PERSPECTIVES FOR AERONAUTICAL RESEARCH IN EUROPE

PARE

CHAPTER 16

Effects of COVID-19 on aviation

Final Report

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16.1 Introduction

The COVID-19 pandemic has caused the biggest crisis in aviation history turning several years of continuous growth into an almost total grounding in the short time span of a few months (section 16.1). The official Chinese version of the origin of COVID-19 starts with the pangolin in remote forests, as the carrier with transmission through bats to people (subsection 16.2.1) who eat them; the press has reported a rather different story (subsection 16.2.2) of origin in a laboratory working on biological weapons of mass destruction near Wuhan, where the outbreak stated. Several analogies have made with the COVID-19 pandemic (section 16.3) including; (subsection 16.3.1) earlier historic pandemics with much higher death rates; (subsection 16.3.2) word wars which caused a much larger number of deaths with attempts to occupy territory; (subsection 16.3.3) natural disasters, like earthquakes, volcanic eruptions, floods, fires and tsunamis of much more limited geographical or temporal extent; (subsection 16.3.4) biological weapons of mass destruction with no known cure leading to diseases whose spread is extremely difficult to contain.

The basic medical aspects to be taken into account in the context of the effects on aviation (section 16.4) include: (subsection 16.4.1) the means of protection against the transmission of the coronavirus via water droplets; (subsection 16.4.2) the treatment and healing leading to deaths mainly in elderly people with previous ailments; (subsection 16.4.3) the prospects for developing a vaccine which should have high effectiveness and a lasting effect, without undesirable secondary consequences and be available in larger quantities at a moderate cost. Without a cure or vaccine available the main way to counter the spread of the infection and avoid overwhelming the available medical resources (section 16.5) is confinement: (subsection 16.5.1) quarantining in infected cases and work at home to avoid contagion at outside: (subsection 16.5.2) avoiding large gatherings in confined spaces through teleconferences. These precautions cannot be easily applied to essential services such as the supply of medicines and food at pharmacies and supermarkets.

The social and economic effects of COVID-19 include some of the most undesirable records (section 16.6) such as: (subsection 16.6.1) the deepest economic recession for a long time, due to the decline of industrial production and most services; (subsection 16.6.2) the highest unemployment level due to the paralysation of the economy; (subsection 16.6.3) increased budget deficits and debts attempting to mitigate business and job losses. Only a few sectors like informatics have benefited from the lockdown (subsection 16.6.4) with a larger number of people staying longer at home and meetings replaced by teleconferencing.

Aviation is one of the worst-hit sectors (section 16.7) in almost every area: (subsection 16.7.1) airlines have high fixed costs and no revenue from suspended flights, exhausting existing liquidity and leading to bankruptcy in a few months unless a rescue package is provided; (subsection 16.7.2) the air cargo sector becomes essential in the fast delivery of urgent medical supplies and protection equipment, but this hardly compensates the general decline due to reduced economic activity; (subsection 16.7.3) aircraft leasing, which has grown from 4% to 35% of the market in two decades faces a sharp decline between high demand from airlines needing additional aircraft to less demand from the same airlines having most of their fleet grounded; (subsection 16.7.4) airports lose revenues from cancelled flights and lack of passengers, and cannot balance fixed costs, just as airlines; (subsection 16.7.5) a similar situation applies to ANSPs (Air Navigation Service Providers)

with no flight charges to cover costs with personnel like ATCs (Air Traffic Controllers) and navigation ground infrastructure. The only niche sector with growth prospects is business aviation (subsection 16.7.6) that is the only alternative to cancelled airline flights with reduced health risks.

The decline in airline traffic (section 16.7) has an equally massive effect on industry (section 16.8) with losses everywhere without a single exceptional niche: (subsection 16.8.1) airlines finding themselves unexpectedly with grounded or oversize fleets may not make new orders, and be forced into cancellations or delayed deliveries all of which mean less revenues for aircraft manufacturers to add to production slowdown or shut-down; (subsection 16.8.2) first- tier suppliers, like aero engine manufacturers, are even worse adding to (i) the loss of production of engines for new aircraft also (ii) the reduction in maintenance and spares revenue due to reduced flying; (subsection 16.8.3) down the supply chain the effect (i) of reduced aircraft production may be amplified for smaller companies with less resources and high dependence on the aeronautical market; (subsection 14.8.4) the Maintenance; Repair and Overhaul (MRO) sector is hit as first tier supplies by (ii) reduced flying leading to less regular servicing and postponement of major work; (subsection 16.8.5) used aircraft prices have a sharp drop as airlines dispose of surplus aircraft, starting with the oldest, less efficient and more polluting models. The prospects for survival (subsection 16.8.6) are: (i) worse for small suppliers of services that can be taken up by higher tiers with excessive workforce; (ii) better for unique small suppliers needed for recovery and large companies that cannot be allowed to fail.

The dire situation caused by COVID-19 was addressed in the U.S. by the CARES (Coronavirus Air Relief and Economic Stability) Bill passed by Congress, that included aviation (section 14.9) besides other sectors. Substantial sums were made available setting conditions lasting only for 6 months such as (subsection 16.9.1) no dismissal or pay cuts for employees; (subsection 14.9.2) no reduction in domestic flights; (subsection 14.9.3) support to airports. In spite or because of the large sums involved, the rules of allocation lead to widespread controversy about unequal treatment in all cases airlines, airports, and employment. The CARES act was less controversial on (subsection 16.9.4) bailouts for industry, although the size of the 60 B$ Boeing fund did raise some eyebrows. However, the biggest issue is after spending 80B$ with airlines and airports for six months, what happens (subsection 16.9.5) after October 1, 2020: worker lay-offs and route cancellations or another large subsidy without long-term prospects?

Unlike the U.S. that applied blanket temporary rules lasting 6 months, other countries took a longer-term view, with a case-by-case analysis, leading for airlines (section 14.10) to: (subsection 14.10.1) a rescue package in case of flag carriers with strong or not so strong records, sometimes with environmental and other conditions, mostly in developed countries with strong economies; (subsection 14.10.2) bankruptcies of major airlines and flag carriers with poor performance records mainly in developing with weak indebted economies already in financial strain before aggravation by the COVID-19 pandemic.

In Europe government policy towards rescuing airlines differed by country (section 16.11) with significant contrasts: (subsection 16.11.1) the 9 B$ rescue of Lufthansa by the German government involved strict conditions on the reduction of fleet size and loss of airport slots, leaving an open road to increased or decreased state control towards nationalization or privatization; (subsection16.11.2) France and the Netherlands agreed on an 80:20 split of a 7 B$ rescue for Air France-KLM; (subsection 16.11.3) Italy provided Alitalia with an ambitious rescue plan assuming

far better performance in the future than that achieved in the past; (subsection 16.11.4) British Airways-Iberia have protested against government travel restrictions, besides receiving limited support. The Low-Cost Carriers (LCCs) may survive on their own, with lay-offs, salary reductions and limited support (subsection 14.11.5) trying to ramp-up services and recover revenues as quickly as possible.

A good example of a comprehensive rescue package for the aerospace sector is provided (section 16.12) by France: (subsection 16.12.1) the collapse of the civil market can be partially compensated for the industry also active in the defence sector by keeping or expanding military contracts that are stable in the long-term, as long as economic conditions allow; (subsection 16.12.2) the industry support includes not only the large Original Equipment Manufacturers (OEMs) but also smaller companies down the supply chain whose products and skills are essential for post-COVID-19 recovery; (subsection 16.12.3) supporting research and technology for 20-30% more efficient airliners in the 2030-2035 time frame keeps the design and development active and ready to support future competitiveness.

Comprehensive and well-coordinated support programs for the aerospace sector, at a national level like in France and Germany, become most effective together with initiatives at the level of the European Union: (section 16.13), for example: (subsection 16.13.1) the overall COVID-19 cohesion fund strengthens national economies, enabling the support of several sectors including aeronautics; (subsection 16.13.2) the aeronautical and space programs of the EU support continued competitiveness and initiatives like electrification, a hydrogen economy and cleaner environment; (subsection 16.13.3) EU-wide measures on deconfinement and health rules, even with local exceptions are essential to accelerate recovery of the aviation sector from the COVID-19 crisis.

The prospects for recovery of the aeronautical sector from the COVID-19 crisis are (section 16.14) different for: (subsection 16.14.1) a faster V-shaped ramp-up for regional and short-haul flights among regions with almost simultaneous deconfinement; (subsection 16.14.2) the uncoordinated deconfinement measures at world-wide level harm long-haul travel, that will remain at low-level longer until global deconfinement leads to an abrupt U-shaped recovery. Besides the uncertainty of when short-haul (2021?) and long-hall (2023?) traffic recovers there the major question (subsection 16.14.3) of ultimate recovery level in the range from full (100%) to partial (down to 70%?) due to changed habits, like more teleconferencing instead of professional travel.

The post-COVID-19 recovery of aviation depends not only on coordinated deconfinement between travel destinations but also on non-board health (section 16.15) provided by anti-pandemic measures, like: (subsection 16.15.1) directed air conditioning flows and hospital grade virus filters. The airport screening and passenger compliance with health protection measures are essential to regain trust in air travel (subsection 16.15.2). Bearing in mind that flight crew, in particular cabin attendants, fly often with a large number of passengers, their health protection deserves particular attention (subsection 16.15.3).

Although most countries have emergency planning for natural disasters (fires, floods, earthquakes, etc...) there appears to be little planning for a pandemic, that has far greater consequences, countered in the case of COVID-19 by an assortment of improvised measures often late and not fully effective. The Covid-19 may not be the last pandemic the world will see, and pandemic planning (section 16.16) should cover at least the following aspects: (subsection 16.16.1) isolation

and confinement measures to limit the geographical spread, to ensure that a minimum of the affected population is supported by a maximum of the healthy population; (subsection 16.16.2) using all the resources of the healthy population to help, recover and cure the affected population; (subsection 16.16.3) making sure medical and other essential services and resources are not overwhelmed by having pre-planned reserves, facilities and ability to ramp-up rapidly production of protective equipment and treatments.

As one of the worst pandemics affecting mankind, and the biggest crisis in aviation history, covid-19 has challenged the survival and recovery prospects (section 16.17) of all sectors, namely: (subsection 16.17.1) airlines with reduced passenger demand met by a fraction of the fleet, with remaining aircraft parked, or stored or likely to be disposed of, until traffic recovers sufficiently; (subsection 16.17.2) aircraft manufacturers facing cancellations, delayed deliveries and a lack of new orders for several years until airlines need additional or replacement aircraft; (subsection 16.17.3) industry in all tiers 1 to 4 of the supply chain with high investment to increase production at low prices before covid-19 facing an abrupt slowdown due to the pandemic In conclusion (section 16.18) although the evolution (second wave?) and recovery (full or partial, when?) from the covid-19 pandemic is unpredictable, its effects have shown that better planning is needed to avoid comparable disruption in the future.; the aeronautical section should plan to rapidly convert to support the fight against the pandemic, and then recover quickly. The government interventions during the COVID-19 pandemic have differed around the world, and support for the aeronautical sector is no exception. In the U.S. the CARES bill provided large sums with temporary rules whereas in Europe smaller support was made conditional on economic and environmental performance and innovative technology for higher competitiveness.

16.2 Origin

The COVID-19 pandemic started in China, and the official story (subsection 16.2.1) is that the original carrier was a nearly extinct wild animal in a remove forest, and transmission to humans was made by bats. There is evidence to suggest that the Chinese authorities are not telling the full story, leading to various speculations, including newspaper news that the virus came out of a laboratory (subsection 16.2.2).

16.2.1 Remote Habitat

As mankind expands into formerly virgin regions of the world new virus and diseases can appear, that did not occur in other already inhabited regions. The case of Covid-19 is a Severe Acute Respiratory Syndrome (SARS) due to a virus carried by the Pangolin, an almost extinct species living in remote Chinese forests. The virus would be passed to bats, and then to humans who eat them. Bats are used as food in China and other Asian countries like Indonesia. Some questions are implied about food health standards.

The appearance of COVID-19 was reported by China in December 2019, but there is evidence it may have occurred earlier. After the disease spread to Europe, it was found that earlier cases of hospital internment in France, as far back as October 2019, were in fact instances of COVID-19, not identified at the time. Also, the analysis of waste in more than one country, including the Netherlands and Italy, showed the presence of COVID-19, at about the same time, that is about 2 months before the Chinese announcement.

The domestic air traffic in China had a significant drop in the second half of 2019, that could be associated with some form of confinement. This suggests that the COVID-19 may have appeared around the middle of 2019, and being unable contain or confine it, the Chinese authorities chose to become open about a pandemic that could no longer be concealed or disguised. This led to some questions not only about the calendar of the emergence of COVID-19 but also about its origins.

16.2.2 Out of a Laboratory

The New York Times reported that COVID-19 had come out of a laboratory near Wuhan doing research on biological Weapons of Mass Destruction (WMD) based on the COVID virus. In Western countries research on biological weapons is limited to diseases for which an antidote is known, to protect those involved in such work, in case of accidental infection. It is said that in Russia, and possibly China, the research includes diseases with no known cure and that some researchers have died as a result of being infected during their work.

In the case, the laboratory in Wuhan was involved in the development of biological weapons based on the COVID and without a known cure, any failure of isolation from the outside could have dire consequences. It is possible that a researcher involved in such developments could be infected without being aware, and during the incubation period of the virus, without external signs, continued a normal life outside the laboratory, unknowingly contaminating others.

President Donald Trump blamed China for the disease, without giving details; this claim may not carry much weight since he also blames the World Health Organization (WHO) that is instrumental in fighting the pandemic and decided that the U.S. would leave the organization. Asked about the origin of the COVID-19 other western leaders were a bit evasive, for example (i) Emmanuel Macron replied that China was not telling the full story; (ii) Angela Merkel asked China to give a full account of events related to COVID-19.

The prime minister of Australia was more explicit asking for an independent international enquiry into the origins of COVID-19, drawing an angry rejection from the Chinese authorities. A British spokesman responded that these are very serious charges that require evidence. It is possible that the evidence exists in the files of Western intelligence services but is too sensitive to be revealed publicly. Some World War II secrets were made public many decades after the end of the war in 1945, and some may still be restricted, due to their sensitivity. Thus, the question of the real origin of COVID-19 may remain open to speculation for a long time.

16.3 Analogies

The COVID-19 pandemic has been compared to tragic events, like other pandemics in the past (subsection 16.3.1), the two world Wars (subsection 16.3.2) and natural disasters (subsection 16.3.3). Its effects may be comparable to those of a biological weapon of mass destruction (subsection 16.3.4).

16.3.1 Previous Pandemics

As of 16 August 2020, the COVID-19 had caused more than 21.4 million infections in 188 countries and territories causing 771 thousand deaths and 13.4 recovered implying a death rate of 3-6 %. This can be compared with some of the worst pandemics in the history of mankind: (i) the bubonic plague of Justinian in 541-542 that killed 25-100 million or 40-50% of the population of the Roman

Empire; (ii) the bubonic was also the cause of the Black Death in 1346-1353 in Medieval Europe killing 75-200 million people or 10-60% of the population.

Large death tolls were also associated with: (ii) the Cocoliztli epidemic, possibly due to Salmonella Enterica, that killed 5-15 million people or 80% of the population in Mexico during Spanish Colonization; (iv) the influenza A virus H1N1 killed 17-200 million worldwide in 1918 at the end of World War I, causing even more deaths than the conflict; (v) the HIV/AIDS pandemic still ongoing since 1981 has already killed more than 32 million worldwide.

Although the total number of deaths and the death rate are lower, the number of infected by COVID-19 is comparable to the worst pandemics in history with the rate of spread around the world much faster in the age of globalization. With rising health and living standards the COVID-19 is one of the most dramatic events in the history of mankind, for which there was no warning or preparation, leading to a mixture of improvised and poorly coordinated responses to a largely unknown deadly phenomenon.

16.3.2 World Wars

The COVID-19 pandemic has been compared to the two World Wars: (i) WWI killed an estimated 22 million, including 9 million combatants and 13 million civilians, over the period 1914-1918, and was fought mostly in France near Paris, though it spread over Europe and beyond to the Ottoman Empire; (ii) WWII was the deadliest conflict in history with 70-85 million deaths, focused in two fronts: Europe and the Mediterranean and Atlantic and Asia and the Pacific.

The COVID-19 pandemic differs in a much lower number of deaths because it is not a conflict motivated by some nations trying to annex the territory of others with armed forces trying to cause death and destruction. The number of people affected is however comparable for the very opposite reason of an open society free of major wars, where freedom of movement worldwide allows the fast spread of a virus facilitated by contamination even before the health effects become evident. This has led to the description of COVID-19 as a hidden enemy of mankind.

16.3.3 Natural Disasters

Most nations have emergency plans to deal with the kind of natural disasters more likely to occur in their territories, such as: forest fires in the Mediterranean, California or Australia; (ii) earth quakes along the Saint Andreas fault around the world; (iii) lava and ash from volcanic eruptions; (iv) sea tides from tsunamis; (v) extreme winds from tsunamis and tropical storms; (vi) floods from monsoons and torrential rain; (vii) landslides and avalanches.

All these natural disasters can cause death and destruction on a large scale, but most are limited in geographical location and temporal duration; the unaffected neighbouring regions of the same country and indeed other countries can come to help. The COVID-19 can be considered a natural disaster caused by an unknown virus (subsection 16.2.1) but its global spread and temporal extent affect all countries, that are ill-prepared to counter it internally, and less able to help others.

16.3.4 Biological Weapons

The Weapons of Mass Destruction (WMD) are classified as ABC for Atomic, Biological and Chemical. The atomic weapons are difficult to disguise because their development requires large facilities,

and their long-term effects of radioactivity beyond a large explosion were found tragically after their use in Hiroshima and Nagasaki to end World War II; the number of victims was higher in an incendiary bomb attack on Tokyo that had predominantly wooden housing, but it was the sole use of atomic weapons that registered most in war history.

After the infamous use of mustard gas over the trenches of northern France in the First World War, the Geneva convention banned both Chemical and Biological weapons. The production of chemical weapons can be disguised due to their similarity to fertilizers and pesticides, and they have been used in local wars, by the regime of Saddam Hussein against the Kurds in Iraq, and the regime of Bashar al Assad against the opposition in Syria. Biological weapons are the easiest to conceal in a laboratory.

