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The Modern Age of Discovery

The future of industry to government relationships in civil and defence aerospace

Introduction

March 23rd, 2020. An unprecedented pandemic forced countries to put a halt on 75% of all non-essential flights worldwide. Meanwhile, merely two months later, the first crewed spaceflight operated by a private company, a joint effort between NASA and SpaceX, occurred. These two events clearly highlight the (un)desired control governments have in the make or break of the aerospace industry. In an ever-changing world, should this interdependence between the defence/civil industry and authorities cease to exist, or is a remodelling of current relations possible and fruitful for both sides?

Instead of looking in the future for answers, it is possible that it can be found in a thrilling past for Humanity: the Age of Discovery. In a period where brave explorers risked their lives in the hope of a better future, most developments in science were accomplished with the aim of reaching unknown lands, often supported by their respective governing body. In aviation as well as in the space sector, most advances came during times of tension, such as both World Wars, and the Cold War. It being a matter of national security, large investments by governments were made, and there was no hesitance to take risks.

In today's world, the situation is substantially different. Tension is still there, but in different forms. In the aviation sector, there is an ongoing battle against climate change, where it is the task of both the authorities and the private sector to become more sustainable. In the space sector, it is the competition between private companies that has grown notably, with the goal of making the access to space cheaper, more frequent, and increasing payload capacities. Simultaneously, the goal of making life interplanetary has attracted many players, both in the public and private sector. With government agencies lacking behind on many occasions, reflection on their position in the industry is essential.

Thus, the aim of this report is to provide suitable options/ideas for the issues previously addressed, investigating how governments and the industry should work together to tackle the ongoing issues. With their implementation, a prosperous relationship between the aerospace sector and governmental entities can be assured, propelling humankind to a Modern Age of Discovery.

Taxation or Subsidisation?

Aviation in Numbers

In December 2015, a huge step towards climate change was made in Paris. In what is known as the Paris agreement, a deadline has been set for net-zero greenhouse gas (GHG) emissions: 2050. As all industrial sectors, aviation is attempting to decrease its emissions. However, this ecological awareness seems to hinder air transportation's profits.

Adding to this a massive labour shortage resultant of the Covid-19 pandemic, in which airports and airlines find themselves with their hands tied, an urgent solution needs to be placed on the table. Several states have already started taking measures, but were they the right ones? Let us look at the numbers.

Air Transport Emissions

According to the European Aviation Environmental Report of 2019, air transport has been responsible for 3.6% of the total EU28 greenhouse gas emissions in 2016 and approximately 14% of emissions of transport [1]. Additionally, from 2009 to 2017, an increase of 40% in the number of passengers was accompanied with a surprising slow rise in CO2 emissions of 15% and almost no change in noise impact, as Figure 1 exhibits.

This finding is explained by means of cleaner and more fuel-efficient aircraft and improved operations throughout the years. Hence, *investments in greener technologies seem to slow down the rise in emissions.*

Moreover, EUROCONTROL states that flights of less than 500 km make up for 24% of flights departing from the CRCO area (all EUROCONTROL member states except Monaco and Ukraine) but emit only 4% of CO2 emissions. Therefore, *domestic flight bans seem ineffective to control GHG emissions*, bringing more downsides to aviation and its globalization than environmental benefits.

Meanwhile, flights of more than 3000 km account for at most 9% of departing flights but are responsible for 53% of CO2 emissions [2]. *Decarbonization of medium-to-long-distance flights is thus essential to achieve relevant reductions in aviation's carbon emissions.*

Impact of Various Factors in Aviation

Similar to any transportation sector, there are elements that heavily alter the state of aviation. For instance, air transport clearly follows the law of supply and demand, as higher request leads to an increase in the number of flights, which is subsequently accompanied by an inflation in ticket prices.

