributed to ANS.

In fact, environmental objectives may even be conflicting and have an impact on ANS performance; for example noise abatement procedures at airports might lead to longer trajectories and hence additional emissions.

The PRC is supportive of the continued work to further develop and refine the understanding of:

(1) the level of inefficiency in the European ATM system;

(2) the underlying drivers; and,

(3) the real scope for improvement in each area.

Following the dramatic drop in traffic due to the COVID-19 pandemic in March 2020 all operational metrics improved, with a positive effect on fuel burn and environmental impact. This provided a unique opportunity for ANS to review and remove existing constraints in the ATM system. An increased focus on the improvement of the efficiency of the ATM system will help to maintain the achieved efficiency levels when traffic returns after the COVID-19 crisis.

[1] The ECAC area corresponds to the EUROCONTROL area plus Azerbaijan, Iceland and San Marino.

Additionally, ATM may be asked to play a role in reducing the non-CO_2 impact of aviation for which the scientific community is gathering evidence. Together with ANSPs and airlines, EUROCONTROL is evaluating some possible measures to mitigate the formation of contrails in the Maastricht UAC area.

However, "climate optimised trajectories" will require improved aviation weather forecast models and deciding on trade-offs between contrail avoidance and additional fuel burn/flight time. This may apply to both the aircraft flying such optimised trajectories and the different environmental optimisation goals (e.g. CO_2 reduction vs contrail production). These decisions are not an ATM decision, but a decision to be taken by policy makers or other stakeholders.

Moreover, depending on the region, the avoidance of ice-supersaturated airspace altogether or the change of flight levels to avoid contrails at short notice will have an impact on capacity which will need to be part of the overall equation. It goes without saying that the avoidance of contrails will be more feasible in less dense airspace where latent capacity is available. In dense airspace, restricting areas to avoid contrails could result in considerable additional fuel burn or delays which will need to be taken into account.

If the meteorological forecasts systems are not sufficiently accurate, there is a risk of additional fuel burn with no contrail avoidance or even worse of additional fuel burn AND formation of contrails [13].

Nonetheless, it is clear that overall it will not be possible to tackle the environmental challenge without addressing capacity (en-route and airport) and airspace organisation together.

Which way to go?

Clearly, there is no single solution for reducing the climate impact of aviation quickly.

In 2019, aviation accounted for 4.3% of total GHG emissions in Europe (i.e. 27 EU-states and UK) but the share of aviation is expected to increase further over the coming years.

Although emissions from aviation more than halved in 2020 because of the COVID-19 crisis, it is clear that the environmental challenge for aviation will remain throughout the recovery phase and beyond. It will be a non-negotiable requirement on ANS to contribute to reducing the environmental impact of aviation.

However, in view of the necessary investments to reduce aviation's impact on climate required at a time when the industry is still recovering from its deepest crisis there is a need for a rational and balanced debate to identify the most suitable solutions to reduce the climate impact of aviation.

When analysing the CO_2 emissions generated from all flights departing from Europe in 2019 it is worth pointing out that flights shorter than 1500km accounted for 70% of the departures but for only 25% of the CO_2 emissions.

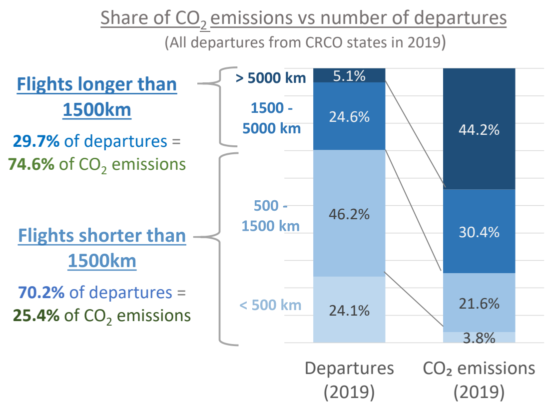


Figure 7: Distribution of flights and estimated CO_2 emissions by distance category (2019)

On the other hand, around 30% of the flights departing from Europe were longer than 1500km but generated some 75% of the total CO_2 emissions. Longer flight operations are expected to continue to rely on liquid fuels for some time to come with new propulsion technology for this type of operation not readily available.

Short or domestic flights below 500km are often mentioned in political debates as being particularly environmental unfriendly. While responsible for 24.1% of departures, this segment only accounts for 3.8% of CO_2 emissions and include a number of flights serving regions that are remote or face geographic barriers.

Alternative propulsion systems and the substitution of flights by high-speed rail could be an option to reduce net CO_2 emissions from aviation. This only make sense if based on renewable sources and when the total lifecycle emissions, infrastructure and construction costs, implementation time, and land use are taken into account [14].