It is said that attempted use of chemical weapons by Iraq during the American invasion to liberate Kuwait had unexpected consequences when the wind direction changed against the unprotected users. In the subsequent invasion of Iraq, the Americans were prepared for chemical weapons that this time was not used. Although available to major belligerents during the Second World War, chemical and biological weapons were never used. It was realized that biological weapons, in particular, are hardly uncontrollable in their geographical spread and temporal duration, as COVID-19 is tragically showing now.

16.4 Medical Aspects

The medical aspects of COVID-19 are not the focus of the present report, but it is necessary to mention some topics relevant to its effects on aviation, namely: (subsection 16.4.1) the means of protection to avoid the spreading of the pandemic; (subsection 16.4.2) the means to cure the disease and the contribution that aviation can make as means of support; (subsection 16.4.3) the prospects for a vaccine and the extent to which it could end or alleviate the pandemic.

16.4.1 Protection

The COVID-19 is transmitted through water droplets, by coughing or sneezing, or by contact with contaminated surfaces. The social distancing of 2 meters prevents transmission by normal respiration, but not by coughing when water droplets can travel much farther. The most effective and guaranteed protection is the face mask covering mouth and nose. It prevents water droplets from the wearer to reach others, and it prevents water droplets from others reaching the mask wearer.

The surgical mask with single use has proved unfailingly effective in millions of cases over many years. There are washable masks and masks with filters. The screen is by no means a substitute for the mask, although it can be used as a supplement. There is no evidence of the effectiveness of the screen as there is for the mask. The screen does not prevent the user from sending water droplets in certain directions nor does it prevent water droplets from coming in.

It must be assumed that a mask can be contaminated by others from the outside and could be contaminated from the inside by the wearer, as the main virtue is separating the two. The contact of droplets with the skin is another means of infection and may imply the use of gloves and indeed complete protective clothing. Putting on and removing the mask, gloves and clothing also need to

take into account that they may be infected after use or by contact with the hands and must be disposed of safely.

16.4.2 Healing

The COVID-19 has an incubation period of several days before the main symptoms (fever above 38 degrees Celsius, respiratory difficulties and loss of strength) become apparent. A simple temperature check with a thermometer may serve for detection after the incubation phase, but during the asymptomatic incubation phase, medical tests are needed. Tests to detect the presence of antibodies are most useful to show that the patient has been infected and is cured and therefore immune to COVID-19 in the future.

The treatment of infected cases needs quarantine and in extreme cases intensive care units with ventilators to help respiration. If the disease spreads too widely the intensive care units may be overwhelmed. The improvisation of additional medical facilities depends on the fast supply of a sufficient quantity of means of treatment. Aviation may have contributed to the spread of COVID-19 as the worldwide means of fast transport but has also allowed the provision of urgent medical supplies across nations and continents faster than any other means of transport could do.

Some words of caution are needed about the effectiveness and availability of screening methods. Temperature measurement is the simplest, but can give both: (i) false negatives since the temperature is normal during the asymptomatic incubation phase; (ii) false positives if body temperature is higher than normal for reasons other than COVID-19, such as hot climate, inside a car in the sun, personal variations. In this case (ii) it may be necessary to resort to medical tests that take longer and may provide a certificate valid for a stated time period.

16.4.3 Vaccine

Since COVID-19 is an unknown disease there are no known vaccines despite dubious claims that this or other product is effective, for example, some compounds that are known to be toxic. Since the death rate from COVID-19 is, fortunately, relatively low at 3-6 % it is possible to do worse with an aggressive medication not adequately proven. This is one more reason for adherence to the WHO standards for developments of vaccines requiring thousands of tests.

The heads of foreign affairs of the US, UK and Canada have held a press conference accusing hackers from Russian state-backed organizations of trying to disrupt the development of COVID-19 vaccines in their countries. The motivations for this may have been made clear barely a month later when President Vladimir Putin came on television announcing that Russia would be the first to make available a COVID-19 vaccine on January 1, 2021. He claimed that the vaccine had been used on his daughter, although the number of tests, in the tens, fell quite short of the WHO standards of thousands.

Shortly after a German research institute claimed it should have a COVID-19 vaccine ready by October 2020, although earlier the German health minister had predicted that a COVID-19 vaccine would not be available before the mid of 2021. There are major well-funded efforts in several countries in the race to develop the first COVID-19 vaccine. Governments have signed sizeable contracts for the production of millions of vaccines with the few pharmaceutical companies in the world able to produce such quantities.

Aside from the questions of widespread availability and cost the three main issues about a new vaccine are: (i) effectiveness. It is effective in preventing contamination in what fraction of cases? 70%, 90%, 99%? (ii) duration: the protection lasts for how long: weeks, months, years, lifetime? (iii) side effects: are there some undesirable side effects from using the vaccine and how long do they take to appear? For an old vaccine used for decades in millions of cases the answers to these questions well known, but for a new vaccine depth of time of usage is a limitation.

A vaccine against COVID-19 will be in any case and undoubtedly a major progress and the best if not only hope of eradicating the pandemic. On the other hand the percentage of the population infected is small (typically 1 per 60) and the death rate after infection also modest (3 to 6%) and this must be weighed against the risks of a new vaccine with a limited test of time. Other issues are whether the vaccine is mandatory or voluntary if it is available to everyone who wishes to take it and how long it takes to vaccinate the whole willing population.

The availability of a vaccine against COVID-10 is a great success and best hope of eradicating the disease but is unlikely to be an instant solution and until it proves widely effective it is best not to let the defences down, and continue the current protective measures. Also, many improvements are possible in the current protective measures and they may provide time to dovetail with a wide use of the COVID-19 vaccine to be able hopefully to finally eradicate the pandemic.

16.5 Confinement

The main protective measures against COVID-19 has been confinement, at least in Europe, with other regions of the world taking similar or more relaxed measures. The confinement has implied working at home when possible (subsection 16.5.1) and replacing face-to-face meetings with teleconferencing (subsection 16.5.2); confinement is not possible for some essential services (subsection 16.5.3).

16.5.1 Work at home

The alternative of working at home instead of spending hours commuting to and from the job had been discussed for a long time, adopted in a few professions or instances, but never widely put in practice. The imperative need to stop the spreading of COVID-19 lead at least in European countries to mandatory confinement at home. The rules were generally respected in most countries, with justified exceptions, and moderate police enforcement and the occasional fine.

Confinement has more serious consequences for industry and factories that are forced to close down. In some countries like the US infected and non-infected workers work alongside in factories with 'protective' measures that are unlikely to compare with confinement. This may be one reason why the effects of COVID-19 are more widespread and have a greater scale in some countries, with the US the largest number of cases.

The number of official cases in China now ranks fairly low in the world list as the 33rd country with 84827 infections by 16 August 2020. This contrasts with 21 480 111 worldwide, 5 437 012 in the US, 3 275 895 in Brazil, 2 589 682 in India and 922 852 in Russia. Bearing in mind that China has the largest population in the world and was both the origin of COVID-19 and place of a second wave, a number of cases smaller than Israel does not help the credibility of Chinese accounts of COVID-19.

16.5.2 Teleconferencing

The face-to-face meetings are easily replaced by teleconferences for small groups. Large symposia can still be organized, and some are simply cancelled. Replacing the face-to-face meeting of an international committee by a teleconference saves one or two days of travel time. On the other hand, the number of teleconferences tends to increase since they are easier to attend than live meetings involving travel.

Other live activities like shows and tourism are severely affected, waiting for deconfinement and ease of travel restrictions. Live entertainment has been replaced by television shows at home. It remains to be seen whether people will be eager to return to live shows when they become possible again. Tourism is discouraged by travel restrictions and government advice that it is safer to make vacations in the home country travelling by car.

16.5.3 Essential Services

The essential services that have to be retained include access to food and medicine implying the supply of supermarkets and pharmacies. Social distancing limits capacity and can lead to long queues. All non-essential services tend to be postponed or closed unless clever workarounds are devised. Restaurants resort to supply takeaway food, and services delivering food, goods and other products at home proliferate.

16.6 Social Effects

The social effects of COVID-19 include the quarantine of those infected or suspected to be infected and the confinement at home or lockdown of the remaining population (subsection 16.6.1). The resulting reduction in economic activity would lead to high unemployment and a large number of insolvencies (subsection 16.6.2) motivating significant government intervention that increases budget deficit and public debt (subsection 16.6.3). Among the generally depressing decline of most sectors of activity, telecommunications contrasts with the high demand and use due to confinement at home and teleconferencing.

16.6.1 Quarantine

The cases of infection by COVID-19 require quarantine in an intensive medical care unit of a hospital, in the more vulnerable cases of elderly people or those with respiratory problems. In order not to overwhelm hospitals quarantine at home is preferred for suspected infections and less serious cases. Homes for elderly people have contributed to more than half of the deaths due to covid.-19 in several countries due to the proximity of a vulnerable population.

Deconfinement leads to a higher risk of a second wave of a COVID-19 due to part of the population not wearing face masks or respecting social distancing. There are also situations like public transport where social distancing is not feasible, the more so for longer travels. Some of the worst cases of COVID-19 infections have occurred in cruise ships and warships where a large number of people occupy a limited space for a long time leading to high infection rates.

16.6.2 Unemployment

The lockdown leads to a decline of economic activity in which many business activities cannot cope with costs or pay salaries and require government assistance to survive and avoid redundancies. Despite these measures, unemployment rises, and the number of bankruptcies increases. The number of requests for unemployment benefits rises in most countries like the US. Despite this, in the U.S. some healthy workers agree to work alongside with infected workers for fear of losing their jobs.

16.6.3 Economic decline

The reduction in economic activity cannot be fully compensated by government support leading to economic decline. The decrease in Gross Domestic Product (GDP) for the worst second quarter of 2020, when confinement measures came into effect varies from 10% for countries like Germany that that took early measures to 20% for the UK that had a slow response. The figures on GDP reduction for the whole year 2020 compared to 2019 will depend very much on recovery from COVID-19 and could be much worse in the case of a second wave.

Perhaps more important than the recession in one year is the recovery in the following years. If the decline in 2020 is 6-10 %, and 4-8% in recovered in 2021, then the difference from 2019 is reduced to 2-4 %. This smaller reduction over a period of two years is still very negative result compared with what should have been 2 years of growth in the absence of COVID-19 A further issue is how many more years more will be needed to come back to 2019 levels, perhaps 2 or 3 with more pessimistic predictions of up to 4 or 5.

16.6.4 Dependence on Telecommunications

The covid-19 crisis has affected negatively almost every sector of activity except telecommunications equipment and services. Work at home and teleconferencing rely almost entirely on telecommunications. The demand for more modern and efficient equipment and the much higher utilization rates translate to a boom in the sector. Confinement at home implies that both work and entertainment depend on telecommunications and live contacts on the job are replaced by teleconferencing.

16.7 Effect on Air Services

The COVID-19 pandemic has caused the largest crisis in the history of aviation, with massive negative effects in almost all sectors: (subsection 16.7.1) passenger traffic declined sharply to levels as low as an almost complete suspension; (subsection 16.7.1) air cargo provided a much needed fast supply of medical equipment and supplies but was otherwise weak; (subsection 16.7.3) aircraft leasing basically stopped with airlines having large parts of their own fleets grounded; (subsection 16.7.4) airports like airlines faced significant fixed costs while lacking revenues to match due to low passenger demand; (subsection 16.7.5) Air Navigation Service Providers (ANSPs) likewise had to cope with high fixed costs and no revenue from flights. The only growing sector is business aviation due to the need for safe business travel with unavailable or limited airline services.

16.7.1 Airline Passengers

The statistics on declining passenger traffic after a widespread lockdown in March 2020 due to COVID-19 are overwhelming both in the size and steepness of the change. The figure 16.1 shows the percentage of global passenger traffic by region overlaid on the number of confirmed COVID-19 cases per country on March 15, 2020, showing that the pandemic affected regions with high traffic. The Figure 16.2 shows a decline in most regions of the world to 10 over two weeks from March 11 to 25 in 2020. The figure 16.3 focuses on available seats in Europe and North America and again shows a sharp dip in March 2020.

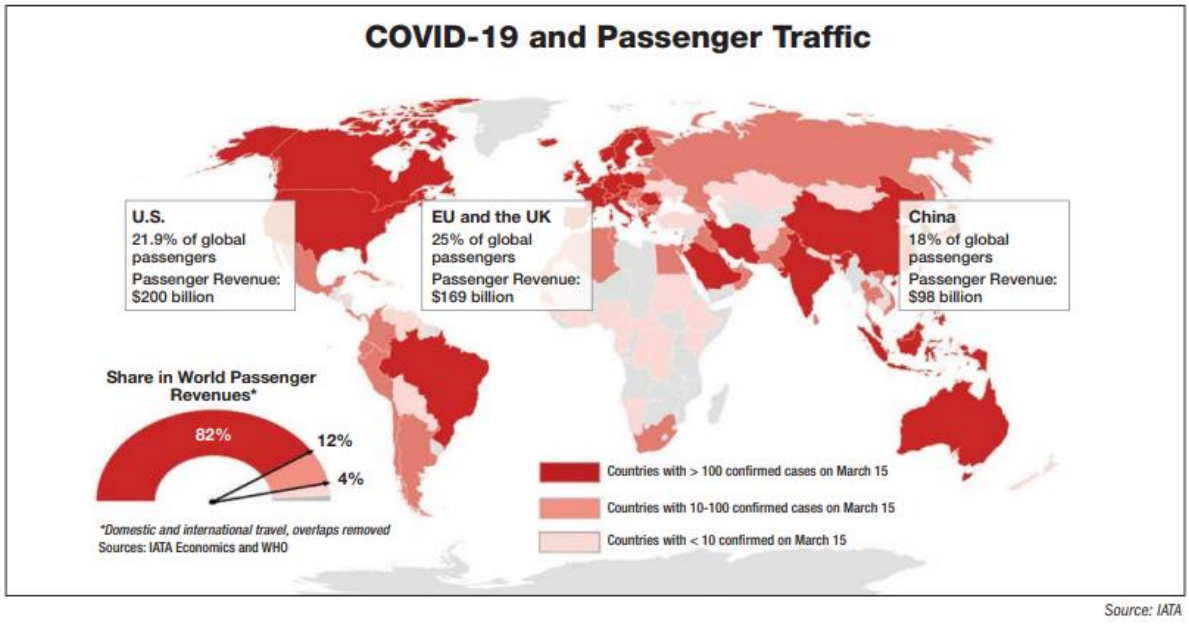

Figure 16.1 - World Distribution of Air Traffic and Confirmed COVID-19 Infection on 15 March 2020 (Source: https://bit.ly/2H7DDYP)

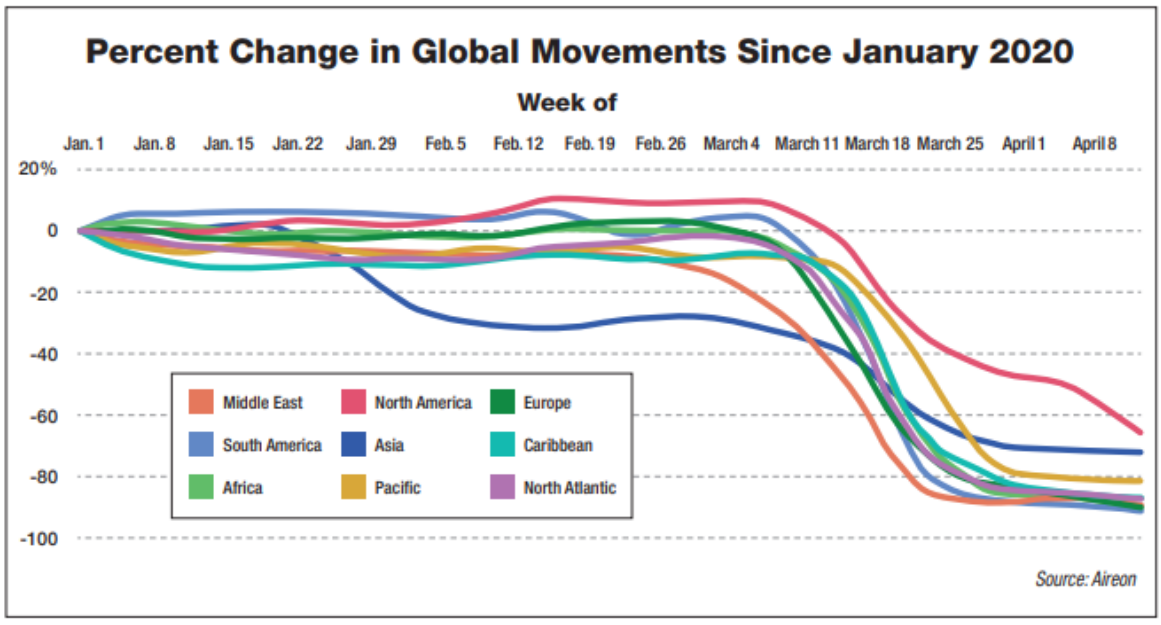

Figure 16.2 - Percent Change in Air Traffic in different regions of the World with a sharp drop on March 11 - 25 2020 due to confinement and travel restrictions

(Source: https://bit.ly/2GWHM1t)

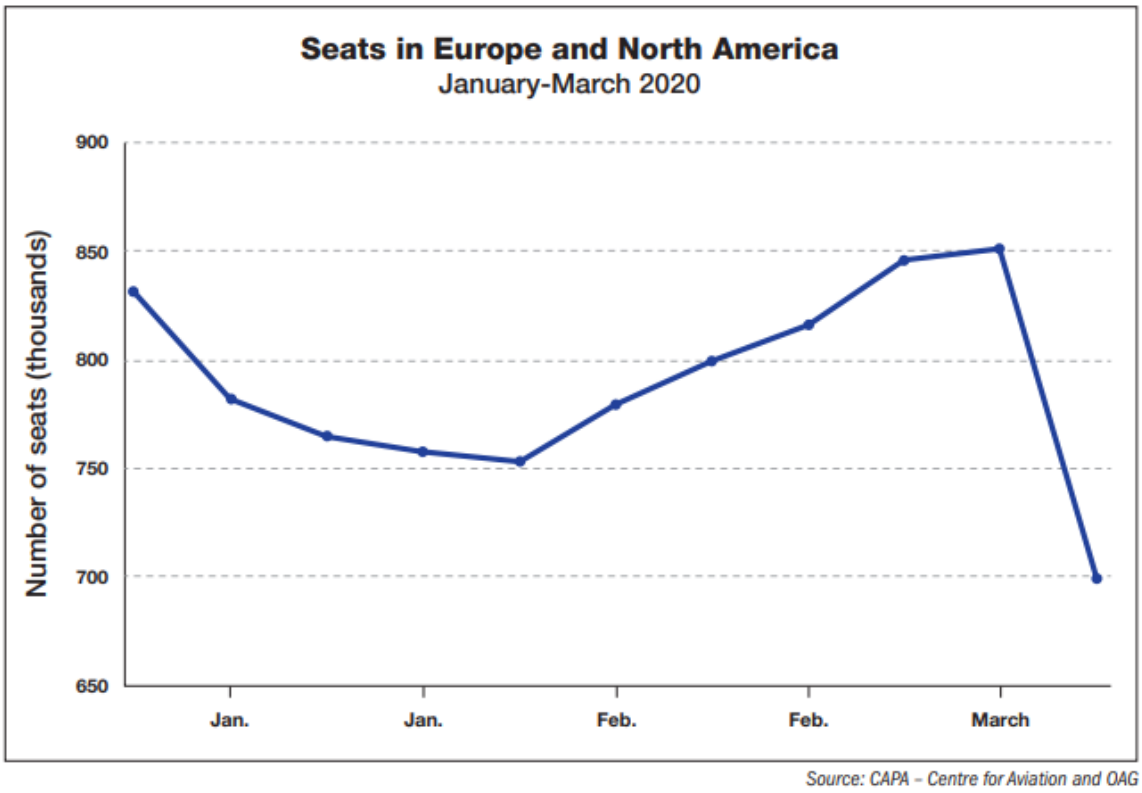

Figure 16.3 - Available seats in Europe and North America in the period January-March 2020 showing a sharp drop in March

(Source: https://bit.ly/2H7DDYP)

Figure 16.4 shows fairly stable passenger traffic in Southeast Asia for the whole of the three years 2017, 2018 and 2019, followed by a sharp decline to about half in the first quarter of 2020. The figure 16.5 shows that Chinese airline operations were stable in the period 17 February to April 5 of 2019, and in the same period of 2020 started at one-third of the level and rose to about two-thirds with government incentives. The large gap at the start of the period on February 17 shows the massive decline due to COVID-19 in 2020 compared to the normal level in 2019.

