What Aviation for Tomorrow's World

Personalisation & Flexibility keys for tomorrow's sky

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Introduction

When it is asked to define tomorrow's world, people generally struggle to describe unanimously the perspective and the evolution of our lives on earth. Some with limitless imaginations easily perceive a world like Star Wars, the 5th element, or Back to the future and are certain that technology will bring us in Science Fiction. Others, probably more down to earth, envisage the future as a slow return to a sustainable economy and respectful of our environment where enjoying the little pleasure of life and be content with what surrounded us will be essential. However, both these mentalities have been deeply impacted by two events. Heart of all discussions for decades, the first one is climate change and the ecologic urgency revealed and supported by scientists from all around the world. The second and very recent one continues to impact the life of the 7 billion humans on earth: The Covid-19.

The aviation, communication medium, and transformation vector has this unique ability to mix and meet cultures from all around the world. Therefore, it is often the heart of heated discussion between all visions. Economically it is one of the most fragile and first industries to collapse when something on earth is going bad. Its resilience lead by passionate people allows it to always recover and find solutions, ahead of its time with limitless efforts in innovation researches. However, it will be crucial to change the pejorative image of aviation as it is too often the targeted of bad social and environmental behaviour, probably the result of misleading publicity and marketing. The aeronautical world could for example showcase the two values we hold dear as it will represent the future: Personalisation and Flexibility.

In order to define aviation for tomorrow's world, this paper will be organised around three questions: What will impact tomorrow's world? What will be tomorrow's aviation? What new technologies will shake the industry up?

Tomorrow's world (Covid 19/Environment awareness/Safety)

In order to understand what aviation will look like for tomorrow's world, we need to understand today's world. This first chapter is dedicated to the two events introduced hereabove and one timeless practice that shape the conception and perception of air transport: the Covid-19, the ecological awareness about climate change and Safety.

Covid 19

Started in 2019, this unprecedented pandemic reaches every single human on earth. Governments and institutions have taken historical measures constraining population and closing borders as in times of wars. The aviation industry is very highly connected to the world economy's health. Thus, whenever a financial crisis sparks, it is probably the first industry to collapse. Every crisis implies airlines, manufacturers, and all stakeholders to find solutions and innovate in order to survive and revive commercially.

With the urgency to relaunch the world on new basis, the Covid-19 vaccines have been and are still a crucial challenge for every country in the world. With major laboratories location being restricted to developed countries, it was critical to spread and share vaccine doses in the entire world in very strict and complex conditions of conservations. The unique global solution is air cargo. Notably, Qatar Airways anticipating a very large demand and operating more than 500 flights to the areas most affected by the health crisis (Qatar Airways, 2021). They work closely with governments and NGOs, to transport around the world more than 250,000 tons of medical supplies and aid (Fabi, 2021). The aeronautical world has successfully met the objectives raised by this challenge in record time and has been able to adapt its operations to the health standards, always ensuring an optimum level of safety. This is flexibility.

In parallel and in the short term, the necessity to travel in a safe environment and the continuous improvement of new technologies while enhancing onboard flight experience is shaping the future of the ultra-long-haul market for instance from London to Australia or even Middle East direct to the United States. Especially when stopover in foreign countries goes hand with lockdown, quarantine, and virus spreading risks.

Another critical aspect largely shakedown with the virus is linked to the emergence of connected devices available to any individual in the 21st century. With the possibility to do video-conferencing and phone calls throughout the world with low financial expenditure, the totality of companies eliminated business trips for their employees to consequently reduce the risk of spreading the virus. With online habits now largely rooted to most employees, this trend could leave a long-term if not a definitive footprint on business travels. The uncertainty of the recovery in this domain is such that it could lead to large structural and strategic restructuration of some Full-Service Carriers. Tomorrow's commercial aviation could be largely constituted of leisure and VFR (Visit Friends and relatives) passengers. However, as developed in chapter 2, other aspects of the industry have expanded and even grow during the pandemic.

