Aviation world rethinking strategies after COVID-19 crises

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Abstract: *The COVID-19 pandemic has the potential to trigger a global economic crisis of significant dimensions, affecting all industries and activity sectors. One of the industry sectors in the eye of the coronavirus storm is aerospace. As governments all over the world have closed the boarders and imposed quarantine to their citizens, global air traffic has been brought to an almost complete standstill by the COVID-19 outbreak. Aviation leaders all over the world think that "this is still the worst crisis that this industry has ever been faced with. There's a huge amount of uncertainty going forward." In Europe and all over the world, governments are taking action adopting measures in support of their national airlines, but besides the grounded planes and canceled flights, a whole aviation and aeronautics industry is suffering from this crises. The big manufacturing companies are suffering and have to let go thousands of employees. There is an enormous pressure also on the aviation research to cope with the new situation. The immediate impact of the crisis is a severe economic downturn of the whole industry, starting with airlines postponing or stopping orders and deliveries, creating a snowball effect on the complete value chain, with a drastic lack of cash to finance research projects.*
In this challenging times of unprecedented uncertainties, aeronautics research community is trying to answer to two pressing questions: (1) How does this crisis affect research in the European aviation sector? and (2) What needs to be done to face the consequences caused by COVID-19 and boost aviation research in Europe?

Key Words: *aviation, COVID-19 crises, air traffic, aviation research, COVID-19 impact*

1. INTRODUCTION

Aviation, climate and economy are all inherently global. Aviation's global economic impact is more than €2.4 trillion per year, while the European one is more than €700 billion per year. It contributes to European prosperity, national security, European social integration, Single Market and provides EU leaders the financial strength to absorb external shocks (e.g. financial crisis, coronavirus) and invest in climate neutrality and social challenges.

The world is facing an unprecedented crisis, both sanitary and economic crisis, which impacts the civil aeronautics industry very severely and for a duration that nobody can seriously predict today. And the impact is even more severe because the crisis happened during

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a phase of incredible ramp-up, also never encountered before. Over the last 20 years our industry did not experience any down-turn: the 9/11 terrorist attack in 2001, the sanitary crisis in 2002-2003 (SARS), or the financial crisis in 2008 only resulted in a slow-down of the ramp-up, limited in time (ICAO, [4]). **But this time, global air traffic has been brought to an almost complete standstill by the COVID-19 outbreak.**