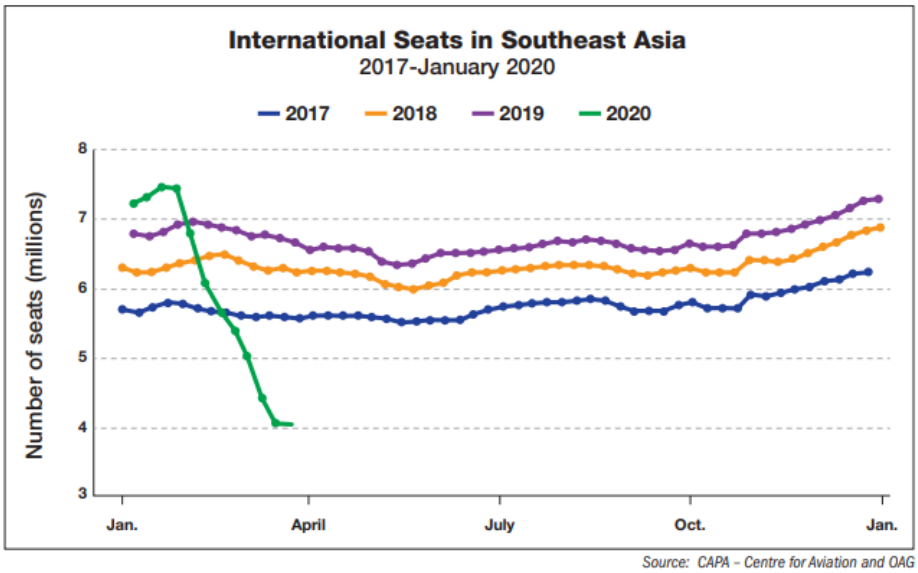

Figure 16.4 – International Seats in Southeast Asia and 2017-2020 showing a sharp drop in February-April 2020 (Source: https://bit.ly/2H7DDYP)

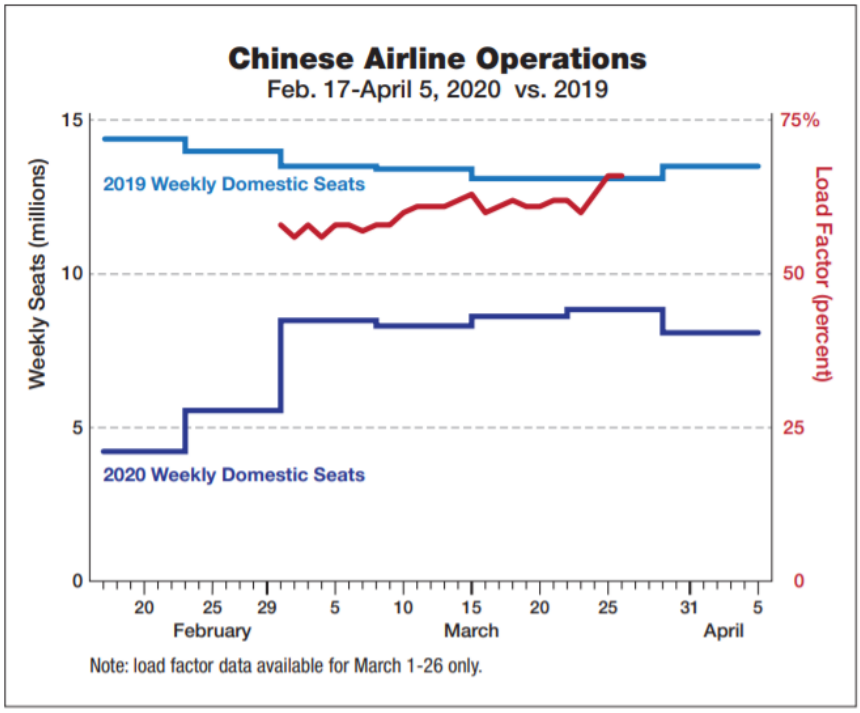

Figure 16.5 – Comparison of weekly domestic seats in China in 2019 and 2020 showing the effect of the COVID-19 crisis and government-mandated recovery

(Source: https://aviationweek.com/)

The figure 16.6 shows that the almost simultaneous adoption confinement in Europe leads to a sharp drop in traffic visible on a day to day basis between March 22 and 29 in 2020. The figure 16.7 shows that the activity of the four mainline airlines in the US dropped to less than half during March 2020 and less than a third by the end of April. With high fixed costs and a sharp reduction in revenue, the airlines can survive only a few months consuming their liquidity.

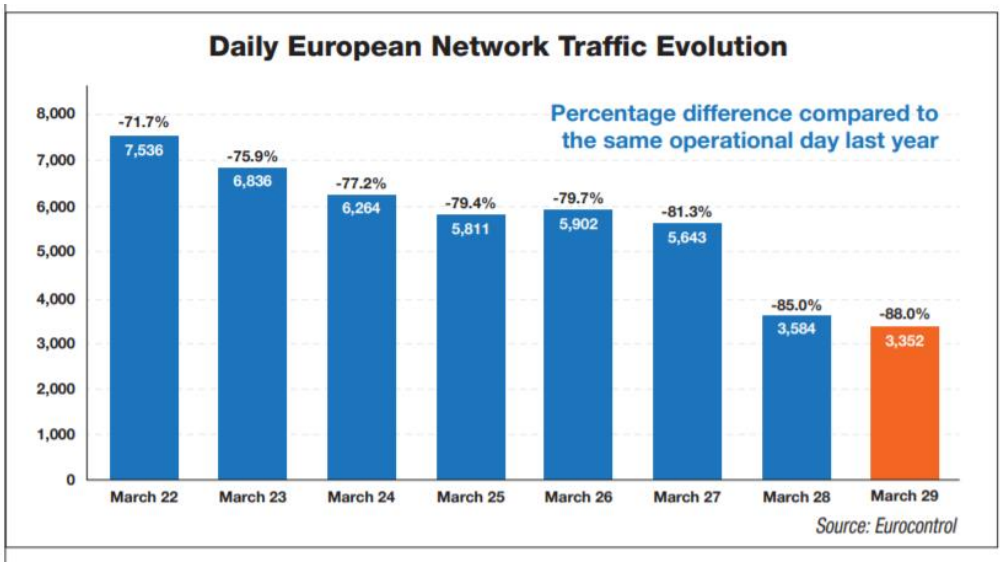

Figure 16.6 – Comparison of weekly domestic seats in China in 2019 and 2020 showing the effect of the COVID-19 crisis and government-mandated recovery

(Source: https://aviationweek.com/)

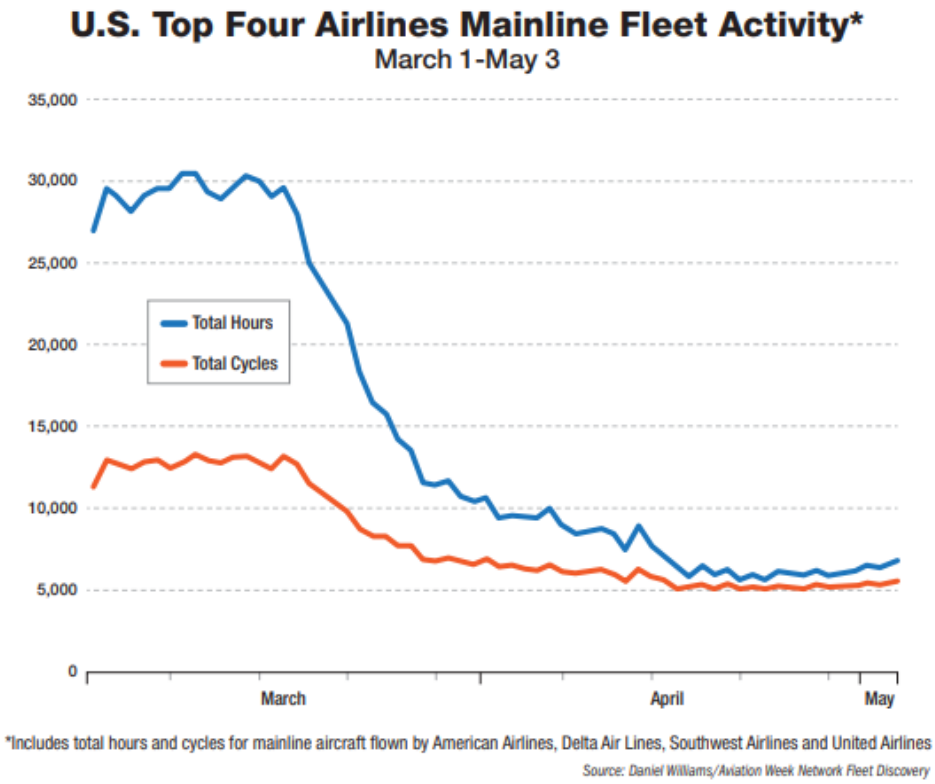

Figure 16.7 – U.S. Top Four mainline Traffic Activity in total hours and total flight cycles in the period March 1 to May 3 of spread of the COVID Pandemic

(Source: https://bit.ly/3mqFYhr)

16.7.2 Air Cargo

Airlines may have contributed to the spread of COVID-19 by providing the fastest and most convenient means of long-range transport unaware that some of their passengers were infected

by an unknown disease. Air Cargo, both civil and military, was essential in efforts to stop the spread of the disease and cure those affected, by providing rapid supplies of large quantities of medical supplies and equipment for countries with overwhelmed medical services. The normal cargo services declined due to COVID-19 much like passenger's flights.

Special passenger flights were also organized, with civil and military aircraft, to bring back home passengers stranded at their destinations, either on business or tourism, by the unpredictable imposition of travel restrictions. In some countries like France, aircraft were used to transport patients from regions with overwhelmed medical services to others with spare capacity. All these flights included thorough health precautions against COVID-19, showing that this could be implemented in the context of aviation.

16.7.3 Aircraft Leasing

Aircraft leasing rose from about 2% of the world fleet 20 years ago to about 35% today. The figure 16.8 shows the rise in lessor fleets in 2009, 2014 and 2019 reaching about one-third of the world fleet. The growth in importance of lessors is due to several factors. Airlines may prefer to size their fleets to the average traffic and use leased aircraft to cover extra demand over peak periods. Lessors can use the aircraft all year-round providing aircraft to airlines around the world with different season needs.

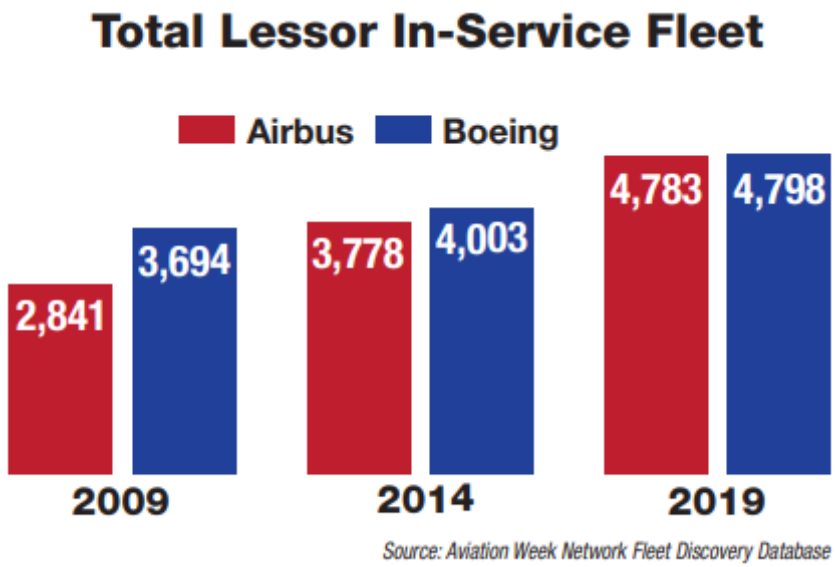

Figure 16.8 – Increase in the number of Airbus and Boeing Aircraft in service with leasing companies comparing the years 2019, 2014 and 2019

(Source: https://bit.ly/3mvzFJQ)

For purely financial reasons airlines may prefer to lease new aircraft rather than a direct purchase even if they intend to fully own the aircraft later. Lessors can place large orders of hundreds of aircraft over several years providing much-appreciated production stability for aircraft manufacturers. In return, they can obtain favourable discounts on aircraft prices compared with smaller airlines that place small orders occasionally.

Despite high demand, the leasing market was facing excessive competition due to the entry of Chinese lessors. Western lessors maximize profit, whereas Chinese lessors are subsidized by their government and maximize market share. Thus, Chinese lessors offer airlines leases at a price that

western lessors cannot possibly match. The figure 16.9 shows the in-service fleets and aircraft on order by the 10 largest lessors.

Figure 16.9 – The 10 largest lessons by the number of aircraft for leasing in service and on order.

(Source: https://bit.ly/3mvzFJQ)

Before the COVID-19 crisis demand for leased aircraft was increased by the Boeing 737 Max crisis (Chapter 14). With 385 B737Max grounded and 470 undelivered the airlines, there was a need to replace temporarily all these aircraft until the B737Max were ungrounded and delivered and returned to service. The covid-19 crisis came in this period of excessive competition among lessors and high demand from airlines. The steep decline of passenger flying after the COVID-19 crisis left airlines with excessive fleets, parking or storing or disposing of part of their fleets.

The marginal economics and environmental legislation imply that airlines use preferentially the most modern efficient and less polluting aircraft available, regardless of whether they own or lease the aircraft. Lessors are keen to keep their customer airlines, agreeing to payment delays up to 3 months or more with repayment 1 year later. At the start of the pandemic the majority of the airlines (50% to 80%) asked for and obtained deferred payments: most did their repayments on time, generating a positive cash flow for lessors, with a smaller number of new requests for payment delays. Thus the lessors were savvy enough to survive, and also creative and open to various alternatives, like swapping delivery slots or buying stock.

16.7.4 Airports

Effect of the COVID-19 pandemic on airports is similar to that on airlines: with high fixed costs and no passenger revenues to compensate the situation becomes simply untenable for more than a few months, so that survival depends on government aid. Some airports became mostly parking spaces for grounded aircraft, sometimes lined along unused runways, with very little traffic in surrounding roads, in contrast with intense activity usually associated with airports.

16.7.5 Air Navigation Service Providers

The ANSPs were struggling to cope with air traffic growth before the covid-19 crisis. In the region of densest traffic in the centre of Europe flights were diverted to longer routes alleviate saturation.

Some ANSPs were criticized for not predicting traffic growth and not having trained enough Air Traffic Controllers (ATCs) years in advance. Like airlines and airports, ANSPs face a decreased revenue due to the lack of flights and decided not to charge for flight services at all, to avoid burdening even more cash strapped airliners.

ANSPs have high fixed costs with salaries of personnel, including Air Traffic Controllers that have pay comparable to airline pilots. ANSPs also have the costs of navigation infrastructure and support costs. The decision to waive charges on airline flights did not change the fact that ANSPs would need support from National governments. Also, Eurocontrol, that coordinates air traffic in Europe, and normally distributes air service charges to ANSPs, taking a fraction for itself, was left without revenue and was also funded by agreement among its 29 member's states. Thus, the national governments funded both the ANSPs and Eurocontrol.

The near total suspension of flights during the peak of the COVID-19 crisis has implied that aviation professionals stay idle and cannot practice their skills in a real environment. When flight operations resume, this may lead to the need to relearn past practice until the same levels of efficiency are reached. Although the problem is general across several aviation sectors, and by no means specific to ANSPs, they provide a clear example. ATCs have a demanding task practiced regularly in the safe management of traffic. An interruption of several months followed by a rapid partial ramp-up creates the need to regain skills quickly enough or reassign tasks to maintain the same level of safety.

16.7.6 Business Aviation

The only sector of aviation that did not face a steep decline from COVID-19 and may have grown is business aviation that is understandably quiet about its exceptional situation. Large corporation own business jets to transport their top executives to meetings worldwide, without dependence on airline schedules, using airports closer to headquarters and business location, and allowing work or rest on board.