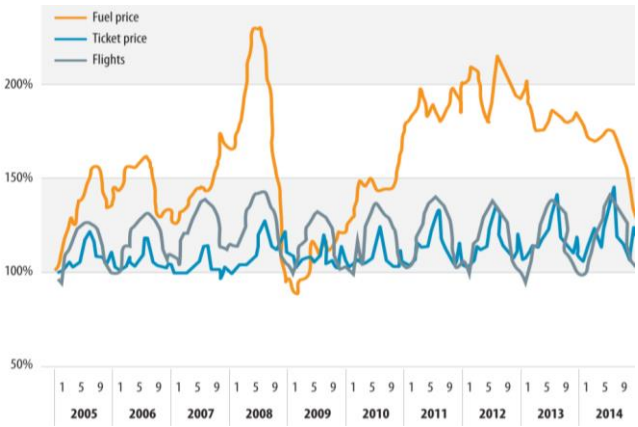

Figure 2 – Evolution of flights, ticket and fuel prices [2]

However, Figure 2 shows that the *surge in ticket prices does not seem to alter the customers' urge to fly*. Apart from a clear seasonal effect, not even the rise in jet fuel price seems to stop flights from taking off (although it heavily impacts airlines' profit).

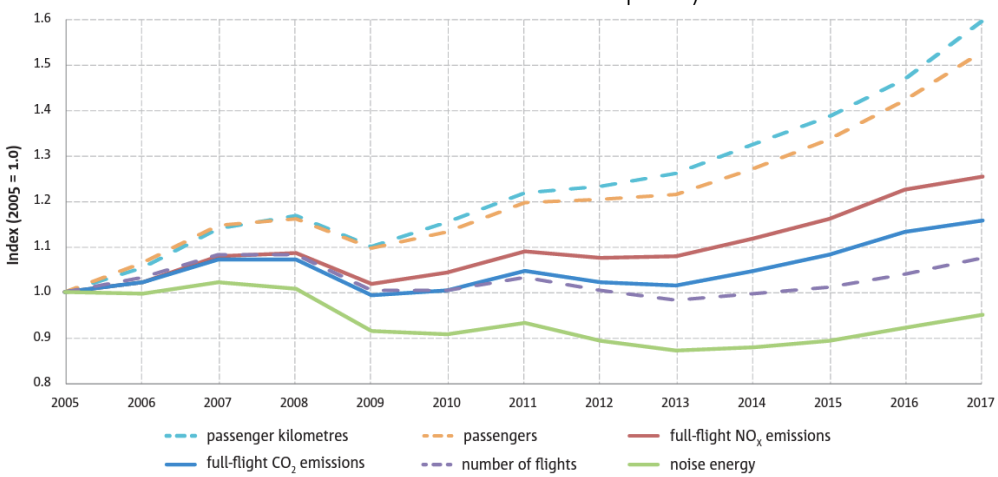

Figure 1 - Relative evolution of key air traffic and environmental indicators since 2005 [1]

Furthermore, data from EUROCONTROL and IATA show that a 1% change in a country's GDP generally induces a 1.5%-2% change in the number of flights [2]. Also, as noticed during the pandemic, aviation is seriously affected by the travel restrictions imposed by governments.

Air traffic, GDP and travel restrictions have a stronger influence on the number of flights than fuel or ticket prices

Should Fuel Tax Exemption remain?

In a global attempt to slow down climate change, many state that an aviation fuel tax is inevitable, as the EU loses out on €27 billion yearly due to fuel tax exemptions alone [3]. Nevertheless, by imposing a global taxation, airlines will struggle to make ends meet, as fuel is already 30%-60% of their annual expenditure [4].

Just as in the Chicago Conference of 1944 (when the International Civil Aviation Organization was formed), governments must be aware that such measures need to embrace the necessities of the world of the future, without compromising international union, aviation and, most importantly, Humanity.

Fuel Taxation is Unnecessary

In 2019, the European Commission released a research paper on the "Taxes in the Field of Aviation and their impact" [5]. Its key conclusion was that *countries which heavily taxed aviation*, such as the United Kingdom, Germany, and Italy, *still reflected a significant increase in aviation's CO2 emissions*, resultant of the industry's increase in demand. In this event, governmental entities should conclude that there is not an effective way of making aviation more sustainable through taxation without compromising the sector.