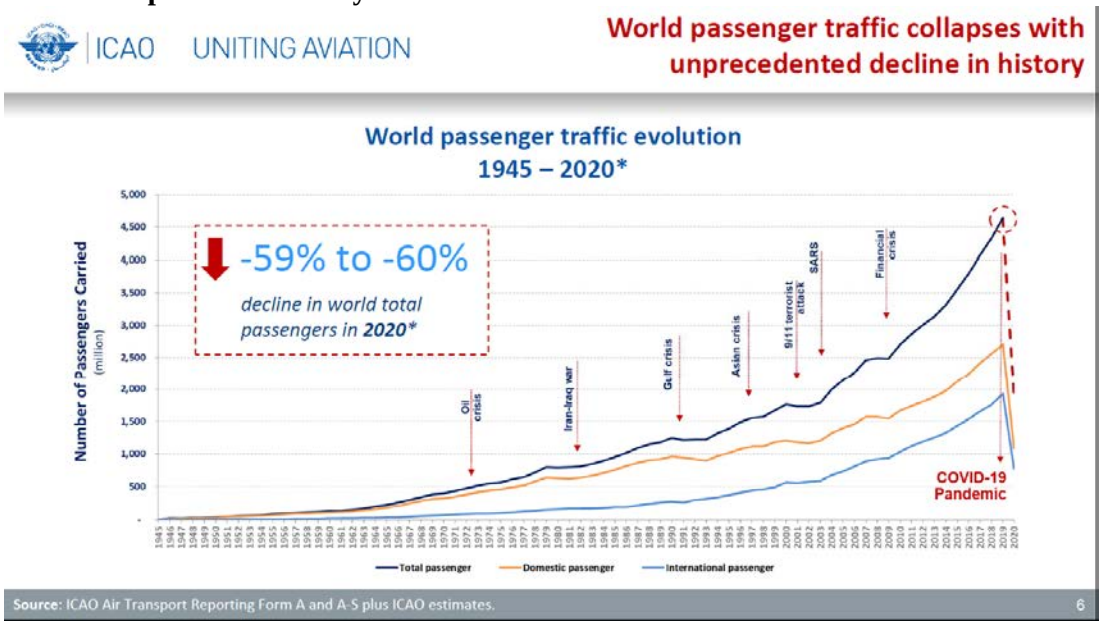

Fig. 1 World passenger traffic evolution 1945 -2020, Source: ICAO [4]

This could be the worst crises in aviation history. The Airbus chief executive, Guillaume Faury, said: "We are now in the midst of the gravest crisis the aerospace industry has ever known" and warned it could take "three to five years" for passengers to be as willing to fly as before the crisis (Aerotime, [2]). Qantas (Australian Airlines) chief executive, Alan Joyce says "This is the worst crisis the aviation industry has gone through". The CEO of EasyJet also thinks "this is still the worst crisis that this industry has ever been faced with. There's a huge amount of uncertainty going forward".

2. IMPACT ON AIR TRAFFIC

The COVID-19 outbreak, resulted in the collapse of air connectivity, putting at risk the future of the entire aviation ecosystem – with far-reaching consequences for tourism and countless businesses and citizens across Europe and entire world. Restarting air transport will play a crucial role in the overall recovery of European economies. But if civil aviation is amongst the hardest hit sectors by COVID-19, it is also one that faces far greater challenges when it comes to climate change – and its ability to decarbonize. Therefore, air transport must be at the very core of the strategy the EU is charting for its recovery.

Aviation transported more than 4.5 billion passengers in 2019 and connected more than 20.000 unique city pairs globally. While the aviation community consider the next "20-year commercial aircraft market forecast/ outlook", and publishes 2050 aviation emissions projections, **merely as facts**, the coronavirus is here to remind the world about the uncertainties of life and their impact on human health, globalization and the state of global economy.

Initial reports suggest that coronavirus **could wipe out up to $113 billion in worldwide airline revenues in 2020**. This figure is nearly half of the 5-year (2015-2019) cumulative profit of the airline industry, estimated at $269 billion – the best in airline history.

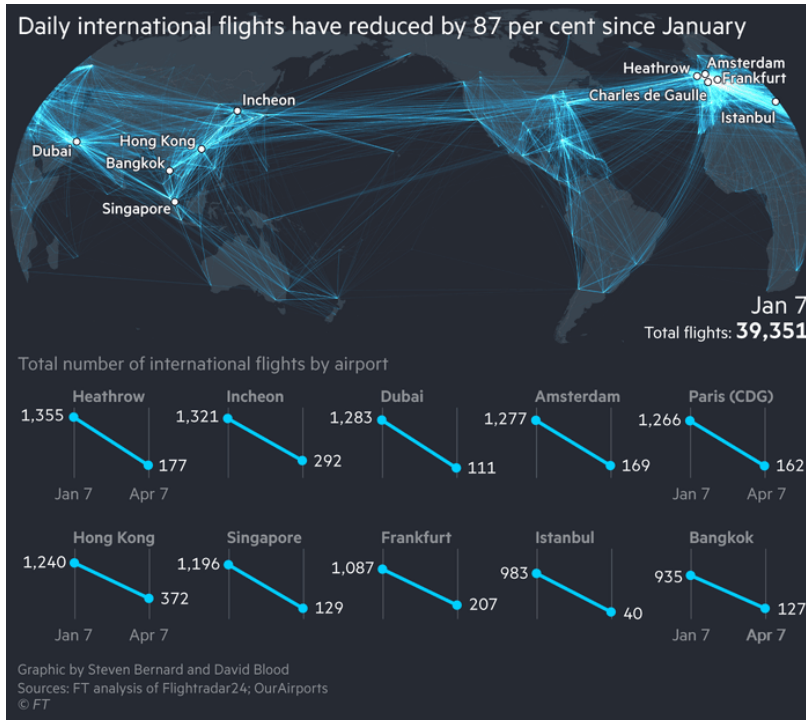

Fig. 2 Daily international flights, January 7th, 2020, Source: Flightradar24 [6]