The COVID-19 did not end the need for business travel, and the reduced airline schedules and risk of last-minute flight cancellations are often unacceptable. In addition, corporate jets flying with a few known individuals may place less risks than an airliner with unknown passengers. Thus, corporate jets may fly more hours with executives lower down the ranks than usual. For the same reasons of schedule choice and lower health risk have led to increased use of fractional jet ownership and fly-by-the-hour tickets

16.8 Effects on Industry

The sharp decline in passenger traffic left airlines with excessive airline fleets, more conductive to cancellations and delayed deliveries than to new orders, leading to decline of about 30% in the sizeable pre-COVID-19 order books of both Airbus and Boeing (subsection 16.8.1). The first-tier suppliers like engine manufacturers are affected both by production decline and reduced maintenance due to less flying, leading to larger declines up to 50 % (subsection 16.8.2). The picture is not better in the tiers 2, 3 and 4 down the supply chain depending on how exposed smaller companies are to the civil market and whether what they supply is essential for post-COVID-19 recovery (subsection 16.8.3). With reduced flying and cash strapped airlines deferring major services the Maintenance, Repair and Overhaul (MRO) companies may find less work and more

competition from the Original Equipment Manufacturers (OEMs) with less orders and more overcapacity (subsection 16.8.4). With airlines disposing of surplus older less efficient and more polluting aircraft the used market values could reach historic lows (subsection 16.8.5). The prospects for survival (subsection 16.8.6) are better for companies supplying unique essential parts that the OEMs cannot do without, than for providers of services that overstaffed OEMs can carry out themselves.

16.8.1 Aircraft Manufacturers

The COVID-19 has caused not only a sharp decline in passenger traffic but also a slow recovery that may or may not reach pre-COVID-19 levels. The airlines with large parts of their fleets grounded may simply retire older larger less efficient more polluting aircraft that would be increasingly difficult to sustain in the future. With a likely cash-strapped future and reduced traffic, the smaller more modern efficient and environmentally friendly aircraft are the best choice for survival; airlines may even exceptionally order a few of those profiting from discounts from manufacturers short of orders.

The prospects for Airbus and Boeing are similar: more cancellations, delayed deliveries and postponed orders (Figure 16.10) reducing the backlog by about 30%. With production rate cuts of about 30%, the backlog would not change much in the number of years. What has changed radically is the transition: (i) from the pre-COVID-19 status of more demand than offer with Airbus and Boeing struggling to increase production rates from an overstretched supply chain; (ii) to the post-COVID-19 market of excess capacity over demand all the way down the supply chain.

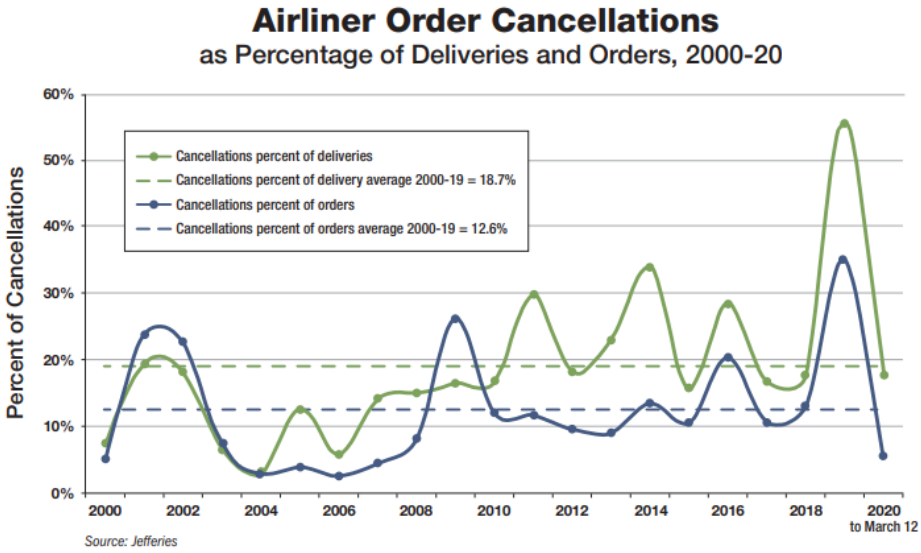

Figure 16.10 – Airliner order cancellations as a percentage of deliveries and orders 2000-2020 (Source: https://bit.ly/2H7DDYP)

The figure 16.11 shows the possible future scenarios for aircraft production with a large variation depending on how long the COVID-19 crisis lasts and how the recovery will look like. The Airbus and Boeing deliveries are compared in Figure 16.12 for the Asia-Pacific region in 2020 and in the Figure 16.13 for deliveries worldwide in the first quarter of 2020. The deliveries of the 737Max depend on a return to service and only a few older 737NGs can be delivered.

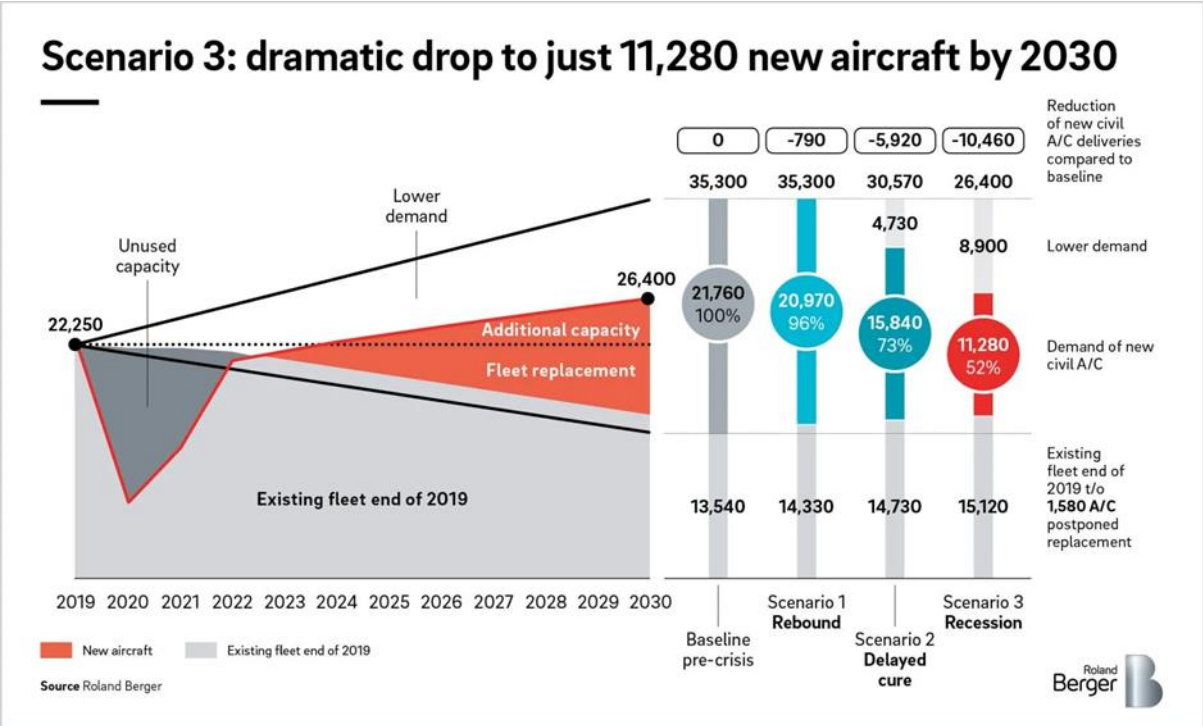

Figure 16.11 – Possible scenarios for future aircraft production
(Source: https://bit.ly/3c2Eaqh)

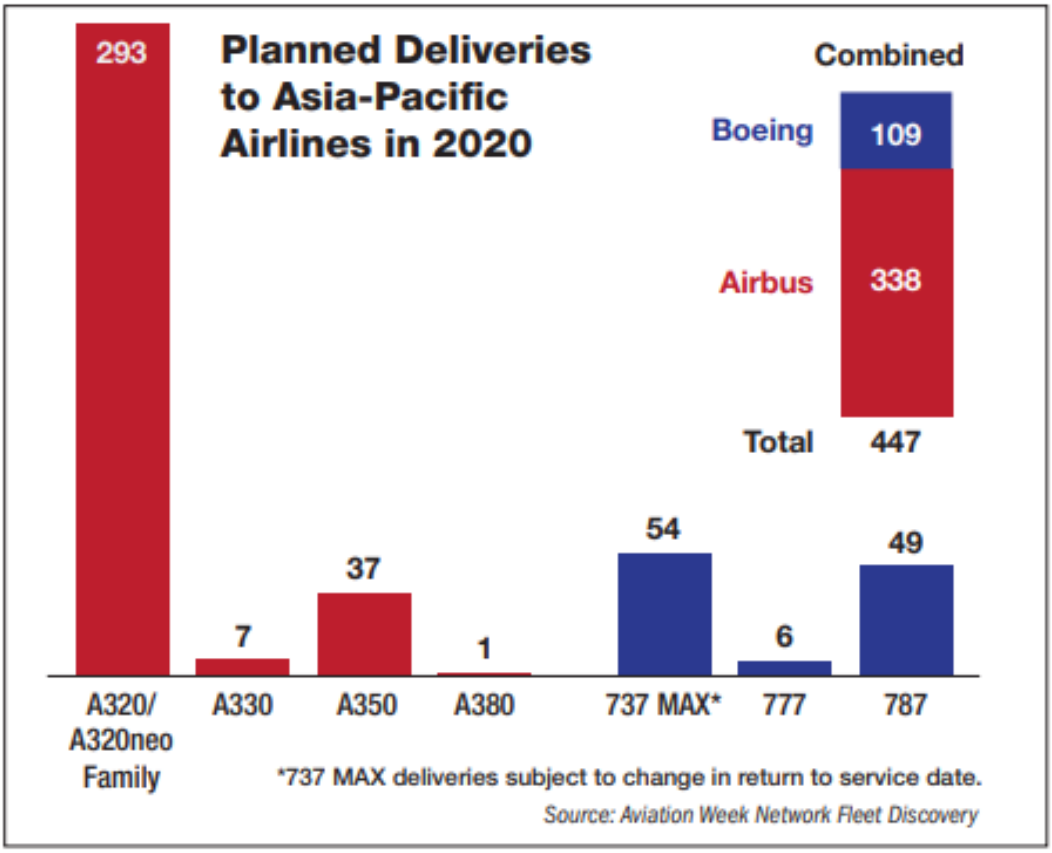

Figure 16.12 – Planned deliveries of Airbus and Boeing airliners to Asia-Pacific Airlines in 2020 (Source: https://bit.ly/3mvzFJQ)

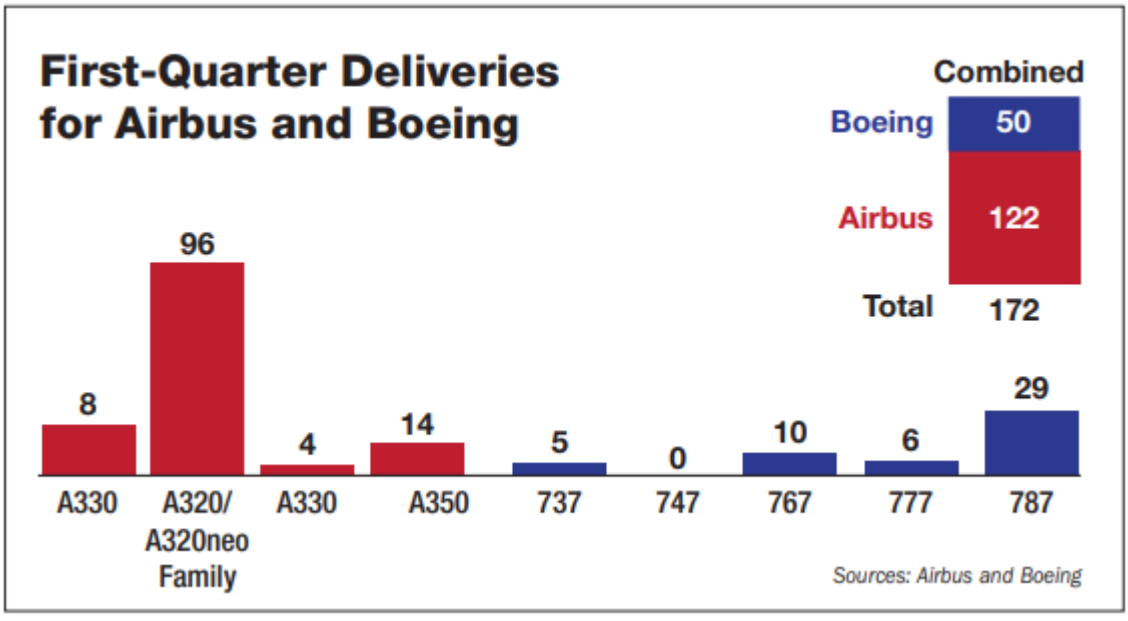

Figure 16.13 – Airbus and Boeing airline deliveries in the 1st quarter of 2020 Source: https://bit.ly/3mq3hbp

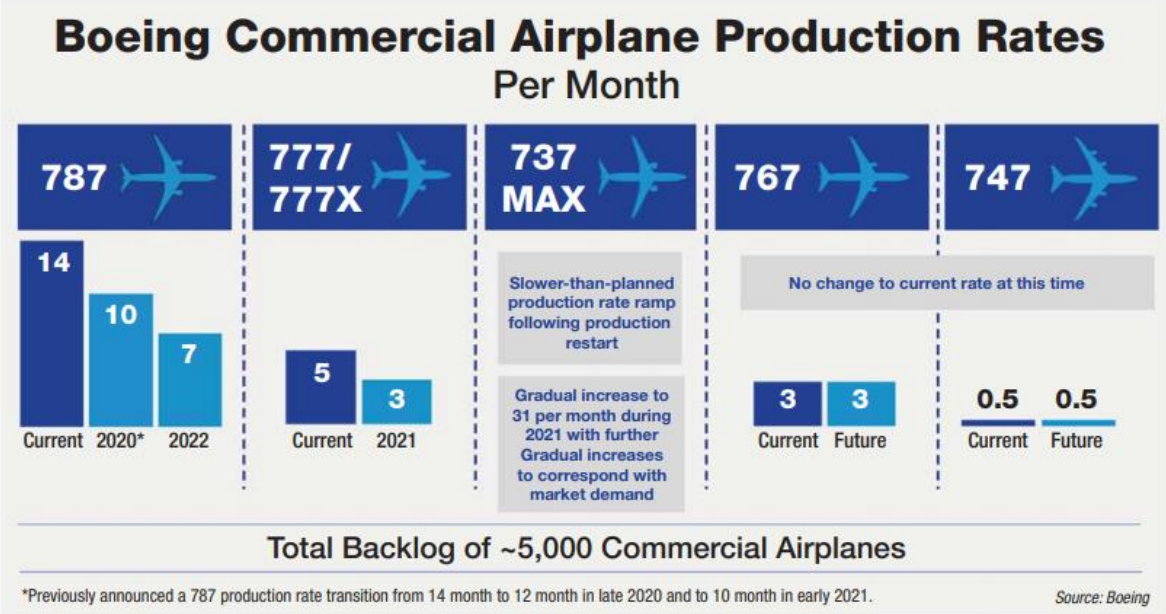

Figure 16.14 – Current and predicted future Boeing Commercial airplane production rates (Source: https://bit.ly/2GWHM1t)

Airbus Key Metrics

	First Quarter 2020	First Quarter 2019 Restated*	Change
ORDER INTAKE (NET)	290	(58)	N/A
BACKLOG (UNITS)	7,650	7,357	4.0%
DELIVERIES (UNITS)	122	162	-24.7%
REVENUES**	€7,569	€9,697	-21.9%
EBIT**	€57	€319	-82.1%

*2019 financial figures restated to reflect the adoption of a new segment reporting structure for "Transversal" activities
**In € million (€1 = $1.08)
Source: Airbus

Figure 16.15 – Change of key metrics of Airbus activity between the first quarters of 2019 and 2020 (Source: https://bit.ly/2GWHM1t)

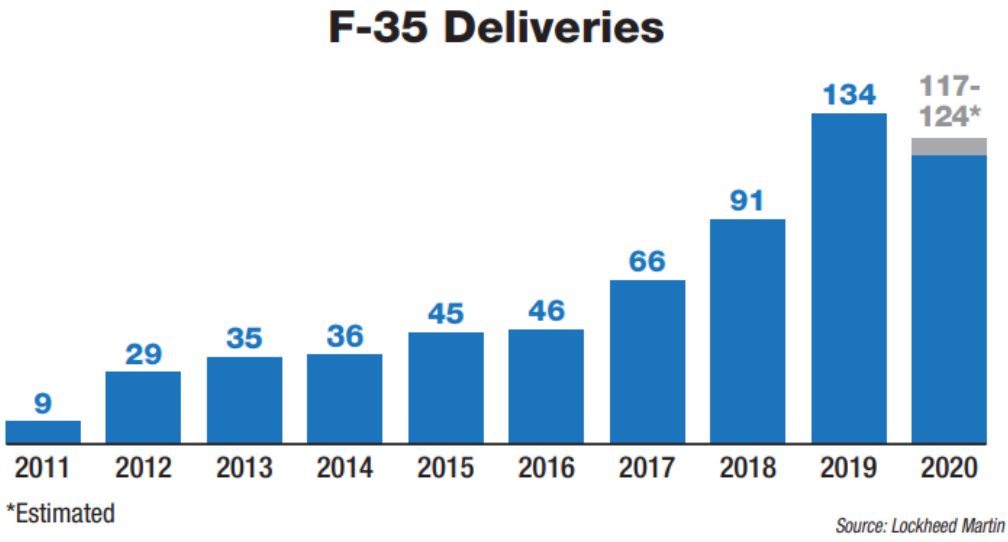

Figure 16.16 – Slowing down of production pam-up of a military aircraft (Lockheed Martin F-35 Lightning II) due to COVID-19 restrictions (not lack of orders)

(Source: https://bit.ly/2Fqsbah)

The figure 16.14 shows the current and future Boeing production rates, with significant reductions in widebodies and uncertainties about the ungrounding of the B737Max (chapter 14). The figure 16.15 shows the key metrics for Airbus demonstrating the negative effects of COVID-19 in 2020 compared to 2019. Although military aircraft production is sheltered from the collapse of the civil market, the figure 16.16 shows how the ramp-up of production of the Lockheed-Martin F-35 Lightning has been affected by parts shortages and industrial issues caused by COVID-19.