As stated before, imposing taxes and increasing ticket prices barely influences the number of flights and, unfortunately, have no meaningful impact on aviation's climate footprint. Moreover, a significant part of the tax revenue collected by governments is lost due to inefficiencies of the governmental machines. Thus, *countries should not only attempt to limit the problem, by means of taxation, but try their best to find a solution to it.*

The solution: Stimuli for the development of new technologies

Technological evolution has been the core reason behind the slow rise in GHG emissions, as previously mentioned. For this matter, countries need to invest in cutting-edge airplane designs, more fuel-efficient engines, Sustainable Aviation Fuels (SAFs), among other novel machinery. Such grants could be done via subsidies, fiscal benefits, and/or banking guarantees.

Additionally, the concept of an international center for innovation could be implemented (which will be discussed afterwards in further extent). Summarily, the idea is simple: *a support must be given to public companies, private companies, and universities with the aim of finding new ways for aviation to thrive more ecologically.*

Automation: Key to Labour Shortage

Aviation's post-pandemic recovery has been everything but calm. Due to massive lay-offs during the last years, the sector struggles to find a way to re-hire staff, as they demand better working conditions and higher salaries which follow the inflation witnessed nowadays. Hence, could the alternative be non-human?

As artificial intelligence is thriving, blue-collar jobs, such as customer service and sales, can easily be done by computer software. For on-site work, like baggage handling and checking-in, plenty are the autonomous machines able to compete such tasks. An example of this is FLEET, a system which seeks to replace the need for fixed conveyors and sorting systems [6]. Lastly, long lines in security checks could be an issue of the past in a couple of years, with the help of SeeTrue's Autonomous AI™ Detection, a novel system capable of recognizing threats and other illegal items in a matter of seconds [7].

Thus, a robot would quickly prove to be better than a human, due to its cost-effectiveness, continuous work (no fatigue) and lack of human errors. Even the replacement of pilots is already in advanced stages of development to support the boom in the Advanced Air Mobility market expected in the next decade, via the use of Unmanned Aerial Vehicles. The world will just have to wait and admire the upcoming future.

The future of the space industry

We as humans have always sought to extend our boundaries. A long time ago, explorers would get on boats and sail to where no person had gone before. Later, we figured out how to go faster, by train, car and eventually by airplane. However, there was one place we had not been to yet: outer space. Hence, during the Cold War, the United States and the USSR both set their sights on being the first in space, as well as being the first to land on the moon.

These new exploration efforts were led by the governments of both countries, as it was a matter of national security (and pride) to them. Moreover, the investments necessary were too high for businesses as spaceflight was not commercially viable at the time. Fast forward to today, private actors have become important players in the space industry. In the past few years, the world has seen a considerable rise in investment in private companies within the space sector, as seen on figure 3.

This surge in private companies brings up an important question for national space agencies: will they stay the way they are, or will they have to drastically change to stay relevant? Furthermore, what should the future look like for quicker and more efficient innovation?

The new Space Era

Ever since the founding of SpaceX in 2002, the New Space era began [8]. Thenceforth, many new space companies have sought the same success as SpaceX, with cumulative investment in start-up space companies since 2000 rising to $52 billion, with 69% occurring in the last five years [9]. It is thus evident that the private sector will become even larger in the coming years.

Slow or no innovation within government programs

If we as humans want to explore the universe, technological innovation is key to get closer to our goals. However, many government agencies have settled in their *comfort zone*, without seemingly making any significant progress. Roscosmos, the Russian Space agency, has been launching variations of their Soyuz rocket since 1966. With the "*if it ain't broke, don't fix it*" mentality, the Soyuz rocket has been doing a sturdy job at transporting crew from and to the International Space Station, with even having the upper hand on the US from 2011 to 2020, after the Space Shuttle retired. However, now that SpaceX is operating its Crew Dragon spacecraft [10], and with Boeing's Starliner almost operational [11], the Soyuz spacecraft has lost its international competitivity.