Environmentally friendly

On a completely different time-scale than the pandemic, the environmental urgency is also an issue that does exist and will doubtlessly impact the future of aviation. The climate change triggered and largely accelerated by human behaviours is an increasing concern for many people and at the heart and numerous political and strategic decisions. The aviation industry generates an important amount of greenhouse gas that once freed in the air contributes to global warming or the planet. The aviation industry needs to continue on the path already taken since many years which is to reduce the impact of aviation on global warming.

As briefly explained in the introduction, two main reactions are to be expected when raising the subject of global warming. The first one is to refuse to use these pollutant technologies and to come back to more sustainable and environmentally friendly transport modes. The aviation industry has thus seen the flight shaming movement deeply impact the industry in Sweden for example. The other reaction and we believe is the only viable option for any worldwide market like aviation is to continue and pursue efforts and improvement of technologies until reaching a new and sustainable industry that will enable people to travel by air environmentally friendly.

In a joint spirit, the aviation industry has set some very ambitious ecological objectives to counter the effect of climate change that goes beyond the reduction of fuel consumption. Aligned with the Paris agreement on gas emission reduction, the best response scenario for the industry is available in a graph in the annex. It notably shows that the main reduction will be reached through the utilisation of SAF (ATAG, 2020). The willingness of airlines and stakeholders of the industry to change their habits and their impact on the environment is deeply highlighted by the now-famous slogan adopted by many: “Be green keep flying”.

As showed in the graph, SAF will contribute up to 50% in reaching the objectives of the industry. Despite the encouraging improvement made notably by Air France this year by operating the first long-haul flight with 100% SAF a few months ago, the implementation of the SAF in the aeronautical landscape will require a strong collaboration between all stakeholders. (Santos & Delina, July 2021). SAF appears to be a great solution as it reduces the aviation's lifecycle carbon footprint by 80% and of aviation's lifecycle carbon footprint and by 50 to 70% the number of contrails produced while being truly

sustainable (AFKLM, 2021). Its impact on other industries is minimal as it does not compete with useful plantations like food or simply nature as it uses vegetable wastes from food or agriculture as a source of production.

Alternatively to SAF, Airbus has announced the creation of a future fleet propelled by hydrogen engines. Futuristic and unsure yet, these aircraft are expected to have zero pollutant emission and could constitute a great alternative to current aircraft. Consequently to Airbus' announcement, Airbus, Air Liquide, and ADP announced a collaboration agreement to conduct a study on the integration of hydrogen-powered aircraft in current airports (Galéron, 2021) (Groupe ADP, 2021). This is a great example of the resilience of the industry and its profound desire to always improve aviation so that it will remain THE industry ahead of the world.

From the construction of the aircraft to its retirement, all aspects of the industry will have to be environmentally friendly. Daily operations are probably the most reachable option that can reduce its impact on aviation greenhouse gases. From green taxiing with Safran Landing Systems to optimised air transport management, a large number of companies strive for better use of current technologies (Open Airlines, Safran Landing System, Amsterdam Schipol). The main advantage is that reducing fuel consumption means reducing costs, therefore Ryanair and Easy Jet already encourage their pilots to systematically use single-engine cabs to save fuel when taxiing which goes in hand with promoting CAD (Continuous Approach Descent) procedures. These procedures are already in use at major international airports such as Orly and Los Angeles and reduce fuel consumption and noise pollution by eliminating "bearings".
The flourishing of new aviation means, like drones, will doubtlessly use and enhance the development of these green management. It is essential for air transport to become a major player in the ecological transition which will require from all airlines to implement the best practices (Stubler, 2021).

Safety first:

Despite the importance of the two previous subjects, the entire industry starting with ICAO agrees that the number one priority of aviation is and will always be Safety. (ICAO, 2011)
Air transport is nowadays the second safest means of transport after elevators and the researches in this area are tremendous. Our vision of future aviation simply starts by transport mode where accidents, incidents, and any disruption would not even cross the mind of the customer. A future where flying would rhyme for any human as a peaceful, serene, and safe environment.
On one hand, reaching zero safety event implies an important level of involvement from all operators, reducing then the number of technological and technical incidents (EASA, continuously updated). Big data management is slowly bringing to the industry strong leverage as it will allow them to use predictive methods. Safety is constantly improved not only by manufacturers with new efficient and safe technologies but also by international authorities that always set higher standards. Indeed, all major aeronautical authorities that constantly publish evolution of the regulations combined with the capacity of the majority of airlines to quickly and efficiently implement these new rules, make the aeronautical industry one of the most reliable and robust sectors in terms of regulations. A good example this year is the modification of the GRF which forces to strongly increase the runway length for landing on all the airports of the world to reduce safety events (STEFANIOROS, 2021).