16.8.2 First-tier Suppliers

Among the first-tier suppliers, aero-engine manufacturers have a significant share of aircraft purchase and maintenance costs and can be the most critical supplier to the point of Airbus having some "gliders", that is finished aircraft waiting for engines. The engine suppliers are doubly affected by COVID-19: (i) they supply a smaller number of new engines due to lower aircraft production rates; (ii) engine maintenance can be double of engine cost over the lifetime of an engine and is a significant revenue decreased by reduced flying. Thus, a revenue cut of 30% for an aircraft manufacturer can look more like 50% for an engine supplier.

The figure 16.17 shows the number of jet transport engines stored or parked distinguishing regional and narrow and wide-body aircraft. The figure 16.18 shows that over 21 years the value of an airliner (the Boeing B737-800 in this case) may decline to about one-quarter of its price when new, whereas the engine (a CFM-56-7B in this case) hardly devalues at all. Thus, the engine rises in value from 35% of the new aircraft to 80% for a 20-year old aircraft. In fact, old aircraft are often bought for the spare parts of the engine.

Commercial Jet Transport Engines Stored/Parked by Aircraft Class*				
Engine Manufacturer	Regional Jet	Narrowbody	Widebody	Totals
CFM International		17,166	272	17,438
Engine Alliance			480	480
General Electric	3,524		3,802	7,326
International Aero Engines		4,430		4,430
Pratt & Whitney	108	1,713	925	2,746
Rolls-Royce	1,132	674	3,488	5,294
Honeywell	284			284
Totals	5,048	23,983	8,967	37,998

*As of April 18, 2020. Includes 6,077 engines in reduced-activity "parked/reserve" status that flew 1-2 of previous 7 days.

Source: Aviation Week Intelligence Network Fleet Discovery

Figure 16.17 – Commercial jet transport engines stored /parked for regional, single-aisle and wide-body aircraft (Source: https://bit.ly/2GWHM1t)

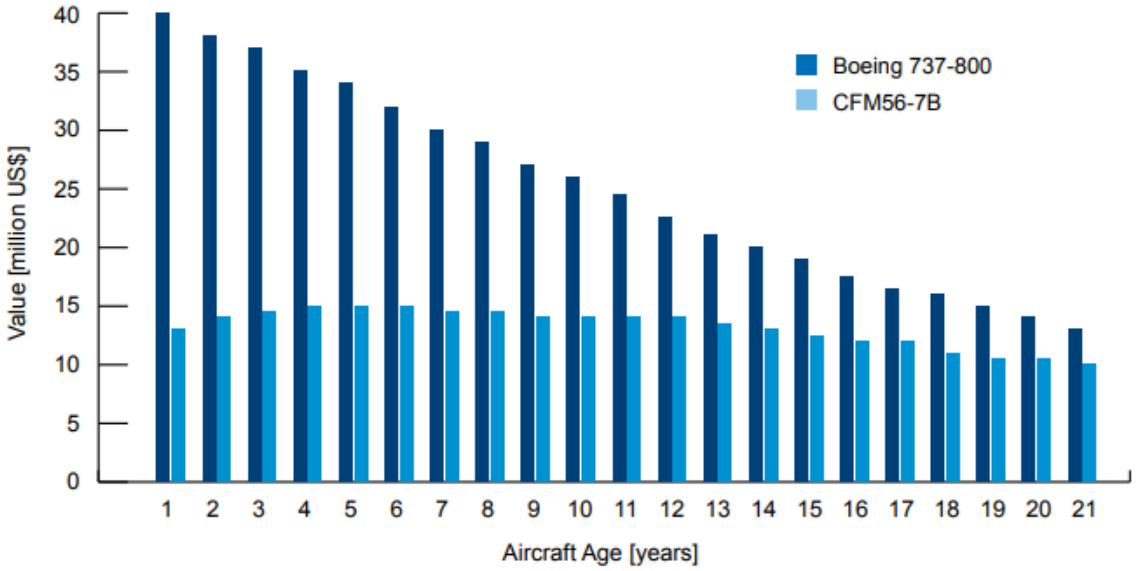

Figure 16.18 – Price evolution with age showing a steep decline for aircraft (Boeing 737-800) and a steady value for engines (CFM 56-7B

(Source: https://bit.ly/2RvFMiR)

16.8.3 Down the Supply Chain

The decline in the civil aviation market passes from airlines to aircraft manufacturers and then filters down from tier 1 to tier 2,3 and 4 of the supply chain. The figure 16.19 shows that the exposure of the supply chain depends mainly on two factors: (i) there a strong dependence on the civil aircraft market, or there is an activity in military aviation or non-aviation sectors?; (ii) is the dependence only as a part supplier or also in maintenance and support?

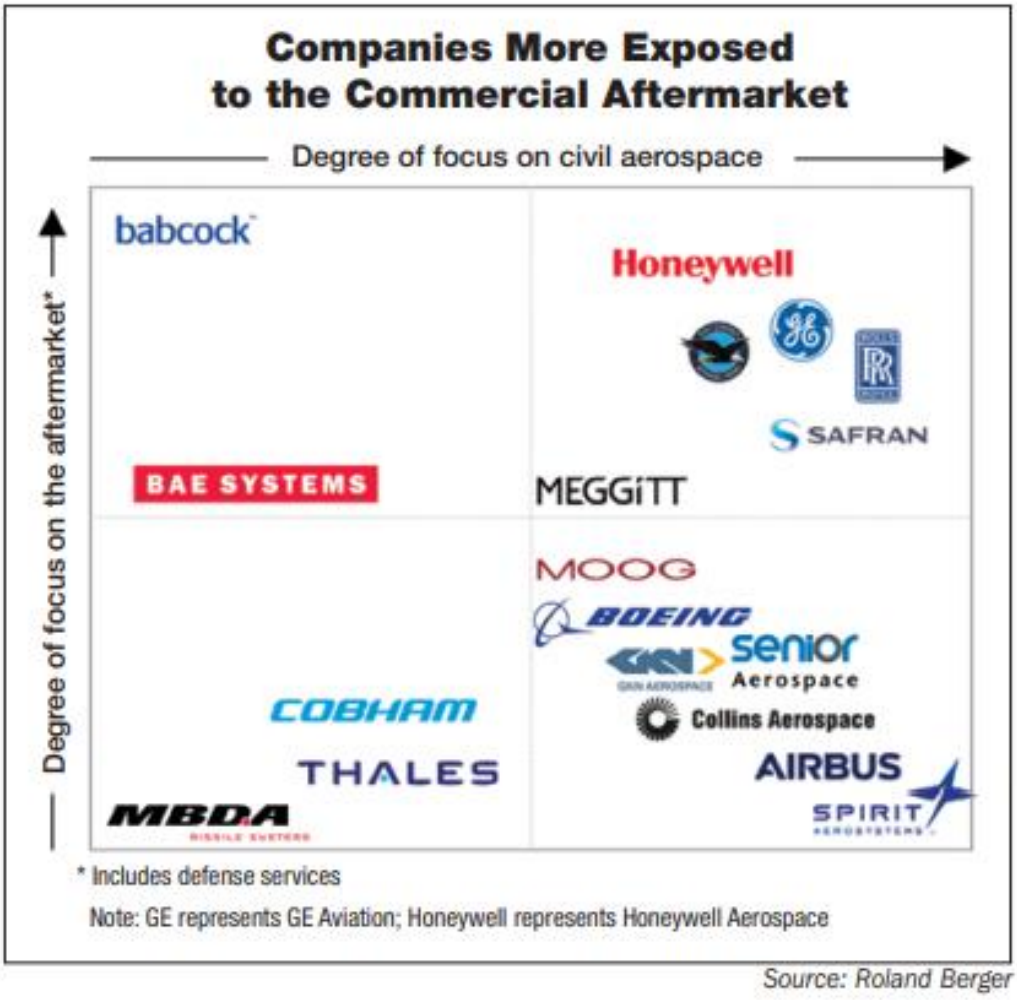

Figure 16.19 – The 10 largest lessons by the number of aircraft for leasing in service and on order (Source: https://bit.ly/3iCruce)

The figure 16.20 indicates the dependence of several suppliers on the aircraft platform. For example, Spirit AeroSystems has a strong dependence on the Boeing 737 because it manufactures the fuselage in Wichita, Kansas; its dependence on the Airbus A320 is smaller because it is mainly a substructure supplier. The Figure 16.21 shows the dependence of suppliers per market. Overall, there is a wide variation of the dependence of the supply chain on the particular platform.

Supplier Exposure by Aircraft Platform

Percentage of 2020 Estimated Revenue

BOEING							
737		747		777		787	
Spirit AeroSystems	48.2%	Triumph Group	5.2%	Boeing	17.3%	Boeing	19.2%
Boeing	22.3	Spirit AeroSystems	1.8	Spirit AeroSystems	16.9	Spirit AeroSystems	16.1
Hexcel	10.5	Boeing	1.7	Hexcel	7.7	Hexcel	10.1
Triumph Group	8.4	Hexcel	0.3	United Technologies*	3.6	United Technologies*	5.3
Woodward	5.9	Woodward	0.3	Triumph Group	2.9	Triumph Group	3.0
TransDigm Group	3.3	United Technologies*	0.2	TransDigm Group	1.0	Woodward	2.0
United Technologies*	2.9	TransDigm Group	0.0	Woodward	0.7	Honeywell International	1.2
Honeywell International	1.6			Honeywell International	0.3	TransDigm Group	1.2

AIRBUS							
A320		A330		A350		A380	
Hexcel	8.2%	Rolls-Royce	3.0%	Hexcel	12.4%	Hexcel	3.6%
Triumph Group	7.6	Triumph Group	2.5	Spirit AeroSystems	3.8	TransDigm Group	1.1
Spirit AeroSystems	7.4	Hexcel	1.1	United Technologies*	2.7	United Technologies*	1.1
United Technologies*	4.8	Spirit AeroSystems	0.8	Honeywell International	1.6	Woodward	0.4
TransDigm Group	3.6	Woodward	0.5	TransDigm Group	1.4	Spirit AeroSystems	0.4
Woodward	3.4	United Technologies Aero*	0.4	Triumph Group	0.7	Honeywell International	0.2
Honeywell International	0.6	Honeywell International	0.1				
		TransDigm Group	0.1				

Figure 16.20 – Supplier exposure to aircraft platform for several suppliers in terms of percentage of 2020 revenues (Source: https://bit.ly/3kiggd6)

A&D Revenue Exposure by Market

	Percent of 2019 Revenues by Market			
Company	Aerospace Original Equipment	Aerospace Aftermarket	Defense/ Space	Other Government
AAR	2%	66%	33%	0%
Aerojet Rocketdyne	0	0	100	0
AeroVironment	0	0	79	0
Astronics	43	36	18	2
CPI Aero	20	5	75	0
Crane Co.	11	5	9	0
Cubic Corp.	0	0	43	57
DLH Corp.	0	0	45	55
Ducommun	42	6	45	0
HEICO	4	49	34	0
Hexcel	68	0	20	0
Kratos Defense & Security	0	0	100	0
Mercury Systems	0	0	100	0
RADA Electronic Industries	0	0	100	0
Spirit AeroSystems	88	5	7	0
The Boeing Co.	52	11	37	0
TransDigm Group	26	32	37	0
Triumph Group	60	18	20	0

Notes: Aerospace original equipment and aerospace aftermarket include all commercial transport and business jet exposure. Defense and space includes both original equipment and aftermarket sales.

Figure 16.21 – A&D Revenue Exposure by Market

(Source: Aviation Week)

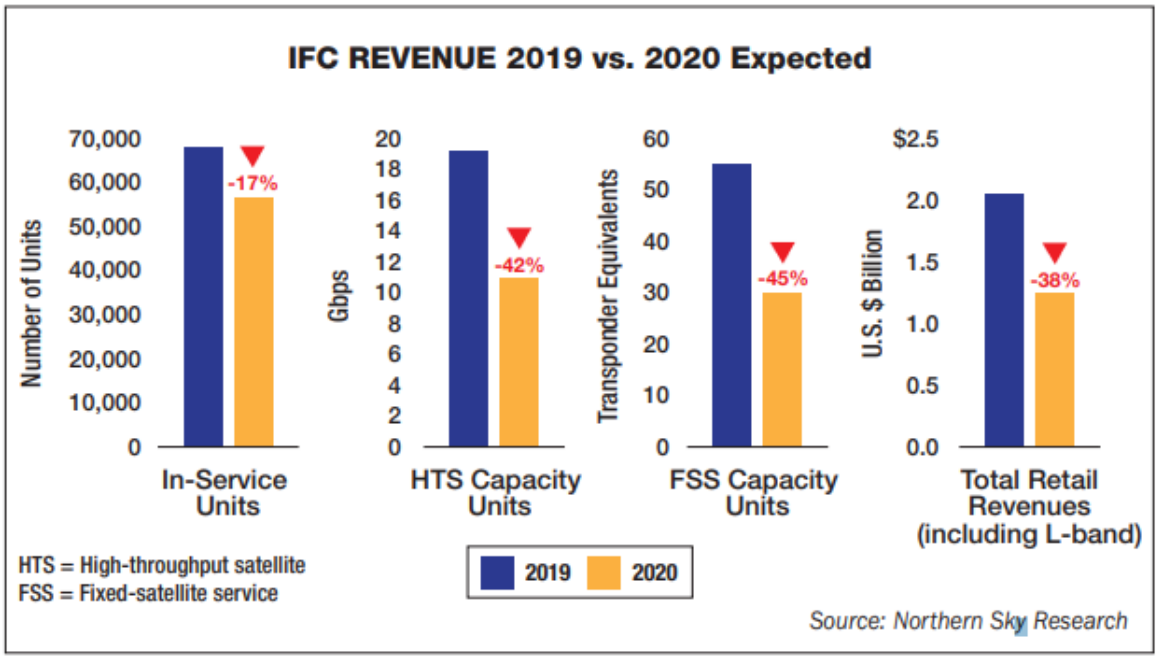

Figure 16.22 – Decline in revenue for in-flight communications (IFC) comparing 2019 records with expectations for 2020

(Source: https://bit.ly/2Fqsbah)

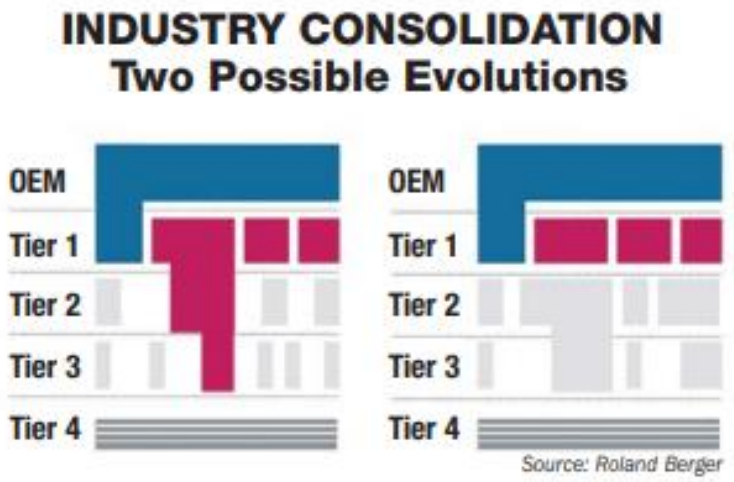

Figure 16.23 – Two possible scenarios for the consolidation of the supply chain of aviation industry

(Source: https://bit.ly/2Fqsbah)

16.8.4 Maintenance, Repair and Overhaul (MRO)

The MRO sector is doubly hit by the COVID-19 crisis: (i) less flying means less maintenance and cash-strapped airlines fighting for survival may postpone non-essential major servicing; (ii) the Original Equipment Suppliers (OEMs) faced with less orders and excess industrial capacity and staff

will make a stronger competition for maintenance to improve revenues. In particular engine MRO that is a large share of the work on aircraft may face stronger competition from OEMs for what is left of a reduced market.

16.8.5 Used Aircraft Market

Airlines left with pre- COVID-19 fleets in excess of post-COVID-19 needs will dispose of surplus aircraft, starting with the: (i) least efficient that may be unsustainable in a cash-strapped situation; (ii) the more polluting that are more likely to be hit by stronger environmental protection measures; (iii) the largest that would have lower load factors in the future in routes with less passenger demand. It is unlikely that many B747, B767, A380, older B737, A300/310, A330/340 will remain in airline service and used prices may reach historic lows.

16.8.6 Prospects for Survival

The decline in the aviation market affects all suppliers and the figure 16.21 illustrates the effects on the In-Flight Communications market comparing 2019 and 2020 concerning several types of passenger and entertainment services. The figure 16.23 illustrates two possible evolutions of the consolidation of the OEMs and the four tiers of the supply chain, including vertical or horizontal integration and mixed cases depending on the value of the acquisition and financial capacity of the buyer.

For companies in the supply chain, the chances of survival lie between two extremes: (i) a supplier of a unique essential part or equipment that is essential for recovery after the COVID-19 crisis will either survive by itself or be saved if necessary by the OEM by contracts to ensure continuity or direct purchase; (ii) a supplier of occasional services when the OEM has excess work is unlikely to be needed when the OEM is short of work, has overcapacity and can do the work itself.

16.9 Bail-Out in the U.S. CARES

Saddled with high fixed costs and vanishing revenue the aerospace sector could not survive the COVID-19 crisis without state help; the way it was provided varied around the world as much or even more as the disparate response to other aspects of the crisis. The U.S. Congress approved the CARES (Coronavirus Aid Relief and Economic Stability) bill. The CARES act covers the 6-month period ending on September 30, 2020, and imposes a number of restrictions: (subsection 16.9.1) workers cannot be furloughed and pay rates cannot be changed; (subsection 16.9.2) all domestic flight connections mist be flown; (subsection 16.9.3) airports must remain operational as before. As soon as the general rules for the distribution of funds were announced, there was no shortage of imagination on how to circumvent them, leading to widespread controversy about inequalities in their application. There are also sizeable bailouts for industry, including 60 B$ for Boeing (subsection 16.9.4). Left completely open is what happens after October 1, 2020, when the rules no longer apply, and the billions have been spent (subsection 16.9.5).

16.9.1 Keeping employment

The CARES rules forbid dismissing employees or cutting pay rates. Some major U.S. airlines were quick to cut the working hours, thereby reducing salaries in the same proportion, with unchanged pay rates. This led to angry protests from worker unions with workers filling the corridors of Congress to make sure they were heard. The management of airlines eventually backed down

partially, as little as possible, and rather grudgingly, leaving little doubt on what will happen after September 30, 2020

16.9.2 Maintaining Internal Flights

The rule to maintain all internal flights hit hardest small regional airlines and tourist operators forced to keep flying nearly empty aircraft to have CARES funding. The large airlines fared much better, because they need not fly international routes, and can reduce the number of internal flights by flying through their hub and reducing flight frequencies. This put the large airlines that are financially stronger at advantage relative to small regional airlines that may be absorbed or not survive on their own.