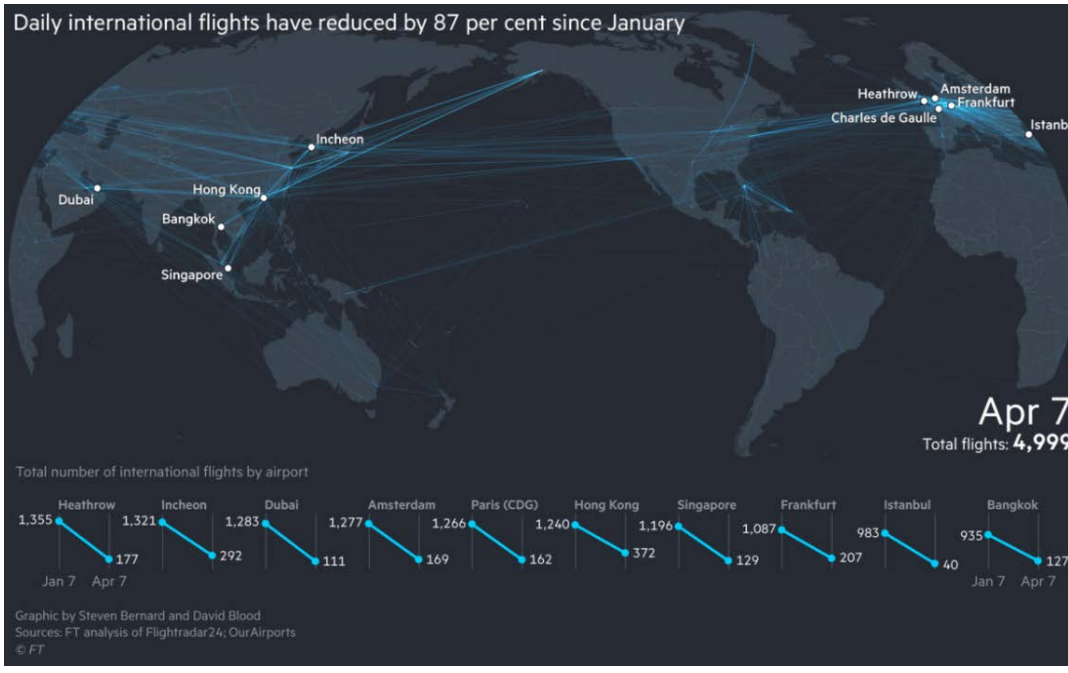

Fig. 3 Daily international flights, April 7th, 2020, Source: Flightradar24 [6]

The 2 graphs above offer representation of Daily international flights on January 7th, 2020 and on April 7th, 2020, showing a clear reduction of daily international flights by 87 per cent from January to April 2020. This is a direct consequence of grounding more than 60 per cent of the world's commercial aircraft, as governments all over the world have closed the boarders and imposed quarantine to their citizens. In order to survive this crises, having limited or no revenue coming in, airlines are cutting costs, drawing down huge credit lines to bolster liquidity, and calling for billions in state aid (Financial Times, [5]).

In Europe, governments are each adopting their own approach to supporting airlines. France has agreed aid for Air France (subsidiary of the Air France-KLM Group and based in Paris, Air France is the national airline of France. The airline merged with Dutch flag carrier KLM in 2004, forming one of the world's largest airline groups) and the Netherlands aims to help KLM (KLM Royal Dutch Airlines is the national carrier of the Netherlands and together with Air France form Air France-KLM Group) (Flightglobal, [3]).

Lufthansa Group (Deutsche Lufthansa AG is a global aviation group, headquarters in Cologne, Germany) is seeking support from its home countries (Germany, Switzerland, Austria, and Belgium), while Virgin Atlantic has asked the UK for aid and is also seeking new investors.

Italy plans to renationalize Alitalia, while Norway's proposed aid to Norwegian (low-cost company in Norway) will almost wipe out existing equity.