On the other hand, and now speaking about security, studies have shown that the most stressful moment in a passenger journey located in the airport is the border crossing and the baggage collection. Air transport is the only mean of transportation enabling any human to enter any country from anywhere in the world. This sentiment of freedom is also strongly monitored by national authorities and especially customs. These organisations have a

double task: avoid illegal transactions of passengers and assure the security of everything that enters an aircraft. The first task has partially been resolved by the European Union by removing physical borders and therefore facilitate the migration of people. Achieving this on a global scale is probably impossible nevertheless, new technologies like biometrics will strongly enhance passenger's experience and provide a seamless experience.

Ultra-Connected World

Now that the three main challenges of the industry have been mentioned and partially answered in chapter one, this second chapter will entirely showcase our vision of the aviation future. Consequently, our point of view will be presented in three parts: personalisation, flexibility, and digitalisation.

Personalisation

Who reading this paper, does not have a smartphone? How many companies in the world work nowadays without a computer? Digitalisation is all around us, it is in our life, digitalisation is today. Any human from a younger age and living in a developed country uses and possesses a digital tool. Its utilisation is limitless and Humanity needed only 13 years from the launch of the first smartphone, iPhone on the 29th of June 2007, until today to develop all the utility we know. From purchasing new items, playing video games, watching videos, reacting to pictures, posts, the majority of people use daily these tools that release and create a limitless amount of data. Each human has a digital profile that knows even better than yourself your preferences and tastes. These data are mostly beheld by digital giants like social networks or internet search engines. Google, Apple, Microsoft, Facebook, LinkedIn all understand the behaviours of any human on earth (Poza, 2018). Commercially, these data have an infinite value for any company possessing them.

In the industry, think about what an airline already knows about you, your preferences in booking, your means of transportation, even sometimes your size and weight! Now we cannot predict which company will hold our data in the future, but think about how powerful an airline could be by proposing the exact product expected by a client before it has even been ordered. This is personalisation.

An aircraft operator will be able to anticipate more precisely than ever, the movement of population and create the most optimised air

transport management ever. Not only the impact on the environment will be reduced as previously explained, but the passenger journey will highly be enhanced. Everyone reading this can relate to how satisfying is the experience of traveling in the exact mean of transport you wanted, at the exact time of the day you wanted, and more importantly at the exact price you were expected. Google flights or companies like Kayak, Skyscanner are probably future stakeholders that will have a huge impact on the aviation future.

From an inflight experience perspective, just imagine having during your trip the exact

pepperoni pizza you were dreaming of a few hours ago, thanks to the airline that anticipated your tastes before even ordering it: this is the future. Even though logistically speaking, personalisation will be quite complex, the passenger will have the exact meal without asking for it. While enhancing customer satisfaction and reducing wastes, personal data analysis can deeply contribute to better aviation for all.

Reliable prognoses based on important data management will allow airlines to optimize their costs to the maximum. It's no secret that fuel consumption, which accounts for nearly 30% of the total expenses of airlines, is the number one enemy of aircraft operators and the main challenge for tomorrow as resources will become increasingly scarce (Eller & Moreira, 2014). Personalizing services by targeting customers will lead to the optimization of flight schedules and therefore reduced costs. It is a feasible and relevant alternative for airlines to bounce back from the crisis in the future.

Flexibility

One important aspect deeply demanded during Covid-19 is flexibility for any stakeholder. Not only the uncertainty of the current situation intimidates the passenger decision to book a ticket, but the airlines also cannot anticipate the demand. New measures have been taken by operators, notably for the reimbursement and voucher granting for travels even in economy classes. We strongly believe that this trend will not only pursue after the pandemic but could also create a new business plan where flexibility for the customer could be the heart of the offer. It is not hard to imagine commercial aviation where a monthly or yearly subscription would be asked and unlimited travel could be granted. Even though the complexity related to this kind of operation is immense, once again, big data management could enable airlines to provide the right supply to the right demand.