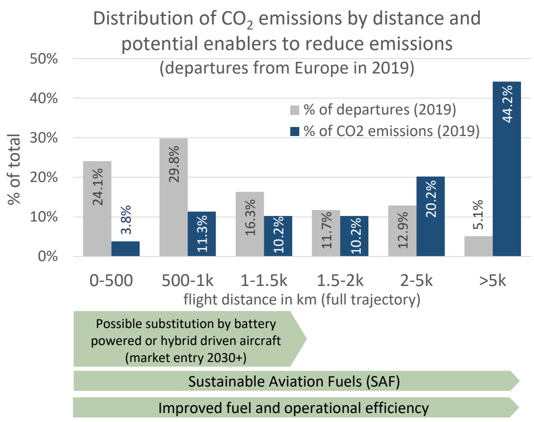


Figure 8: Potential enablers to reduce emissions by distance range (2019)

The transition to SAF and flight efficiency improvements will benefit all aviation distance ranges but the potential to reduce net CO_2 emissions differs substantially.

Although it will be after 2030 until we will see the benefits, the transition to SAF and radical new concepts such as zero-emission commercial aircraft will have the highest impact.

In the meantime, ANS has a crucial role in improving flight efficiency to the extent possible within the necessary safety boundaries. There is however a need to put in context what ANS can realistically contribute towards reducing the climate impact from aviation.

Even if a theoretical benefit pool of 10% (which is not fully recoverable) is assumed, the ANS contribution will be limited to 0.4% of the total GHG emissions in Europe whereas the transition to SAF has the potential to reduce the net CO_2 emissions from aviation in Europe by 80% which corresponds to 3.8% of total emissions in Europe.

Once the vertical and horizontal profiles are optimised to the extent possible (some inefficiencies will remain), the amount of emissions that ATM can influence will be small and the benefit pool will eventually run dry as efficiency improvements from the initiatives under the SESAR umbrella are fully delivered.

While there is no doubt that the entire aviation industry has to work hard and to commit to reducing its impact on climate, the truth is that it will be challenging to achieve the ambitious environmental goals.

This will only be achieved by the commitment of all parties, and with the right metrics and incentives in place to measure and drive progress. While aviation continues to contribute to CO_2 emissions in a de-carbonising world it will be increasingly necessary to demonstrate that these emissions are being minimised, both in total and in relation to the payloads carried.

In support of the necessary but often emotionally heated discussions on how to reduce the aviation's impact on climate and the role of ANS, there is a need for facts and a proper understanding of the communicated numbers, realistic strategies and targets. The focus must be on political and strategic decision-making on actionable initiatives.

With a view to stimulate such a factual debate, the PRC would encourage further dialogue on the following questions.

Areas for further discussion and evaluation

What is the real potential of ANS to reduce CO_2 emissions?
Background: ANS is frequently quoted to be able to improve fuel efficiency by 10% or even more.
• *Are the current performance indicators traditionally based on distance and time suitable to measure the environmental contribution of ANS?* • *In view of the vast number of studies with different scopes (geography, flight phases) and methodologies, is there a need for common definitions and a better understanding and quantification of what is realistically recoverable by ANS improvements (i.e. inefficiencies cannot be reduced to zero)?* • *Long haul flights account for the largest share of CO_2 emissions but a large part of the trajectory is not in European airspace (i.e. outside the responsibility of European States/ANSPs). How can this be better addressed?*

What is the potential role of ANS to mitigate aviation's non-CO_2 impact on climate?
Background: According to recent research, the non-CO_2 effects of aviation could be more relevant than CO_2 emissions. The study suggests that 2/3 of the aviation impact on climate could be from non-CO_2 effects, mainly the formation of cirrus clouds.
• *In view of the high level of uncertainty of non-CO_2 effects of aviation, are we in a position today to take action in terms of operations and policy making, given the knowledge and tools available today (risks of wrong decisions and unintended outcome)?* • *Does it make sense to invest heavily in contrail avoidance if SAF will address this without CO_2 trade-offs?* • *What role should ANS play in determining or even enforcing climate optimised trajectories?* • *Who will decide on trade-offs (climate optimum vs fuel optimum) and what will be the implication on capacity planning and deployment?*

How to consider aviation in the efforts to mitigate the impact of the transport sector on climate?
Background: The analysis of flights shows that 75% of the CO_2 emissions are generated by 30% of flights longer than 1500km for which there is no realistic substitution
• *Are the current discussions on the necessity of short haul flights and proposed substitutes such as high-speed rail taking relevant factors into account (entire emission lifecycle, feasibility, emissions related to building rail tracks, etc.)? What is the cost-benefit in a holistic assessment?* • *How can future strategies aimed at mitigating the impact of aviation on climate address the fact that long haul flights account for the largest share of CO_2 emissions but have the lowest potential for substitution by other transport modes?*

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