Varying levels of support have been agreed for Finnair (national carrier of Finland and majority-owned by the Finnish government), Icelandair (national carrier of Iceland), TAP Air Portugal (national airline of Portugal), air Baltic (the Latvian national carrier - 80% state ownership), TAROM (the flag carrier of Romania and majority owned by the Romanian government), Blue Air (Romania's first low-cost carrier) and Croatia Airlines (the national carrier of the Republic of Croatia and is wholly-owned by the Croatian Government) (Flightglobal, [3]).

The US government approved $2 trillion coronavirus stimulus and part of it will go to US airlines and US aircraft manufacturers (i.e. Boeing).

3. IMPACT ON EU AVIATION RESEARCH AND INNOVATION

As showed above (in the 2 representations) the COVID-19 crisis has a strong impact on the aviation sector, and governments are acting in supporting the airlines. This is only the tip of the iceberg, this is what the entire world can see, but besides the grounded planes and canceled flights, a whole aviation and aeronautics industry is suffering from this crises. The big manufacturing companies are suffering and have to let go thousands of employees – Guillaume Faury, the CEO of Airbus, said that the "business is potentially at risk" after airlines worldwide have slowed or even canceled deliveries of ordered aircraft, pushing Airbus to cut a total of 15,000 jobs (more than 11% of its workforce) (Aerotime, [2]). There is an enormous pressure also on the aviation research to cope with the new situation also from the financial perspective. The immediate impact of the crisis is a severe economic downturn of the whole industry, starting with airlines postponing or stopping orders and deliveries, creating a snowball effect on the complete value chain, with a drastic lack of cash to finance research projects. Besides supporting the air travel industry, other important actions can be taken in the EU in response to the coronavirus crisis and the research and innovation have a major role to play in overcoming this crisis. This ***also holds opportunity to accelerate the transition to a sustainable, green aviation.*** As Commissioner Timmermans said: ***the climate crisis has not***

suddenly gone away. Many governments are taking action by adding sustainability demands to their support packages and research and innovation is the key here.

The impact of coronavirus to the economy is also felt in EU aviation R&I – hopefully in the short-term only. Research and market decisions, as well as the financial investments, have long-term impact in aviation. Preparation of new transformative R&I programs entails big financial and technological risk, without any immediate market reward. For **airlines to invest in cleaner and more efficient aircrafts, four elements should be timely aligned**: healthy air-traffic demand (high regional and/ or global growth, limited geopolitical instabilities), high airlines profitability (over a number of years), low interest rates and high fuel prices (pushing for research on alternative fuels). At times of high uncertainty (i.e. coronavirus, trade wars, increased geopolitical instabilities), these four parts of the "invest-in-more-efficient-aircrafts" equation do not add up.

As a consequence, **aircraft manufacturers do not easily decide to invest** €20-40 billion for a new aircraft. In addition to the nearly complete halt of air-traffic, the recent (March 2020) drop in oil-prices due to coronavirus, exposed airlines to billions of euro of fuel hedging losses. These **hundreds of billions of euro in total losses for airlines** due to coronavirus will have a direct impact to ongoing as well as future orders and decisions. This **makes the investment in aviation R&I even more urgent and more financially demanding.** That's why the **limited available European R&I investments** should have clear **ambitious and achievable objectives.**

The aviation sector is one of the most severely affected sector by the COVID-19 pandemic and the research community is trying to answer to two pressing questions:

Question 1: How does this crisis affect Research in the Aviation Sector?

Question 2: What needs to be done to face the consequences caused by COVID-19 and boost Aviation Research in Europe? (EASN, [1])

Question 1: How does this crisis affect Research in the Aviation Sector?

In the aviation sector, as in many other sectors, research cycles are longer than the typical cycles of production, thus the long wave of the economic crisis did not hit yet in a full sense the research activities. It's worth mentioning that the COVID crisis is appearing in a moment when on one side the request for mobility (both people and goods) was on a continuous ascendant path and on the other side facing possible restrictions to Air Transport System due to the emerging sensitivity and reaction of society to climate change and the perceived negative impact on climate by Air Transport. In perspective the COVID crisis will affect the aviation research in different ways.