This same comfort zone problem can also be seen at the European Space Agency. The Ariane 6 is being developed as a replacement for the Ariane 5, with the goal to halve the costs, bringing down the cost from $177 million per launch to just $77 million [12]. That being said, the Ariane 6 has been in development since the early 2010s and is currently projected to fly somewhere in 2023 [13]. Meanwhile, the development of SpaceX's partially reusable Falcon 9 rocket started in 2005, with a first launch in 2012, and a first landing in 2015 [14]; a much shorter timeframe.

Undoubtedly, considering the successful track record of the Ariane 5, the Ariane 6 will be a reliable option in the market for medium-heavy launchers. Nevertheless, with the development of fully reusable heavy-lift launchers such as Blue Origin's New Glenn [15] and SpaceX's Starship [16], the Ariane 6 might turn out to be uncompetitive, even with the reduced price compared to the Ariane 5.

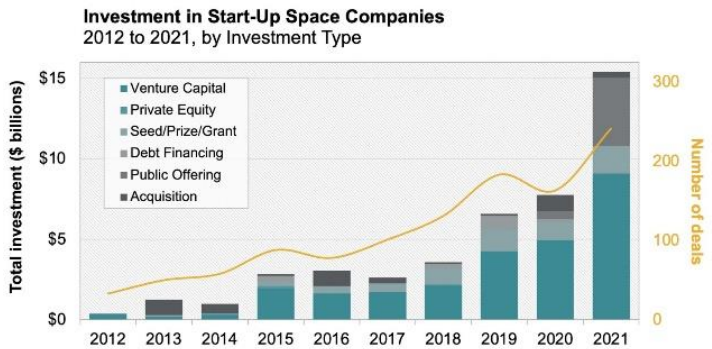

Figure 3: Investment in Start-Up Space Companies.
Source: BryceTech Start-up Space Report 2022

As a response to the trend of reusable rockets, the European commission, the European Space Agency, and ArianeGroup are developing a reusable mini launcher [17]. However, this would not be able to compete with the payload capacities of the likes of SpaceX or Blue Origin, but rather with small satellite launchers such as Rocket Lab's partially reusable Electron launcher [18]. Thus, Europe remains behind.

Governmental agencies not only struggle with timing, but with efficiency as well. In a 2011 study, NASA found out that developing the Falcon 9 with their traditional methods, the costs would have led up to almost 4 billion US dollars, while SpaceX managed with just $390 million [19]. In a similar fashion, the Space Launch System (SLS) currently being developed by NASA has costs that have risen to 23 billion US dollars, while the original budget was just 7 billion dollars. Furthermore, the cost-per-launch is estimated to be $4.1 billion [20]. Compared to the estimated $10 million per flight of SpaceX's Starship [21], SLS might become obsolete if these alternatives turn out to be succesful.

Why is it that private companies are so much more efficient than national agencies, often referred to as "Old Space"? The answer is quite simple:

Old Space […] is slow, bureaucratic, government-directed, completely top-down. Old Space is NASA, cautious and halting, supervising every project down to the last thousand-dollar widget. […]. Old Space coasts on the glory of the Apollo era and isn't entirely sure what to do next.

J. Achenbach, Washington Post [22]

In addition to that, private companies are able to operate at a much quicker pace compared to governmental space agencies, as they are not bothered by bureaucracy and political instabilities, such as administration changes [23].

Cooperation with private businesses

National space agencies are also seeing this trend, and they themselves realize that it might be time to change. NASA has fully embraced this emergence of private companies in the space sector. Before the retirement of the Space Shuttle, NASA was considering the Orion spacecraft for ISS cargo and crew rotation, as part of the Constellation Program [24]. However, in 2009 it was found that the program was going over budget too much. As such, NASA decided to look for alternatives. Thus, the Commercial Orbital Transportation Services (COTS) program [25] was created, where NASA contracted private companies such as Orbital Sciences Corp. and SpaceX for delivering cargo to the ISS. With SpaceX delivering their first cargo in 2012 and Orbital Sciences doing so in 2013, NASA was quickly able to fill the gap that was created after the retirement of the Space Shuttle.