To consolidate our vision of aviation's future related to flexibility, we will use the only two aeronautical commercial domains where the crisis impact was only limited: Cargo and Business Jet.

Commercial aviation is not only about transporting passengers, it is also about transporting goods. Due to high prices, air cargo is generally only used for urgent and expensive goods like fruits, or cars… However, the offers delivered by cargo operators are also the most competitive in terms of deadline and delivery speed. Qatar Airways promises to all its customer to deliver an aircraft wherever they want in the world within the next day after notice. These very short timelines and showcased flexibility are very appreciated by customers and can even be a sales force when negotiating.

Effective solutions related to cargo to minimize the effects of the health crisis have been brilliantly and quickly implemented by manufacturers, for instance for small regional airlines. Indeed, manufacturers like ATR (Avion de Transport Regional) offered the possibility at the beginning of 2021 to obtain an STC (Supplemental Type Certificate) cargo seat bag to transform their passenger aircraft into cargo capabilities (Aeroconseil, 2021). Minor airlines with this new flexibility can optimise their flight schedule and their yields by carrying passengers during the day and cargo at night and thus offer a more personalised and flexible service to their customers. This is the case for the regional airline Air Antilles.

With the advent of online shopping always promising shorter delivery schedules, even the biggest online shopping platform Amazon acquired a complete fleet of air cargo freighters (Amazon, 2021). Once again, the flexibility related to air transport is a major asset in the very competitive world. If we add to all these opportunities new technologies like drone deliveries, a good could be easily transported entirely by air within 24h from one side of the world to the other with great accuracy as most human and unpredictable factors would be removed from the delivery.

Jointly to cargo, the other aviation domain that has recovered from the crisis and even

outpaces the figures of 2019 is the business jet market. With very important stakeholders like NetJets, it is nowadays possible to assure a client a complete personalised and premium Business aircraft anywhere in the world within a 10hours notice (Netjets, 2021). Once again, the flexibility proposed to premium customers is the crucial element standing out from the mass. With information and data moving faster than humans, it is crucial for a competitive industry to keep its major employees and leader in constant and flexible motion no matter the hour.

Once again it is the flexibility of the aeronautical world that is leading and will always lead the industry into recovery and adaptation to the market. It would also enable aircraft to fly toward new destinations that were previously underserved. Aviation should then rhyme with the integration and the access of everyone without exclusion. No disability, fear, or handicap will never ever inhibit someone to take part in an air travel journey. Having said that, only 20% of the entire world population has ever taken at least once a flight. Continuing to break down the international borders as much as social boundaries would mean that any people on earth could access air transport, discover a new culture, understand them with an open mind, and in a dreamt world, restore peace in the world.

Digitalisation in the Aviation

However, aviation's flexibility and personalisation are constrained by one major factor: Physical limits. It is and will probably never be possible to teleport itself instantly (we never know though, let's keep dreaming). An airline's concept has successfully tackled this issue: digital airlines. Indeed, a digital airline sells seats in traditional airlines without owning a single aircraft. They are fully released from any operational constraints and are able to propose the exact trip wished by its customer. Focused on the core mission of flying a passenger or a good, these airlines are a perfect example of flexibility in a digital world (Franko, 2021). We firmly believe that this type of airline could be the future and be owned and run by online booking platforms like Kayak, Google Flight, or even Skyscanner because they understand even better than airlines the customers' behaviours.

The last iPhone invades the world probably as fast if not faster than any vaccine for the Covid-19 and it is the perfect illustration of the importance given to digitalisation in our world. Its development seems limitless and new abilities are being created every minute. Already highly present in the production industry, Artificial intelligence is slowly but surely entering the cockpits of modern aircraft. By removing the human factor out of the air travel journey, single-pilot cockpits where constant adaptation and automation would be enhanced are to be expected in the coming years.