- Due to the COVID crisis a lot of public funding will be directed toward health research in order to fight the current pandemic and, hopefully, to increase preparedness level of Europe and national governments to possible future health crisis. **This might have a negative impact on the amount of funding dedicated to research in the aviation sector.**
- How long the COVID-19 crises will last and what other crisis will affect the request of mobility? These are other elements that will influence in a negative way the impact on the Aviation sector.
- The vaccines are here and countries all over the world started the vaccination process and the general predictions are that the vaccines will stop very soon the COVID-19 pandemic, nevertheless there are no guarantees on how long it will take to really impact and defeat the virus all over the world; it is worth considering that the vaccines will not be available for all people around the world in a short time (if ever considering

the disparity of economic conditions). Aviation is global, pandemic is global and if there is not a real worldwide covid-free situation we will face a very difficult situation to manage to ensure mobility and health safety. **In fact, we might face for a long time a situation where we have to adapt the aviation offer to the level of health alert in time or geographically**. This implies:

- **a totally different business model and planning of the mobility offer;**
- **dedicated research to ensure a flexible mobility offer but also to ensure health on board of transport vehicles and infrastructures.**

- **Other crisis might be behind the door, one for all the climate crisis with a lot of possible consequences on society and thus on the mobility request.**

These boundary conditions imposed by the ongoing COVID-19 pandemic causing restrictions in nearly all countries is having also huge impact on planned events. Air shows, scientific and aviation conferences, seminars, workshops or meetings were cancelled, postponed or became virtual events. The exchange between researchers has been reduced to on-line communication and e-mails. The cooperative research of international partners in joint projects is hampered by the restrictions.

Question 2: What needs to be done to face the consequences caused by COVID-19 and boost Aviation Research in Europe?

The COVID-19 pandemic brought an unprecedented crises and nations all over the world didn't know how to deal with it and at the beginning of the crises we have seen countries trying to find solutions by themselves only for themselves. This trend changed while we understood more and more that we can overcome this crises only with effective and efficient cooperation at European and worldwide level. Aviation industry finds its roots in a very effective and long lasting cooperation at European level. In order to face the consequences caused by the pandemic, the aviation community in Europe needs to consider the following:

1. Although we are in the middle of a health and economic crises provoked by COVID-19 virus, affecting drastically the aviation sector, **the real challenge of the aviation sector still remains the climate neutral aviation by 2050** and we should not divert our attention from this ambitious goal, on the contrary we should intensify our efforts. The pandemic has brought opportunities as well as challenges, and the European Green Deal and the EU Green Recovery are highlighting the need for cleaner, more sustainable and environmentally-friendly aircraft. A strong investment in innovative approaches is necessary, as greening aviation is a massive technological challenge, involving close collaboration with all actors – universities, SMEs and research centres as well as industry. Provided that research and innovation on national and European level will be enhanced, coordinated and focused, the COVID-19 crisis could even help to accelerate the transformation towards a Zero Emission Aviation. Hybrid and full electric flying, the use of hydrogen and alternative fuels, as well as innovative aircraft configurations must be at the forefront of research and innovation programs. This will lead to a sustainable aviation along the whole value chain and lifetime of an aircraft, securing existing jobs and creating new ones and safeguarding the competitiveness and leading position of the European aviation sector.

2. A strong European approach. The challenge to reach a climate neutral aviation system is tremendous: the private sector doesn't have the capability nor the capacity to invest alone, in the same time, no European country has the financial resources, the technological and industrial capability and capacity to achieve this very ambitious goal, nor the capability to

promote and support the required changes to global regulations and operative frameworks that would be necessary to implement those solutions. It is obvious that aviation community needs to act together in a coherent and comprehensive manner at European level.

3. Synergies in order to maximise impact

- **Synergies with other sectors**: coordinated approach with other industrial sectors to develop rapidly the critical technologies: the space sector, where decades of experience in highly safety-critical applications of hydrogen technologies can serve as an important stepping-stone for the challenges related to the hydrogen powered aircraft. Also, synergies with sectors like Hydrogen and Batteries will bring knowledge on fuel cells and hydrogen as potential fuel sources. Looking from the other side, technologies from aviation sector have been successfully used in other sectors.