As this was not enough major airlines came up with codeshare proposals that were flatly and repeatedly rejected by the Transportation Department. The idea was that if airlines X, Y and Z flew from A to B, they would codeshare and only X would actually fly the route. On a route from C to D they would again codeshare with only airline Y actually flying. In this way airlines X, Y and Z would all cut the number of flights by three while receiving the same CARES benefit.

16.9.3 Supporting Airports

The rules for supporting airports were based on the ratio of airport liquidity to debt, leading to widely contrasting situations, for example in the state of Alaska: (i) the largest airport received no funding whereas a small airport would receive funding for several years of operation; (ii) of two similarly sized airports one would receive very little compared with the other. Thus the 80 B$ provided by the CARES bill for airlines and airports gave rise to widespread controversy and protest against unequal treatment.

16.9.4 Bailouts for Industry

The bailouts for the industry were less controversial and adjusted to the needs of each company. The size of the 60 B$ bailout for Boeing did raise some eyebrows in Congress and Boeing cleverly argued that it was not all for itself and would cover the whole supply chain as well. The 60 B$ rescue package had already been mentioned in the context of the B737Max crisis (chapter 14) before the COVID-19 pandemic, that happened to come at the right time to provide a suitable cover under the CARES Bill.

16.9.5 Six-month Duration

The CARES bill allocated more than 170 B$ for aviation over a 6-month period without setting any long-term goals or objectives for industry or services. The rules for airlines and airports were generic and applicable to all making it difficult to deal in a balanced way with very different situations, and thus, leading to controversies about the distribution of funds. The main remaining question is what happens after CARES expires on 1 October 2029: can employees be dismissed, salaries be cut, routes discontinued, or another sizeable bail-out bill will come? There are estimates of up to a quarter million job losses

16.10 Opposing Alternatives

The high fixed costs and small profit margins in the aviation sector mean that the loss of revenue over an extended period due to COVID-19 crisis is the biggest crisis ever and simply not survivable without state aid (subsection 16. 10.1) although in some cases it could not or was not provided (subsection 167.10.2).

16.10.1 Supporting Survival

The figure 16.24 shows the minimum, maximum and median liquidity of airlines in several regions of the world in terms of months of operation. It is clear that due to high fixed and operating costs, with small profit margins, the liquidity available to most airlines would cover only a few months of operations. An extended crisis like COVID-19 with grounded aircraft and no revenue to cover fixed personnel and maintenance is simply not survivable.

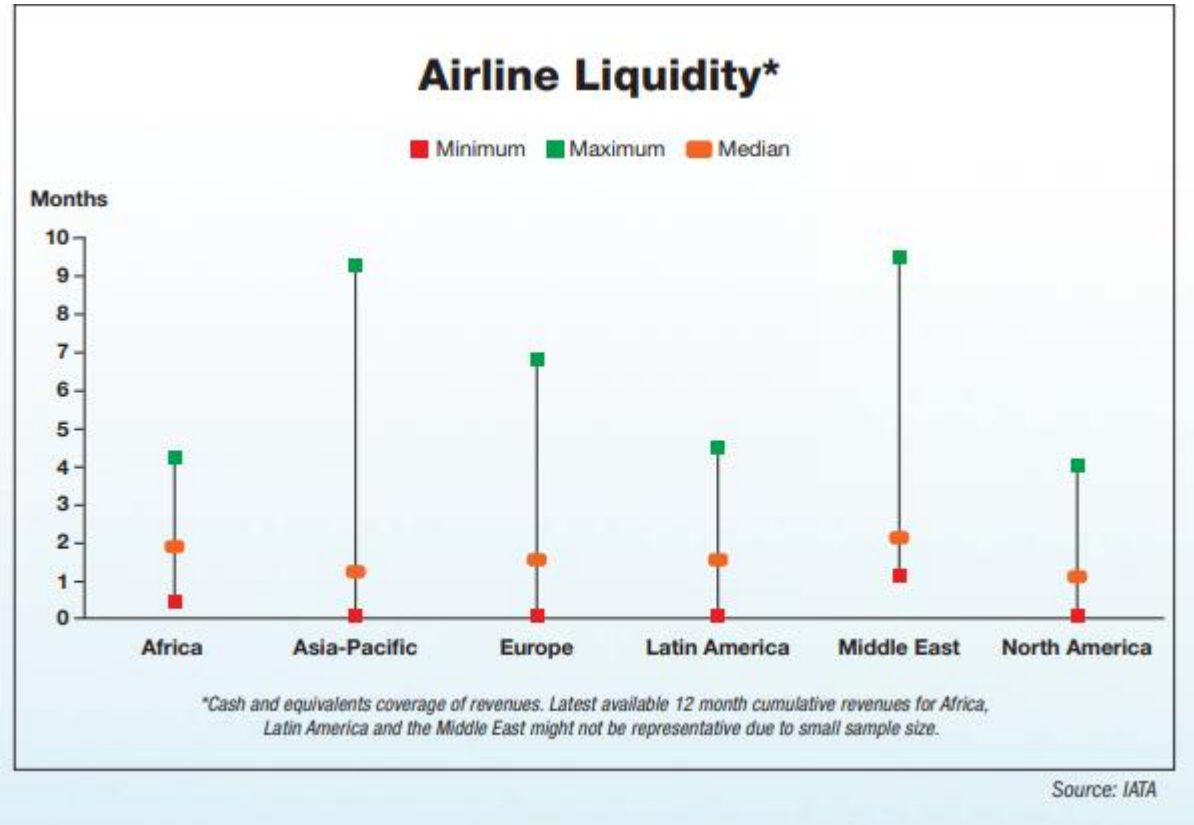

Figure 16.24 – Minimum, maximum and median airline liquidity in terms of the monthly cost of operations for different regions

(Source: https://aviationweek.com/)

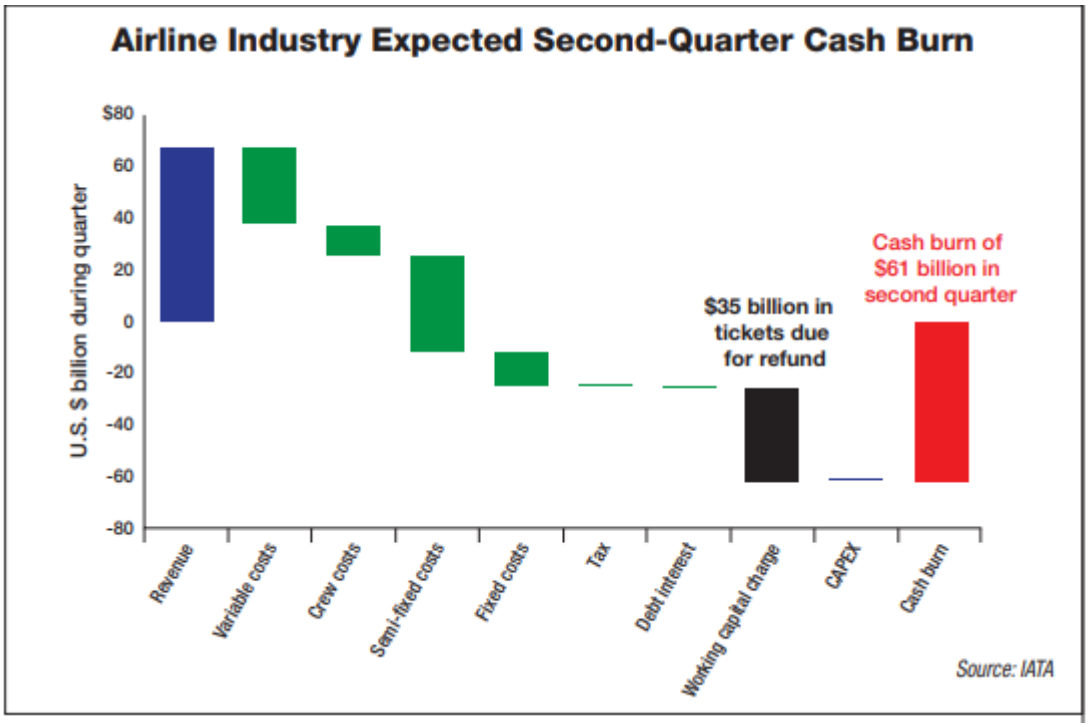

Figure 16.25 – Airline positive and negative cash flows during the second quarter of 2020 when the COVID crisis hit (Source: https://bit.ly/3iCruce)

The figure 16.25 shows the expected industry cash burn in the second quarter of 2020 of 81 B$. The figure 16.26 shows that the widespread of the COVID-19 pandemic around the world affects nearly all airlines. The figure 16.27 details the expected airline performance per region showing declines in passenger demand and capacity of the order of 50% corresponding to 85 B$ losses. The figure 16.28 shows the airline revenue per region in 2019 and the percentage of state aid, with more detail on the distribution of funds in the U.S. in figure 16.29.

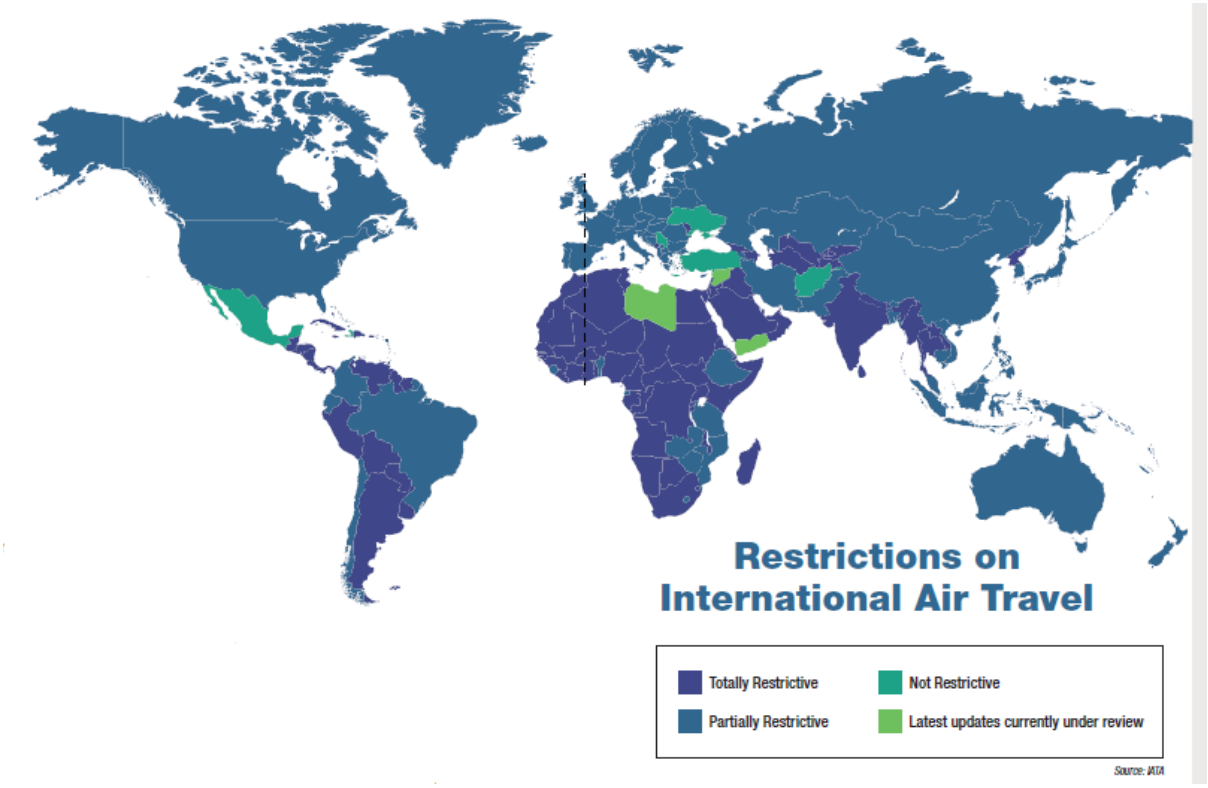

Figure 16.26 – Restrictions on air travel due to COVID-19 pandemic in different regions of the world (Source: https://bit.ly/3iEfO8J)

Projected 2020 Airline Performance By Region

Region	Passenger Demand (revenue passenger kilometers)	Passenger Capacity (available seat kilometers)	Net Profit (U.S. $ billion)
AFRICA	-58.5%	-50.4%	-$2.0
ASIA-PACIFIC	-53.8	-39.2	-29.0
EUROPE	-56.4	-42.9	-21.5
LATIN AMERICA	-57.4	-43.3	-4.0
MIDDLE EAST	-56.1	-46.1	-4.8
NORTH AMERICA	-52.6	-35.2	-23.1
GLOBAL	**-54.7**	**-40.4**	**-$84.3**

Source: IATA

Figure 16.27 – Decline in airline performance per region in terms of passenger demand and capacity, in 2020 relative to 2019, and net losses due to COVID-19 pandemic (Source: https://bit.ly/2E6J4pD)

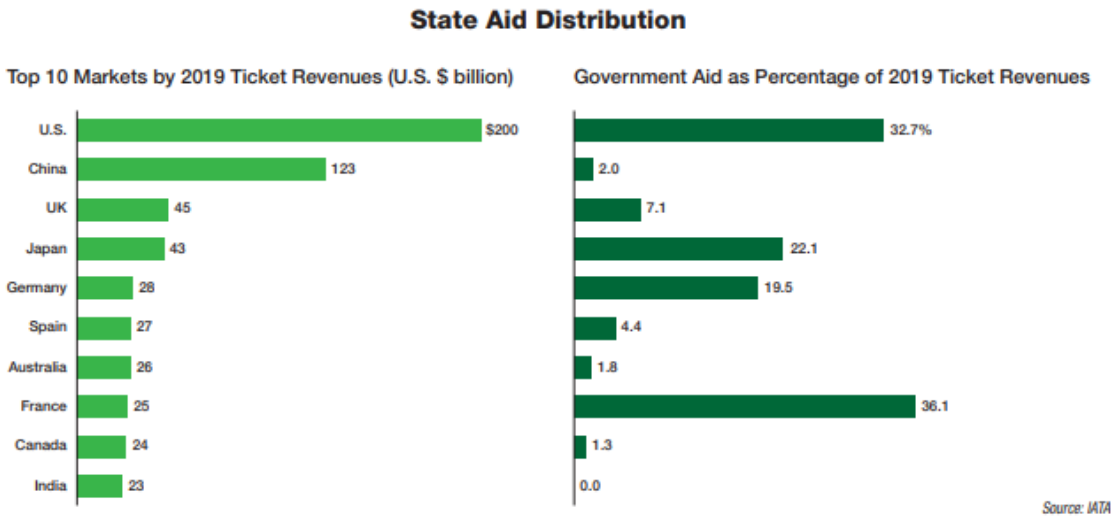

Figure 16.28 – Airline ticket revenues in 2019 in the top ten countries, and percentage of support given in 2020 to help survive COVID-19 crisis

(Source: https://bit.ly/2Fqsbah)

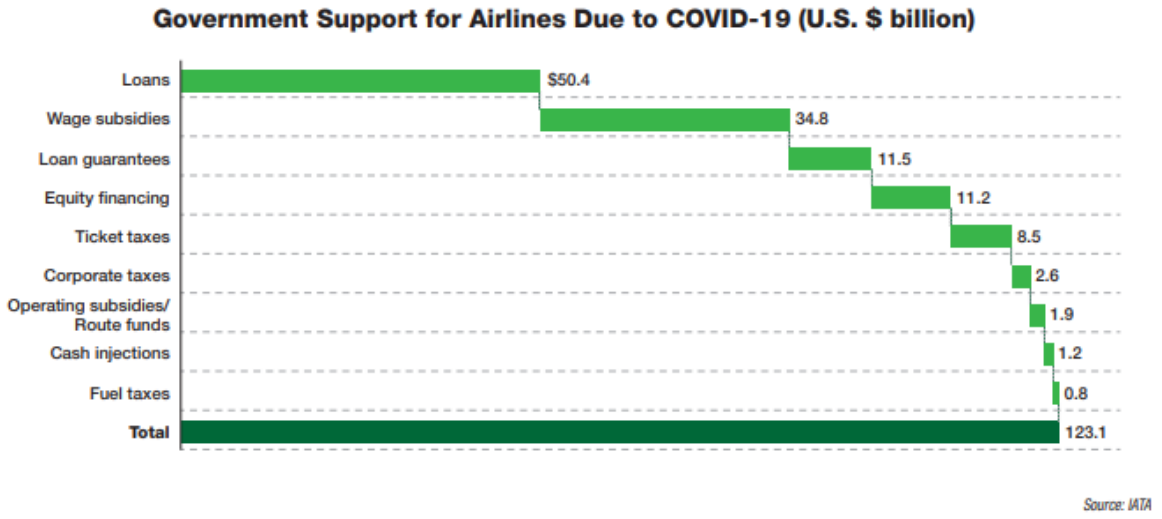

Figure 16.29 – U.S. Government support to airlines under the CARE (Coronavirus Aid Relief Economic Stability) act in the 6 months from April 1 to September 30

(Source: https://bit.ly/2Fqsbah)

16.10.2 Allowing Bankruptcies

The government reactions to the unsustainable airline situation were very different even in the same region. In Asia Singapore Airlines and Cathay Pacific were in a particularly difficult situation, with no domestic market, flying out of a single airport, with only international flights from Singapore and Hong Kong respectively, that will take longest to recover from the uncoordinated worldwide deconfinement. Both airlines have a long record of profitability and high reputation for

service, and their wealthy parent states were in a good position to provide sizeable financial support to ensure long-term survival.

Not so far away Thai Airlines with a long record of poor financial performance was let into receivership by a government lacking either the confidence or the means for an effective bailout. The situation was similar with some airlines in Latin America, including JENAM despite partial ownership by American Airlines. The local governments with weak debt-ridden pre-COVID-19 economies, further strained by the pandemic did not find the funds or priorities for the required sizeable bail-out of airlines, even flag carriers.

16.11 Government Policies

In Europe most but not all governments took steps to rescue the national flag carrier, as shown by the cases of Lufthansa in Germany (subsection 16.11.1), Air France/KLM in France/Netherlands (subsection 16.11.2) and Alitalia in Italy (subsection 16.11.3) with Britain/Spain less keen on British Airways/Iberia (subsection 16.11.4) and private airlines like Low-Cost Carriers (LCCs) left to their own devices (subsection 16.11.5).