Always pushing the industry toward new limits, the Defence industry appears to be the perfect starting point for any technological innovation. Flexibility and personalization match perfectly with their values. Contrary to commercial aviation, no mission is similar to a previous one. They do not have history or anticipation to rely on. Being able to have flexible aircraft and personalised weapons would enable them to be always more efficient no matter the operation. And indeed, it is well known that military helicopters or aircraft are always reaching new countries and environments. Digitalisation is not unfamiliar with the domain and already countless digital military tools are used day-to-day. Now more than ever, and efficient dataflow management could result in any operation in a successful teaming of the best from technology and the best from humans.

Nonetheless, data utilisation is raising safety issues with among other things: cybersecurity. On the commercial side, personal data held by digital giants are constantly the victim of cyber-attacks that could release and leak all the information of any customer. This issue is even worth the military data that contains critical information about the security of nations. The ability to attack from wherever in the world with only a computer is leading to some new form of terrorism especially with AI and automatic aircraft for example. The challenge of today and which will be crucial in the future is to learn how to quickly and efficiently counter these virtual attacks. As highlighted earlier, security is the top priority in the air, and these growing non-physical threats are growingly a priority for the Defence sector.

Besides, a very important aspect that is only starting to be raised in people's minds is the impact of data storage on the environment. The clarity of visual fuel pollution made by fumes is nowadays the issue to tackle for aviation. But the increasing number of data stored daily by worldwide users requires a high quantity of energy for them to run efficiently. The impact on the environment is still unknown and it will someday have to be answered (Liu, Gailhofer, Gensch, Köhler, & Wolff, 2019).

New technologies

Because it is important to dream, that last part will introduce a wide number of innovations that are developed and will be part of our daily lives in the coming years. Even though these technologies are not fully operational yet, they will contribute to the industry and probably force humans to redefine the boundaries of our approach to aviation.

VTOLs

Now that it is possible to even for a child to acquire a drone capable of complex flights, hasn't it ever crossed your mind to fly one day in a human-scaled toy and fly it freely wherever you want? VTOL comes directly from factories to answer your biggest dreams. Vertical Take-Off and Landing aircraft (VTOL) and Electric VTOL are being developed in the entire world by a varied number of companies. Considered by many as an ecological alternative to other means of transportation, they are even expected to be operational for the Olympic Games of Paris 2024 (AFP, 2021).

The utilisations of this type of aircraft are simply limitless. From unblocking traffic jams in crowded city centres to improving the access and travel time of enclave countryside, it will simply improve the lives of millions of users. This unknown domain of aviation will require from industrial and regulatory authorities important work in order to assure the integration of these technologies in the aeronautical landscape while keeping safety as the number one priority (EASA, 2021).

VTOLs also deeply contribute to what we considered as being the core aspect of tomorrow's aviation: personalisation and flexibility. Indeed, a VTOL could as much be owned by any human as it already is possible with cars. If it becomes similar to the automobile industry, diversification and personalisation would simply be infinite. Just imagine being able to buy next to the just-released Electric Jeep, the VTOL you had in the poster as a child and on which you can now choose the colour of the blades, the seats, the engines, and the livery.
But before reaching this sweet dream, big regional authorities like city halls or regions will be the ones operating them (TIPHANEAUX,

2021). This new kind of public transportation will enable any user to fly and access that beautiful feeling of freedom. This would be another step forward into flexible aviation open for all.

New Aircraft design

In parallel, in the limitless quest for emission reduction, numerous ambitious manufacturers and researchers have developed new interesting designs. For a non-aircraft aficionado, it is very complex to differentiate two aircraft models, and apart from the A380 and the 747, all aircraft have the exact same design with one cylinder, two wings, and two engines. This historical look has some wonderful ability and allowed aviation to become in less than a century more than vital for the world's economic health and growth. But wouldn't it be time for a manufacturer to start their design revolution? The efforts given to the integration of connected cockpit and digital air transportation have provided a level of safety and some great improvement in the reduction of emission. But as previously mentioned, reaching a carbon-neutral industry before 2050 also means that every single improvement has to be adopted.

One major breakthrough is the flying wing aircraft and notably the latest design made by the KLM Flying-V model (KLM, 2020). Using relatively similar technology in terms of the engine to today's aircraft, this type of wing is expected to reduce by 20% the average fuel consumption compared to today's latest design. After the digital revolution of the industry that has already started, designs could be the next significant milestone of aviation.