- **Synergies with other EU national and international funding programmes**: besides the synergies with other sectors, another important lever for synergies is the link to national research and innovation programmes through cooperation agreements and steering mechanisms, which can enable coordinated and/or joint programming. Organising this kind of synergy programmes will require a clear, shared, flexible and easy-to-implement framework at Member State and Union levels, based on a common vision with respect to the interventions needed to create the future climate-neutral aviation system.

4. Strong and authentic political support: the COVID 19 crises has also an impact on funding for aeronautics R&D and the investments in this sector will dry up, and the sector is risking falling significantly behind the great ambition to become the world's first climate neutral continent. Research and Innovation in aviation will bring exciting new innovations that will revolutionize aviation and the transport system it operates in. Fully autonomous aircraft, revolutionary configurations and new, climate-neutral propulsion mechanism are just few of the areas where significant changes can be expected in the next decades.

The question is not if, but how fast all these new and existing innovations will become a reality. This is more a political question, than a technological one. Policy makers (European Parliament, EU leaders, and national governments) should consider a budget ambitious enough to fit the ambitious purpose to reach climate neutrality of Europe by 2050 and be the first climate neutral continent.

5. Investment in human resources - harness the talents and the energies of the young, enthusiastic and brightest researchers and entrepreneurs. Aviation domain must interest and attract the next generation best and brightest to work in aerospace. Only by managing to do that, aviation will be able to face the challenges of tomorrow. If order to stay relevant, innovative and attractive for young talent, the way of doing things in aviation must adapt and evolve:

- **Implement a new way of working:** working in open innovative environments like living labs should become the standard. These environments or communities should be interdisciplinary by definition and such new ways of working will generate the solutions of tomorrow's problems.
- **Break down barriers:** students are no longer interested in one field alone, but are much broader educated to tackle societal challenges.
- **Welcome new talent at an earlier stage. For some time now there** has been significant attention for interesting young pupils for a career in science and technology, especially geared towards girls. First results are positive and the future innovators are more numerous in numbers and more diverse than ever before.

Research institutions have a vital role to play in offering practical experience to young pupils, trainee and internship positions to develop students, PhD positions to develop young researchers and challenging junior positions for young professionals.

- **Free circulation of people, young people in particular:** mobility of young talents bring great benefits and help them develop on many levels, professional by learning how colleagues from other organizations/countries study, work, do research and learn from each other but also personal by learning about other traditions, cultures, languages. This should not be looked as brain drain, but a Brain Gain.

4. RESEARCH SOLUTIONS IN OVERCOMING THE VIRUS

Until the end of 2019, aviation was facing three main transitions: climate-ecological, social and economic. Since January 2020, with the Covid-19 outbreak, aviation is facing with a fourth transition: the health/safety transition. *In aviation, for many obvious reasons,* ***health on board of aircraft was always a very important topic. Because of the airflow in the cabin and the HEPA-filters, nearly all bacteria and viruses are removed from the air. As a result, flying is actually quite safe.***

However, aviation being an ever growing instrument to free movement all over the globe, it has been **the main carrier and responsible for the fast spread of coronavirus** from Asia to the rest of the world – as happened in the past with other respiratory infectious diseases (Aviar flu, SARS, etc). Consequently, advanced measures need to be developed to enhance hygiene standards, on-board infections safety, and ground based control technics detecting infected passengers before entering the airplane. This requires research and technology development for aviation in new areas. ***Research will turn aircraft from a mechanism for spread, towards an early warning and monitoring system and if we will have to face such a devastating crisis again, we must be prepared by making flying even safer than it already is.***

Investment in R&I will help Europe to understand the many faces of the virus and to find solutions to overcome it, by answering to pressing questions:

- How does it spread? A better understanding on how a virus like COVID-19 spreads in aircraft is essential, using the current fleet as a benchmark. Even if detection of COVID-19 is not possible yet, there may be opportunities to investigate the spread of similar substances. This research builds upon previous work done for the SARS outbreak and can be conducted through simulation tools and validated by experiments in wind tunnel and flight tests for verification. **Artificial Intelligence** may be used to predict contamination in aircraft.