After this fruitful collaboration, NASA continued contracting private companies for shuttling crew to and from the ISS, in the Commercial Crew Program (CCP) [26]. For this program, Boeing and once again SpaceX were contracted to develop crew transportation capabilities. Ever since the successful launch of the Crew-1 mission in 2020, the US is no longer dependent on Russia for crew transportation, once again showing the convenience of collaborating with private companies.

For its Artemis Program, which is a program envisioning a return to the moon, NASA is once again contracting several private companies such as Dynetics, Blue Origin, and SpaceX for developing hardware such as a moon lander [27].

SpaceX Crew-1 Launch (Credit: NASASpaceflight)

It is undoubtful that cooperation between governments and the private industry is key for technological innovation. Governmental space agencies are more and more becoming *enablers*. They enable private businesses to cooperate with one-another, and they support them financially with subsidies/fiscal benefits/banking guarantees/land concessions (to name a few) as well as with legislative support, by creating the legal framework for the companies to develop/test/bring to market their technology. Ideally, the government institutions should consider becoming *innovation hubs*. These innovation hubs could operate in both the space and aviation industry. A distinction between two types of innovation hubs can be made: national and international hubs.

National Innovation Hubs

The national hubs would be the successors of the national space agencies. Instead of starting its own projects, the national hubs set the space and aviation policy and the general direction or sector they want to head towards. Companies settled in that country can then request support for projects related to the national policy. An example of such an agency is the Luxembourg Space Agency (LSA), which gives funds to Luxembourgish space start-ups [28]. Luxembourg has set its visors towards space resource mining and encourages companies that want to engage in this sector to settle in Luxembourg [29]. This way, while the LSA does not produce any hardware themselves like most space agencies, Luxembourg is able to have a presence in the space industry.

International Innovation Hubs

On an international scale, a possible approach to accelerate innovation and progress of aerospace technology could be the introduction of an international institution, comparable to the International Monetary Fund (IMF) [30], or the North Atlantic Treaty Organization (NATO) [31], that is responsible for leading the future efforts to advance technology. A possible name for this institution could be the International Aerospace Hub (IAH).

Like in NATO and IMF, countries may become member states on the condition that they pay a certain quota based on their Gross Domestic Product (GDP). Companies settled in a member state are then eligible to request funding for projects, along with mentorship and expertise.

This funding can be done in two ways: if the project's goal is to make a profit in the long term (as is the case with many launch vehicles or airplanes), the IAH may take a certain percentage equity in the project. If the project does not create revenue, such as a science mission for example, there would be zero-equity financing, as is done for contracts in the NASA Artemis program.

Simultaneously, the IAH decides on the strategy and proposes projects, for which they create public tenders, and foster international collaboration. At the top of the organization, there would be two groups of leaders: the council of ministers, consisting representatives of each country, (most likely the minister of economics of each member state), and the Board of Directors, which consists of scientists, engineers, and other functions (non-politicians, in general). The council of ministers is there as liaison between the institution and their respective governments, thus their power on deciding what exactly happens would be rather limited, with the main decision body being the Board of Directors. Having one fixed committee and one changing based on changes in governments, as well as generally constant funding, it is possible to sustain long-term goals. The structure of the proposed International Aerospace Hub can be seen in figure 4. As can be seen, companies can both request funding on their own initiative, but also get funding on contracts proposed by the IAH.