16.11.1 Germany: Lufthansa

Germany provided a 9 B€ rescue package that Lufthansa eventually accepted with reluctance for lack of a better alternative swallowing a bitter pill of conditions, including a reduction of fleet size to better match future predicted demand and loss of precious slots at key airports like Frankfurt and München. The government share of the company may evolve over time depending on future performance ranging from nationalization to full reprivatisation.

16.12.2 France/Netherlands: Air France /KLM

The 7 B$ rescues of Air France/ KLM was shared 80% by France and 20 % by the Netherlands based on the valuation of the contributions of the two airlines to their joint alliance. The conditions were less severe than for Lufthansa but include a reduction in domestic flying in favour of high-speed trains. Although Lufthansa had a better profitability record than Air France/KLM it got a more demanding deal from the German government

16.12.3 Italy: Alitalia

The rescue of Alitalia perennially in trouble with labour union issues remains as uncertain as ever, with successive take-over schemes collapsing. The covid-19 crisis does give the Italian government the opportunity to intervene without the objections and controversies surrounding previous subsidies. The plans are unclear, ranging from a small 100 aircraft fleet of almost irrelevant size to grand rebuilding plans looking rather dubious looking at earlier attempts. The fact remains that Italy is a major tourist and travel destination providing a stable market that should support a flag carrier.

16.12.4 Britain/Spain: British Airways/Iberia

The relations between British Airways and the British Government and Iberia and the Spanish government look more strained, with the airlines benefiting from generic COVID-19 support measures but no rescue plan, and rather complaining about the negative impact of government

regulations. In the case of British Airways, the imposition of quarantine on passengers from a blacklist of countries has led to threats of court action against the government.

16.12.5 Low-Cost Carriers

The LCCs have been as vocal as British Airways about quarantine and travel restrictions in Britain and elsewhere and have flatly rejected social distancing in aircraft cabins as leading to impossibly low load factors that are uneconomic at low ticket prices. The LCCs do not have the benefits of government support for flag carriers, and neither do they have the restrictions, being free to cut jobs, dismiss and rehire with lower wages; this is a model that British Airways may try to use in the absence of government support.

16.12 Comprehensive Support

The case of France is a good example of a comprehensive support package for the aerospace sector including: (subsection 16.12.1) military contracts; (subsection 16.12.2) industry support; (subsection 16.12.3) research for competitiveness.

16.12.1 Military Contracts

The military contracts are usually large investments for a batch of aircraft spread over several years and give much-needed stability to aerospace companies active both in the defence and civil sectors, providing a buffer against fluctuations in the civil market, that amount to an almost collapse in the case of COVID-19. The French plan reasserts military spending and should provide basic support to dual role aerospace industry, assuming future defence budgets resists the pressures of post-COVID-19 economic vulnerabilities.

16.12.2 Industry Support

Unlike Boeing that claimed a rescue package of 60 B$ to compensate a 41 B$ debt and avoid the risk of bankruptcy due to the B737Max crisis (chapter 14) before COVID-19, Airbus was in a healthy liquidity situation before COVID-19 and more concerned about support to its airline customers and essential elements of the supply chain. Airbus never had a reduction of production in its history until the COVID-19 crisis whereas in the same time period since the foundation of Airbus Boeing has coped with 3 periods of reduced airliner production Figure 16.30).

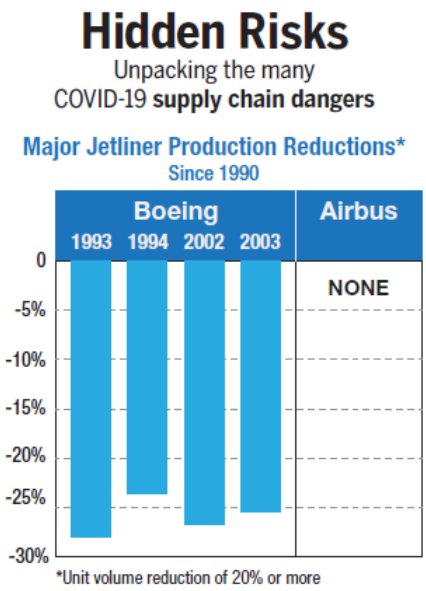

Figure 16.30 – Major jetliner production reductions
(Source: https://aviationweek.com/)

16.12.3 Research for Competitiveness

The 15 B€ package for support of the French aerospace sector includes 7 B€ for Air France, 4.5 B€ for industry supply chain and 1.5 B€ for research of development, including a 30% more efficient successor to the A320 family in 2030-2035, with two alternatives: (i) a conventional aircraft with a 25.! by-pass ratio engine (up from 12 in the current CFM Leap engine) and slender high aspect ratio wings; (ii) a novel configuration like a flying wing with large internal volume for hydrogen as fuel for gas turbines or fuel cells. While this is preparatory research rather in advance of an eventual aircraft program it does provide a focus for the research and development community in future competitiveness. The Future could be 3 families of aircraft: (i) a regional airliner replacement for the ATR with turboelectric propulsion; (ii) an hydrogen powered short-haul aircraft to replace the A320 family; (iii) a long-range twin-aisle aircraft using synthetic sustainable fuels.

16.13 Support of the European Union

The comprehensive support plan for the aerospace sector of France, like a comparable plan from Germany, is conceived to dovetail with the initiatives of the European Union, to bring the benefits of wider cooperation and coordination. The support of the European Union, in general, is based on the fund for economic and financial stability post-COVID-19 (subsection 16.13.1), and specifically includes research in Horizon Europe for a more efficient and environmentally friendly aviation (subsection 16.13.2) and coordination measures to deconfine and open-air travel in a coordinated way across Europe (subsection 16.13.3)

16.13.1 Financial Stability

The European union fund for recovery from the COVID-19 crisis provides the background of economic and financial stability to enable member states to move towards future efficiency and environmental protection goals, including the hydrogen economy, energy conservation, more

recycling, reduced consumption of finite resources, greater emphasis on renewable and sustainable approaches and practices.

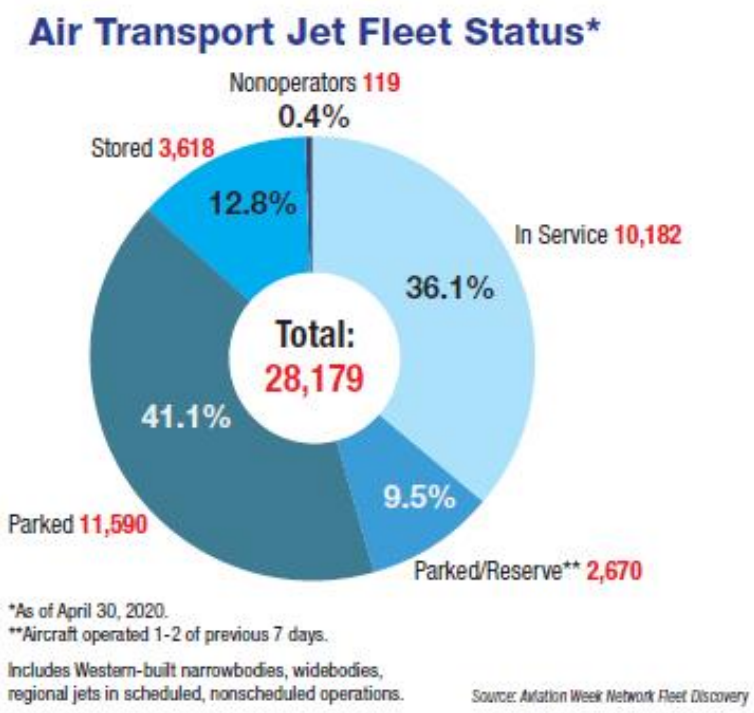

Figure 16.31 – Status of air transport fleet on April 30, 2020, distinguishing aircraft in service, stored, parked and in reserve

(Source: https://aviationweek.com/)

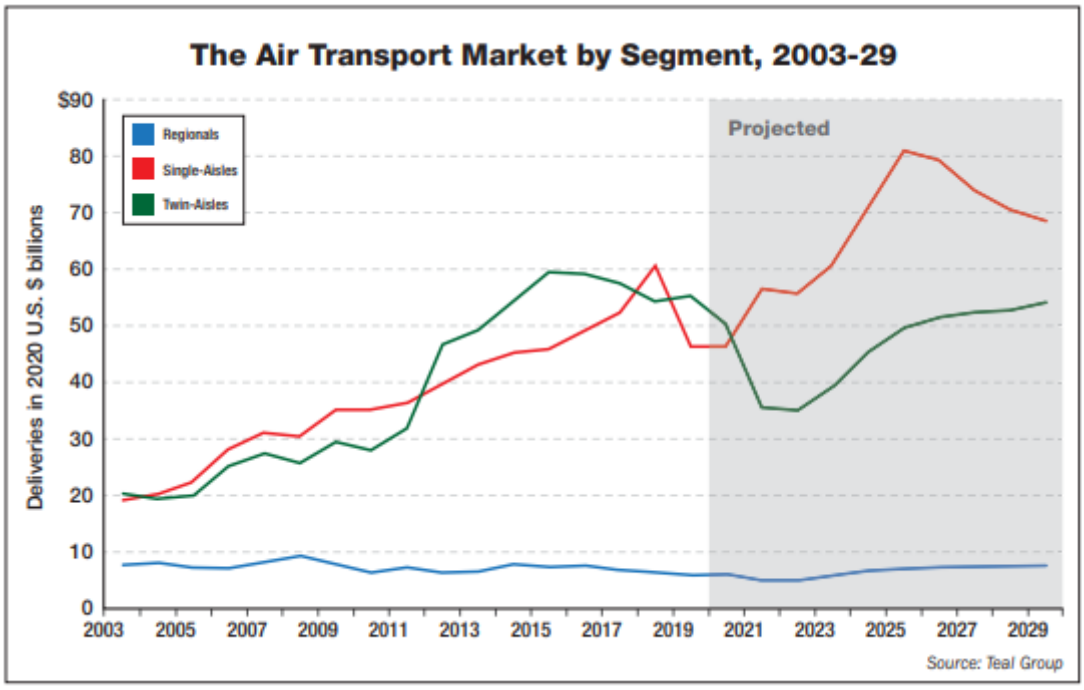

Figure 16.32 – – Number of regional single-aisle and twin-aisle aircraft in service over the period 2003-2020 and projections for 2020-2029

(Source: https://bit.ly/3mq3hbp)

Top 10 Domestic Markets Globally
Ranked by weekly seats for week of June 29

Rank	Market	Country
1	Seoul-Jeju	S. Korea
2	Ho Chi Minh City-Hanoi	Vietnam
3	Tokyo-Sapporo	Japan
4	Osaka-Tokyo	Japan
5	Fukuoka-Tokyo	Japan
6	Shanghai-Guangzhou	China
7	Shanghai-Shenzhen	China
8	Tokyo-Okinawa	Japan
9	Hanoi-Da Nang	Vietnam
10	Shanghai-Chengdu	China

Source: CAPA and OAG

Figure 16.33 – The TOP ten markets ranked by weekly seats on June 29 are all in the Asian far East
(Source: https://bit.ly/3mqFYhr)

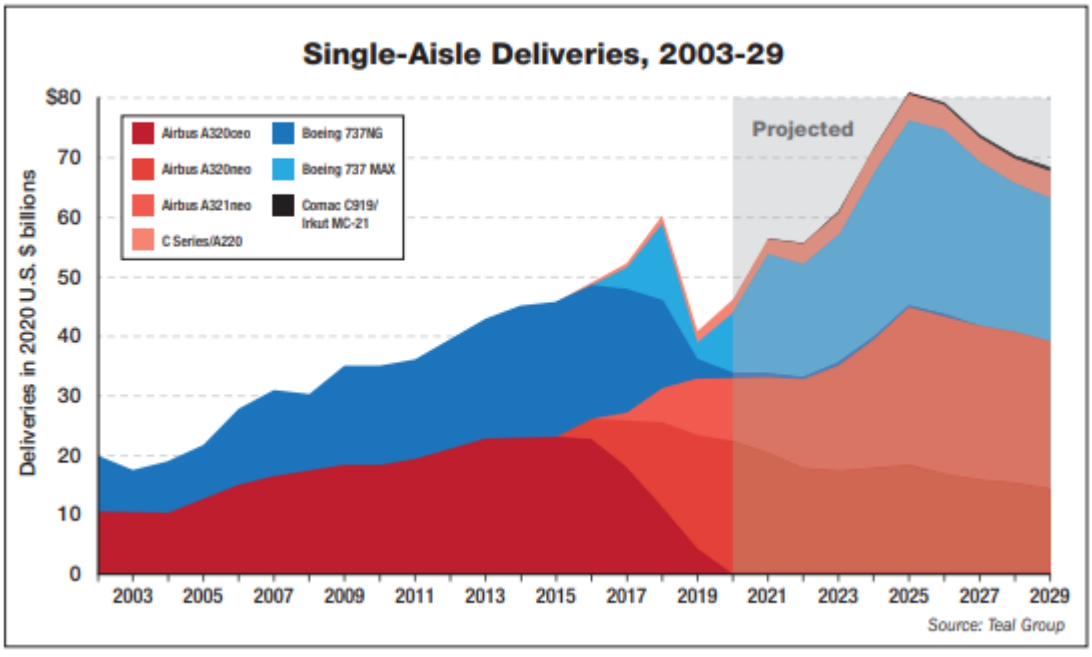

Figure 16.34 – Deliveries of single-aisle aircraft from Airbus, Boeing and COMAC over the period 2002-2020 and predictions for 2020-2029

(Source: https://bit.ly/3mqFYhr)

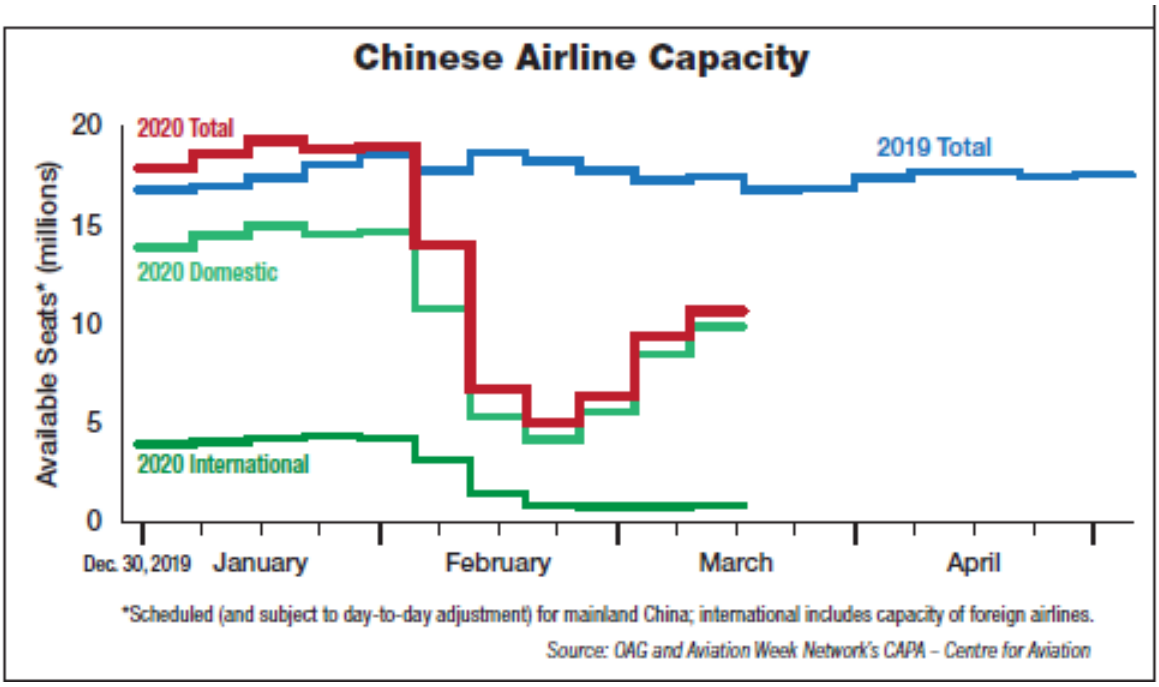

Figure 16.35 – Chinese airline domestic international and total capacity comparing 2019 to 2020 and showing the decline due to the COVID-19 and the prospects for domestic recovery and lag of international recovery

(Source: https://bit.ly/3hBfFSh)

16.13.2 Research and Environment

The convergence towards the hydrogen society includes the hydrogen-powered aircraft benefiting from the experience with cryogenic propellants in the Ariane 5/6 launchers with considerable additional developments in aircraft systems and turbine propulsion. For shorter ranges electric and hybrid propulsion provides an alternative path dependent on progress with fuel cells and batteries. Both approaches bring unquestionable environmental benefits and pose integration challenges.

16.13.3 Coordinated Measures

The prospects for recovery of long-haul air travel are strongly compromised due to the uncoordinated deconfinement measures around the world, leaving regional and short-haul transport as the nearest term prospect for return regular operations. The measures of the European Union to coordinate deconfinement across Europe are an essential contribution for the re-emergence of the airline market in the near term.

16.14 Recovery Prospects

The prospects for air transport recovery from the COVID-19 crisis are better in the short-term for regional and short-haul transport leading to a V-shape (subsection 16.14.1) whereas long-haul flight may continue to be hampered by uncoordinated deconfinement worldwide causing a delayed

rise in a U-shape (subsection 16.14.2). A fundamental uncertainty concerns the long-term level relative to pre-COVID-19 traffic (subsection 16.14.3) from full recovery (100%) to partial (70-90%) and the number of years to reach that level.

16.14.1 Short-haul: V-shape

The figure 16.31 shows the status of the worldwide jet transport fleet on 30 April 2020, with only about one-third of the aircraft in service. The figure 16.32 shows the value of airline deliveries in B$ since 2003, with the steady growth interrupted by the decline during the COVID-19 crisis in 2019-2020; the decline is larger in the for twin-aisle aircraft than for single-aisle, and the predictions for the 2020-2029 period show a slower recovery as well, with the reduced market favouring the economics of smaller planes.