- How can we better detect? Research will develop real-time measurement technologies for pathogens that also work in real aircraft environment with all its limitations especially regarding weight, volume, costs, vibrations, reliability, operating temperature requirements. The detecting device/system must very easily be updatable with additional target patterns on short notice all over the world to be effective against unknown pathogens.

- What can be done when infection is detected?

- Quarantine kit for airplanes: there are quite some solutions readily available for implementation in case a possible hazardous pathogen is detected on board, but for a variety of reasons they are not implemented or used. Bringing together these solutions and developing new ones should be at the heart of EU efforts. This should also include rules and protocols, measures to stop spread in-flight, decontamination, etc. Such efforts can also include measures such as the development of separators between rows and research on the airflow within a row. Such measures prevent spread and allow for less empty seats and, thus, less economic impact.

A more long term measure is the modularity of cabins, allowing for a closed cabin with medical boxes, greater passenger distance and smart cabin systems and passenger support.

- The dedicated **UV-C devices** have to be studied in more extent, also in combination with the whole air distribution system design. UV-C light to sterilize the whole cabin between each flight as a regular measure can't be supported by a cabin interior supplier point of view. The high energetic UV-C that is very effective against pathogens is also very aggressive against all carbon based materials (with most of the parts in the cabin are based on) and therefore it is not recommended for frequently/regular use. An advanced coating for vulnerable surfaces can be developed to address this. Additional devices to be transferred into flight applications are devices for ionizing radiation and plasma sterilization. These exist in medical environments, but they are not yet ready for employment in aircraft cabins.

- Advanced air flow management, such as local, decentralized mixing, would allow for control over which air (fresh or mixed-recirculated) goes where, on row-level and even on seat level. An effective anti-pathogen system (e.g. based on HEPA-filters of UV-C & visible lighting, plasma and ionizing radiation devices) could be studied. Also, strong gaspers could prevent circulating air to reach a passenger's face, preventing contamination.

- Advanced Air Purification such as additive manufactured of air purification filters based on polymeric matrices functionalized with active oxide nanoparticles - capabilities of filtration up to nano level;

- Develop a notification and alarm system for air quality as a function of specific parameters

- How do we reduce risk of infection?

- Develop pandemic alarm level. Such level could guide protocols for, for instance, disembarking, operations and procedures at airports (incl. level of disinfection), crowd management, distribution to regional airports, luggage distribution, etc. This measure should be developed on a global level, possibly also with the involvement of the WHO (World Health Organization).

- Airport detection and decontamination measures would allow for identification (thermography) of sick passengers before they board the aircraft. Advanced decontamination of waiting areas and hall ways needs to be developed and implemented. A detection system should also allow for contacts tracing.

- Limit direct contact with aircraft surfaces by making as many elements as possible touchless, such as in the lavatory (e.g. door, flushing, bin, overhead compartment, etc). The less passengers touch, the better. And if surfaces must be touched, high performance materials covered with antiseptic nanoparticles may be applied.

- Introduce novel cabin material surfaces and with anti-viral and anti-bacterial properties that are employed on highly frequented contact surfaces (textiles, hard surfaces) based on high temperature and functional coatings.

5. CONCLUSIONS

Despite the fact that the severe problems caused by the COVID-19 pandemic will impact the aviation sector probably for some more years, the aviation sector is dealing with another pressing long-term challenge - the global warming. As Commissioner Timmermans said: ***the climate crisis has not suddenly gone away.*** The development of new generation aircraft is a wonderful opportunity for the complete value chain: aviation industry needs better batteries, more effective electric engines, smarter energy management systems, efficient and environmentally friendly solution to produce and store hydrogen. Here beside COVID-19 the

relevant aeronautics research must have top priority and has to be addressed by technology developments on European, regional and national level. Despite all effort and achievements until now, more needs to be done for meeting the ultimate and very ambitious objective of reaching net-zero greenhouse gas emissions, and to enable a ***climate-neutral aviation system in Europe*** **by 2050.**

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