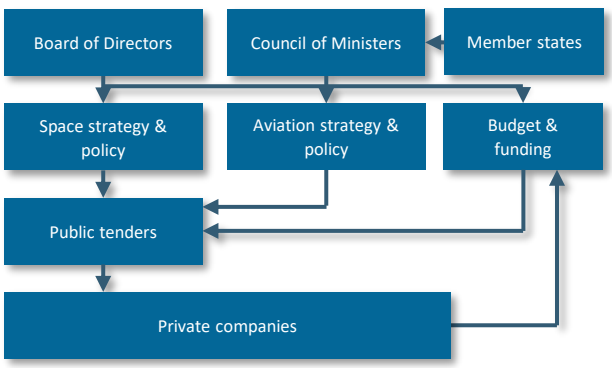

Figure 4: Structure of the proposed International Aerospace Hub

A Schengen zone for dual-use goods

One problem that could come up in collaborating is the International Traffic in Arms Regulations (ITAR), which are the US regulations considering dual-use goods. Dual-use goods are goods, technology and software that can be used for both civil and military purposes. The ITAR was enacted in 1976 during the Cold war to enhance the national security of the United States [32]. Until 2013, satellite technology was still part of the ITAR regulation. The reason for its removal was that many non-US companies were advertising products as "ITAR-free", in order to avoid delays and the meddling of the US government. This rise in ITAR-free products made the US worldwide market share in satellite technology decrease from 83 percent to 50 percent in 2008 [33]. Hence, in 2013, satellite technology was removed from ITAR regulations for 36 countries, including Europe [34]. Nevertheless, European companies are still wary about using US technology, as it may still limit cooperation with countries that are still on the ITAR list [35].

To avoid delaying projects within the Innovation Hub, it is quintessential that there is a sort of *Schengen zone for dual-use goods* in place. This way, international cooperation is facilitated, and projects will not be delayed due to strict export control. Obviously, having such a system in place will unfortunately limit who will be able to join the Innovation Hub, as the US is averse to working with China, and since the invasion of Ukraine by Russia, new cooperative efforts with Russia will undoubtedly be minimal. That being said, one can only hope that one day, humans will be able to set their differences aside in favor of space exploration and aviation innovation. Realistically however, this will still take a long time.

New contracting

Traditionally, the most common contracting method was cost-plus contracting, where contractors get their expenses paid, plus a fee. However, in a recent Senate hearing, NASA Administrator Bill Nelson said that cost-plus contracts are a plague to the agency [36], as does not incentivize competition. Lately, agencies of several countries are leaning towards more fixed-price contracts, where companies get paid based on milestones, in the form of Public-Private Partnerships (PPPs). In the past, a lot of the PPPs were of the type Design-Build (DB), where the private partner builds the hardware, and the public partner operates it, such as ISS modules like Unity, built by Boeing, operated by NASA. A trend that can already be seen is that there will be more and more Build-Operate-Own (BOO) contracts, where the private partner also operates the hardware, such is the case with launch vehicles, and even with privately-build space stations [37] that are emerging.

Possibilities for larger projects

Having a multinational institution like the International Aerospace Hub in place, it could become much easier to coordinate efforts to undertake large projects.

In the space sector, there is the prominent idea of going to Mars. If we want to become interplanetary, there needs to a transportation system to get us there, habitats to live, appropriate life support, good communication, and many more systems in place. Thus, one key to get us there is *cooperation*.

As mentioned before, it is crucial for the aircraft industry to become more sustainable. Undoubtedly, this requires enormous investments, which investors are not always keen on providing, as there is no direct profit to be seen. This is thus an endeavor which would also benefit from appropriate funding from the public sector. For example, public tenders for innovative aircraft concepts, quiet supersonic airplanes, or sustainable aviation fuels could incentivize for companies to take the development more serious as they are able to invest more in it. Thus, with appropriate funding from a *non-profit point of view*, development of sustainable technology could be accelerated.

Christopher Columbus and his contemporaries travelled in search of the "New World" by virtue of the sovereign of their state. However, his majesty not only financed the perilous journeys, but also provided them with state-of-the-art tools and ships, such as the astrolabe and the caravel.

Similarly, any fruitful government-industry relationship needs to be accompanied by thriving technologies. However, before an industry can rapidly start using new technologies, certain problems must be addressed. In the aerospace sector, there is a procedure which needs urgent attention: type certification.

What is Type Certification?

Contemporary aircraft and spacecraft designs rely heavily on novel materials, structures and mechanisms which are still being researched on. However, governmental entities (for instance, FAA and EASA) set safety requirements which need to be complied with such that new concepts are allowed their use in aerospace. Indeed, certification is how safety is assessed. This is done by performing a series of (mainly destructive) tests in order to assess their strength and, subsequently, their reliability. If the values of the tests are within the required strength limits, they can be implemented right away in novel aircraft/spacecraft.