Supersonic Jets and space travel

Speaking of the general public, if there is one aircraft that went through every generation without taking a winkle, it is the Concorde. People that have had the chance to fly in this aircraft are nowadays considered legends and tales around it still make people dream. That supersonic jet simply arrived 60 years ahead of its time. With the announcement of United investment in 15 supersonic aircraft, aviation is ready to enter a new era for a successful launch of supersonic capability this time, and gain back the ultimate advantage of air travel: Speed (Boom, 2021). Indeed, with the approaching operability of the Hyperloop Elon Musk's project, the aircraft would lose the historical advantage of reduced travel time (Virgin Hyperloop, 2021). With capacities very similar to an airplane in terms of speed without the airport constraints, this levitating high-speed train could be the next major competitor to aircraft. Being a real bet for the airline, Boom Supersonic will be able to fly over the speed of sound from 2029 as a net-zero carbon aircraft.

Richard Branson, another incredible forward-thinking entrepreneur of our time also made another of our dream come true: reaching space for fun. Only reserved to space tourism at the moment, if spacecraft would be able to transport passengers from one place to another via a short journey in space, wouldn't it be considered aviation? Once this milestone is reached, aviation might need to redefine its boundaries and even its definition (F abi, 2021).

New airport

No matter the coming innovation or the possible redefinition of aviation, one commonality that has never changed in decades is that an air journey starts from an airport and ends in an airport. However, with the arrival of VTOLs and drones in our daily lives, the future architecture of urban airspace is being redrawn (Vidal, 2020). The boundaries of an air travel journey are therefore in constant redefinition. Airports will never be as close to city centres as in the future. While long haul could be achieved through still

"traditional" airlines, an electric VTOL could be waiting at the exit of the aircraft to transport passengers directly into city centers without interruption.

And even without VTOL, a real revolution has started in the design of new airports. With the integration of new innovations and capacities conducting to seamless experiences for all passengers, the airport should in the future more look like a city centre than a controlled and monitored environment. New technologies should enable airports to importantly reduce the impact of international borders and security checks on a passenger satisfaction journey. Contactless controls and biometrics technologies could lead to travels where a customer will never be asked to stop, to wait in line, and even to be controlled by security agents. Not only the experience will become peaceful but it will also be as easy for a passenger to take a train as a plane.

Conclusion:

The aeronautical world is a wonderful universe mostly composed of passionate people. They are probably the leading reason that makes this industry as resilient as it is. With safety in the heart of any decision, major regulatory authorities are constantly shaping and preparing aviation to become an industry safer than ever. The cyclical and changing nature of world economics and its direct impact on the aeronautical sphere forces stakeholders to constantly adapt themselves to the environment. The increasing and rapid development of e-commerce throughout the world is one of the major changes that is impacting deeply air transportation. Our vision of aviation for tomorrow's world is strongly related to this ability of adaptation with two keywords: Personalisation and Flexibility. Applying these two principles to the industry would not only lay strong foundations no matter the external environment but will also enable aircraft to be closer than ever to human demands. Lastly, it would not be a paper about the future without approaching the very sensitive subject being climate change. As young engineers, born and raised in a world where we were continually repeated that our planet has a deadline because of human behaviours. We can only spot a future where flying would have as much impact as taking the bike nowadays. Over the years, the industry has made significant progress in efficiency of its operations and technology. Yet, the rapid growth in the volume of air traffic constantly outpaces these savings for now. That ideal vision of the zero-emission aeronautical world seems so illusory and, in the meantime, so realistic thanks to all the beautiful projects and pioneers that dreamt and started to build a world we envisaged. That's why today, besides the bad communication sometimes, the aeronautical industry is one of the most sustainable and robust sectors especially in terms of regulations. We believe that it is this passion of the various players and this collective determination that will ensure that aviation a bright and clear future in our hostile world.

Annex

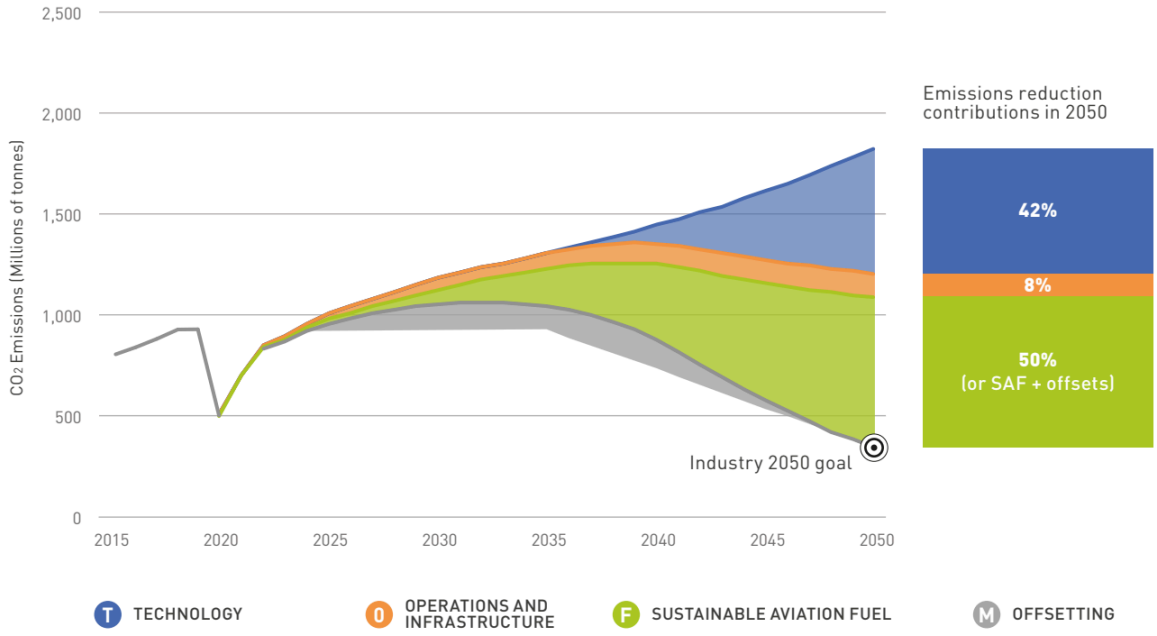

Figure 1: Aspirational and aggressive technology perspective Scenario for the industry response to Climate change objectves. Source: (Air Transport Action Group, 2020))

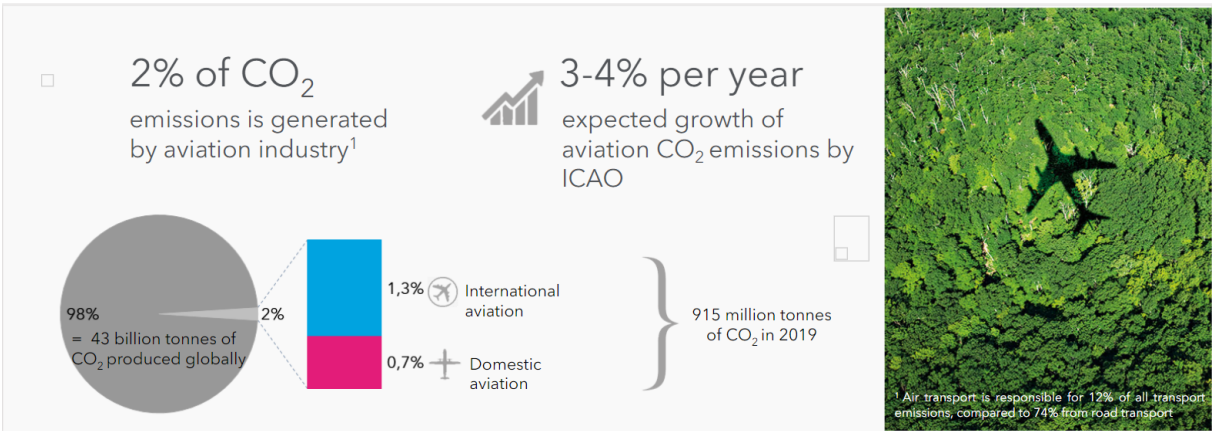

Figure 2: Aviation impact on Climate change (Source: (ATAG ICAO, 2020))

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