> "If you can't certify it, you can't fly it."

states Professor John-Alan Pascoe, one of the scientists behind a breakthrough model to thoroughly alter certification in aviation.

Unfortunately, history provides us with a clear example of how laborious this task can be: carbon fiber composites took nearly three decades to advance from its first tests to its introduction in aerospace. Should the perfect model of an airplane already exist on paper, we would not be able to fly on time of the carbon neutrality goals of 2050.

Therefore, a revolution of this procedure needs to be made in due time.

Artificial Intelligence comes to play

From autonomous driving to healthcare, it is undoubtful how AI has modified human lives for the better. In this manner, why not also use this prosperous technology to change how materials are certified? Three researchers encountered the same question and made it their group mission to revolutionize certification [38].

Figure 5 illustrates their Smart Certification approach and its three pillars to achieve such autonomation.

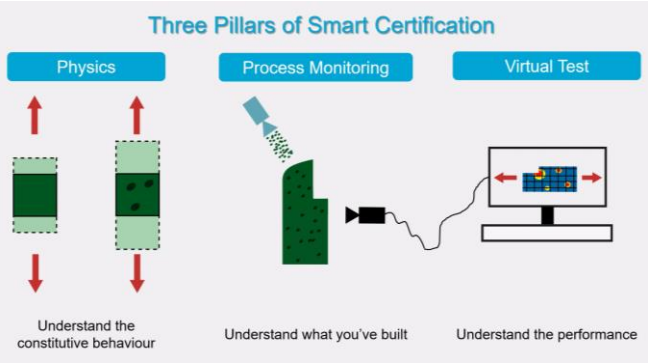

Figure 5 – Three Pillars of Smart Certification [39]

Firstly, a sequence of tensile tests are required in order to understand the material's behavior. Furthermore, a meticulous monitoring of the manufacturing process is done. With this analysis, the structure is entirely comprehended to its molecular basis. Simultaneously, the assembly of a *virtual twin* of the manufactured part will allow that the entirety of the time-consuming tests can be completed in a matter of hours via Finite Element Method .

Certainly, this approach will require strenuous tests for its approval by governmental entities. However, when such is finally operational, it is assured that one of the big "brakes" for the development of greener aircrafts has gladly been lifted.

Conclusion

All things considered; it will still take some time before the aerospace industry can enter its comfort zone. With an imminent climate crisis and a need for rapid technological innovation, it is essential that the industry and government work together to tackle the fast-approaching problems. After considering several major points in the industry to government relationships in the aerospace industry, a few conclusions can be presented.

- Change within the aviation sector is essential in order to reach the 2050 sustainability goals.
- Imposing fuel taxes nor increasing the ticket price reduces the carbon footprint of airlines. This is simply because flying has become a necessity, and people will fly regardless of the price to pay, as long as tickets do not explode to completely unaffordable extents.
- Governments should invest more in green aviation technologies. Examples of such technologies are cutting-edge airplane designs, greener engines, and Sustainable Aviation Fuels (SAFs). In general, there is more incentive necessary in order to become more sustainable.
- The labour crisis can be diminished with the aid of automation. This grants the need for less manpower in security, baggage handling, among other operational tasks.
- Acceleration of certification is key to meet sustainability goals. A possible technology to have faster certification is the use of artificial intelligence.
- Government space agencies are becoming inefficient compared to the private industry. They have settled in a comfort zone, causing slow to no innovation.
- The space sector is moving from an industry with heavy government involvement to an industry where the government is an enabler. This is fruitful for both the public and private actors.
- The foundation of an International Aerospace Hub would be beneficial for the progress in aerospace technology. This innovation hub would provide funding, determine the strategy and policy, propose larger long-term projects, and foster international cooperation.
- A “Schengen Zone” for aerospace technology is necessary within the innovation hub. The Public-Private Partnerships would mainly be of the type Build-Own-Operate.

With the correct symbiotic interactions between government and industry, a bright future is imminent, bringing Humanity one step closer to reaching other planets whilst keeping their own clean.

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