The figure 16.33 shows that the 10 largest domestic markets ranked by weekly seats are all in the far east where faster recovery can be expected. The figure 16.34 shows the single-aisle deliveries in the period 2003-2020 with predictions up to 2029 for Airbus, Boeing and Comac models. The figure 16.35 shows the evolution of the Chinese domestic and international market in the first four months of 2020, with the sharp decline due to COVID-19, followed by a quick partial recovery in the domestic market and a further decline in the international market.

The figure 16.36 compares the share of total passenger associated with domestic and international traffic, demonstrating a clear shift towards domestic and away from international from 2019 t0 2020 for two Japanese airlines: All Nippon Airlines (ANA) and Japan Air Lines (JAL). The figure 16.37 shows global revenue passenger kilometres by quarter in the period 2016 to 2021, with the sharp COVID-19 decline by about 80% in 2020. The apparent better recovery in international than domestic market is due to the use of passenger kilometres rather than the number of seats or flights.

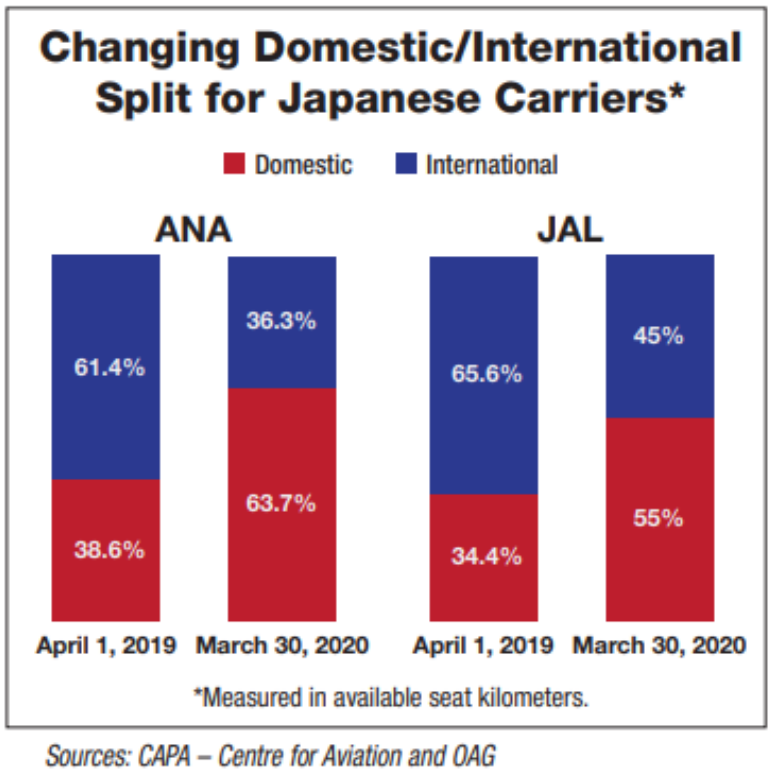

Figure 16.36 – Decline of international relative to domestic flights for two Japanese airlines, comparing April 1, 2019, to March 30, 2020

Source: https://bit.ly/3hBfFSh

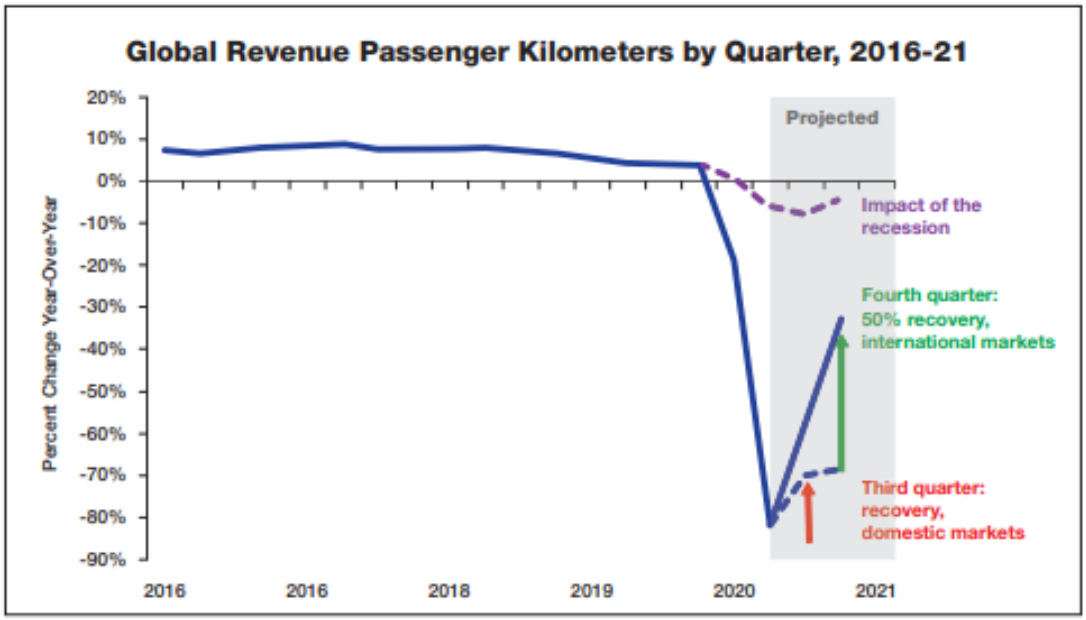

Figure 16.37 – Global revenue passenger kilometres by quarter 2016-2021, showing sharp Drop in 2020 due to COVID-19 and recovery in domestic and international markets and the impact of recession

Source: https://bit.ly/3mq3hbp

16.14.2 Long-haul: U-shape

The coordinated deconfinement allows a rapid resumption of regional and short-haul flights leading to a V-shaped recovery curve. The lack of worldwide coordination leaves long-haul flights is a stagnant position corresponding to the horizontal branch of a U-curve. It is only when deconfinement is generalized worldwide allowing long-haul flights between almost any city pair that the sharp rise is possible in the vertical branch of the U-shape.

16.14.3 Long-Term Level

Airlines will start recovery as soon as possible offering incentives to passengers such as low fares despite lower revenues. In order to capture as much traffic as possible airlines may fly up to 80% of the route network with only 30% of seat capacity, using the smallest possible aircraft to help load factors, and hope that traffic growth gradually improves profitability. The main open questions are whether recovery to 100% of pre-COVID-19 levels is possible or traffic will stabilize at a lower level in the 70-100 % range. Also, how many years will elapse until that ultimate level is reached.

The figure 16.38 shows the projected U.S. domestic traffic recovery by types of airlines with the drop to 40% of pre-COVID-19 level recovered to 85% in three years (2023) and full recovery of 100% in seven years (2027). The figure 16. 39 shows global passenger-kilometre traffic in 2020, with a drop to 10% due to COVID-19 in March and a predicted recovery in December to 64% in the baseline case and 47% in the case of higher pandemic risk.

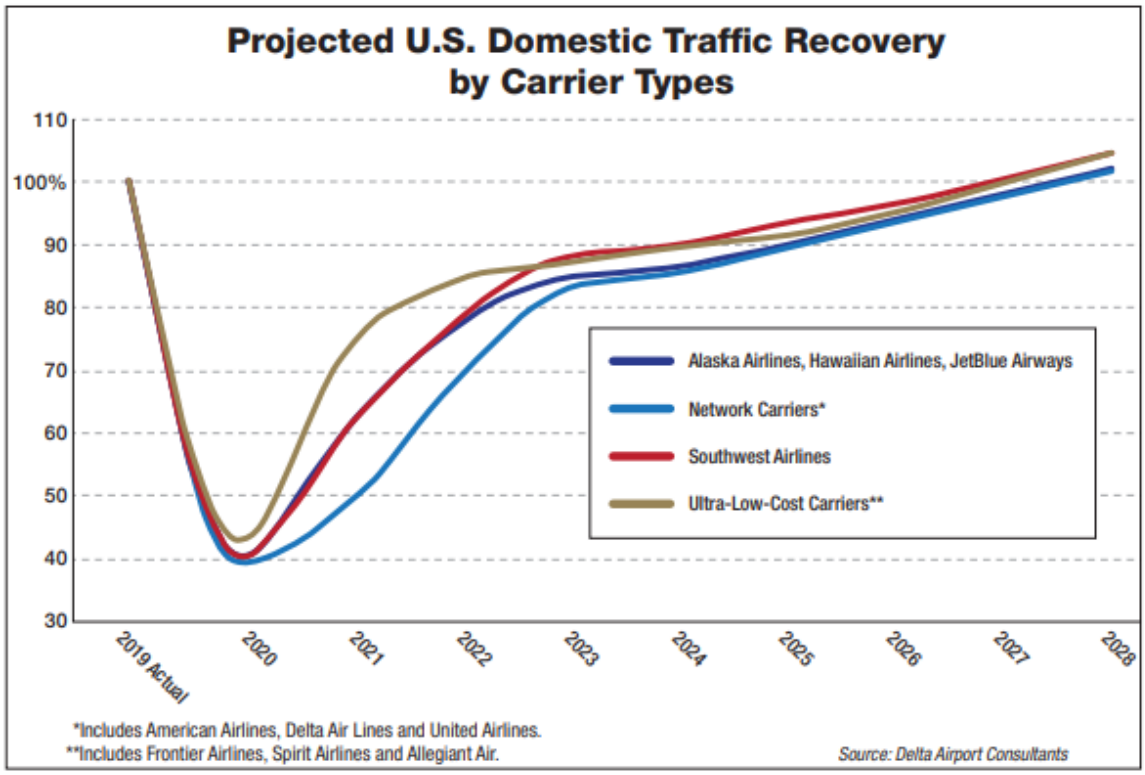

Figure 16.38 – Recovery from COVID-19 crisis of the U.S. domestic air traffic by airline or airline groups (Source: https://bit.ly/2E6J4pD)

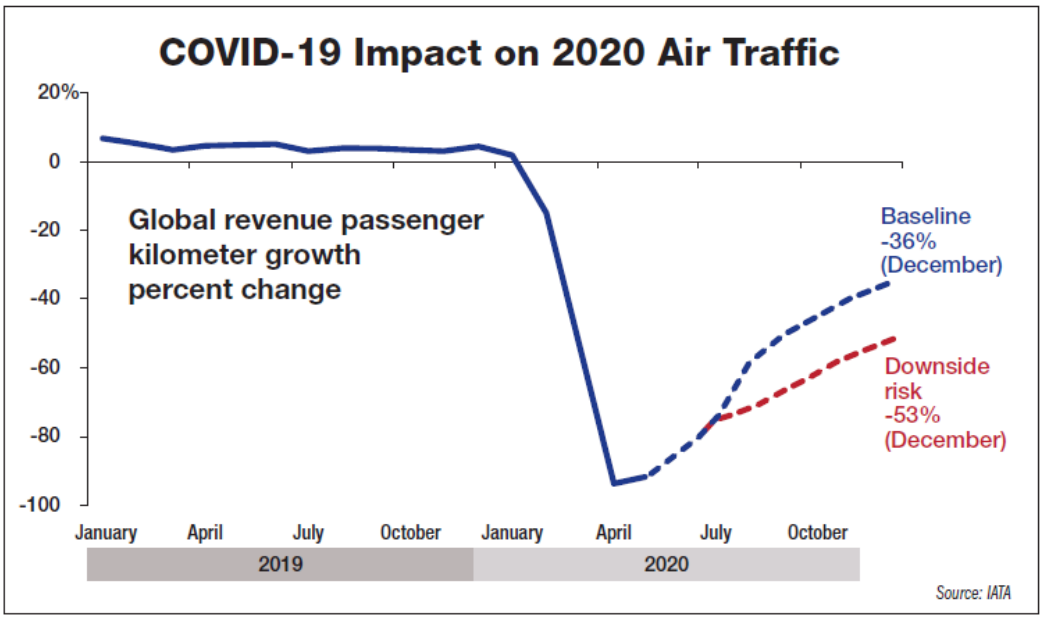

Figure 16.39 – Impact of COVID-19 in 2020 air traffic, with a sharp decline to 10% in March 2020 and recovery to 47-64% by December with the higher figure as a baseline and lower figure associated with slow recovery from the pandemic or second wave

(Source: https://bit.ly/3mqFYhr)

The final figure 16.40 shows that revenue passengers kilometres increased at the same rate for domestic and international flights starting in 2016 at 80% of the pre-COVID-19 level. The covid-19 crisis in 2020 caused a large decline, relatively smaller at 60% for domestic rather than 40% for international traffic. The predicted recovery is that domestic flights reach 2019 levels in 1-2 years in 2022 and international flights recover the 2019 levels in 2-3 years in 2023. Beyond these dates, air traffic is expected to grow beyond pre-COVID-19 levels.

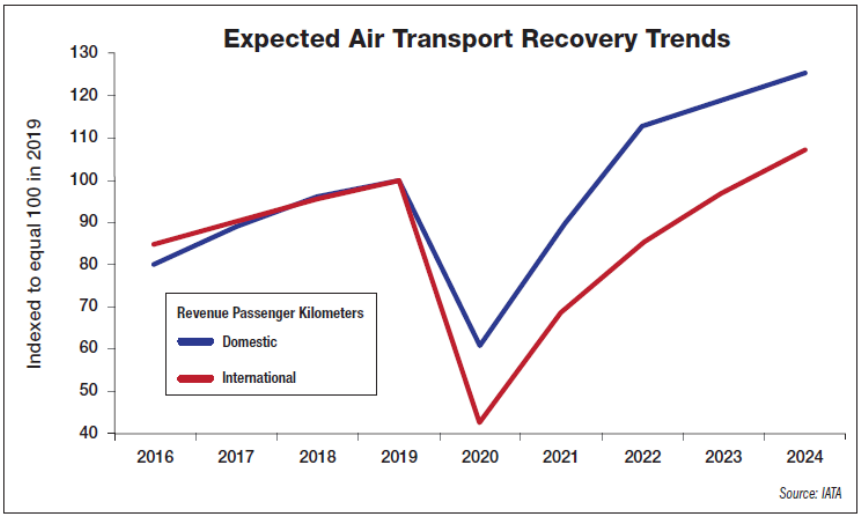

Figure 16.40 – Expected air traffic recovery trends following a sharp decline in March 2020 due to the COVID-19 and quicker ramp-up of domestic flying due to consistent deconfinement and slower ramp-up of international travel due to uncoordinated deconfinement

(Source: https://bit.ly/3mqFYhr)

16.15 On-Board Health

Airlines are keenly aware that in order to regain traffic besides incentives like low fares it is necessary to gain passenger trust (subsection 16.15.2) that anti-pandemic measures (subsection 16.15.1) provide sufficient health protection. The flight crew protection is particularly relevant for cabin attendants (subsection 16.15.3) that make frequent flights.

16.15.1 Anti-Pandemic Measures

The air conditioning systems aboard aircraft use High-Efficiency Particulate Air (HEPA) filters similar to hospitals. Air conditioning uses 50$ recycled and 50% external air and completely renews cabin air every 3-4 minutes that is faster than most buildings. Airbus indicates that its air conditioning systems send air vertically down from the roof that is extracted in the floor. This minimizes sideways flow to passengers in the same row; the effect can be increased by turning on air vents. The high seat backs also avoid air flows forwards or backwards to other seat rows.

All of the preceding measures diminish the likelihood of water droplets from one passenger reaching another. Some airlines consider using transparent plastic barriers between passenger seats. Others leave the middle seat in each row empty to provide greater separation between window and aisle passengers. Some airlines adopt more elaborate seating patterns to achieve greater social separation among passengers at the expense of reduced load factors.

16.15.2 Passenger Trust

In order to regain passenger trust that there is no health risk in flying, airlines put an increasing focus in cleaning the aircraft cabin and toilets and showing to passengers perfectly clean cabins The use of face masks in mandatory throughout the flight is mandatory in the European Union, though not in Britain where for example British Airways makes them optional. The permanent use of masks and the control of air conditioning flows and seat arrangements do nothing against contamination of seats, tray tables, display screens and toilets.

For the latter at least three cleaning methods are available: (i)sweeping with disinfectants; (ii) filling the cabin with gaseous antiviral products; (iii) using ultraviolet light (UV) that kills microbes. The demand for these products has increased significantly due to the COVID-19 pandemic and most can only be used with no passengers in the cabin. Some of the products can also degrade cabin materials like seat fabrics. A basic cabin cleaning takes half an hour and a thorough one 3 to 4 hours. Cleaning between flights or stops may require adjusted flight schedules.

16.15.3 Flight Crew Protection

The flight crew, in particular, the cabin attendants make many flights with many passengers and thus health protection is more critical. Another issue is how to deal with non-cooperative or recalcitrant passenger both in the aircraft and at the airport in some situations. For example, if a passenger tests positive and cannot fly with the family; or the case of a child that tests positive; or a passenger that tests positive at an intermediate stop-over. All of these can become difficult situations.

There are also limits to health protection. Putting all carry-on luggage in the hold would prevent passenger contamination by touching others baggage. This may be resented by passengers use to

carry essentials in cabin baggage to work during the flight or avoid stray luggage undermining their work at destination. This would risk sending electronic devices with lithium-ion batteries in the luggage hold. These batteries can easily catch fire if crushed. Such a fire can quickly be extinguished in the cabin, but in a luggage hold, it is another matter.

16.16 Pandemic Planning

The COVID-19 pandemic has caught the world and the aviation community by surprise leading to improvised and coordinated measures whose effectiveness could be improved based on a tragically earned experience. Covid-19 may not be the last pandemic the world may see, and as for other disasters and emergencies, planning could cover: (subsection 16.16.1) early detection to apply quarantine and containment measures on the small fraction of the population; (subsection 16.16.2) this allows the use of the resources of the majority of the unaffected population to support and heal the infected population; (subsection 16.16.3) some backup reserves and pre-planned actions could enable a rapid reaction in a suitably large scale.

16.16.1 Isolation and Containment

Early detection is fundamental in limiting the number of infected and potentially infected people. The COVID-19 has been detected in waste products and posteriori in hospital patients. Routine analysis of waste products and special attention to abnormal hospital cases could be used for early detection of new viruses and potential pandemics. The potentially infected population would be quickly isolated and severe cases sent to the hospital.

The isolated area would be separated from the rest by a hard border that could be approached or crossed only by authorized personnel specially trained to work in contaminated conditions that would transport all supplies between the outside and inside of the border. No one else would be allowed to approach the border either from the outside or the inside. The border would be open only when the pandemic was fully eradicated inside.

16.16.2 Marshalling of Support

The majority of the population outside the border would have as overwhelming priority helping to recover those inside. Thus,all available resources could be allocated to provide medicine, food and any other essentials on any scale needed. Telecommunication and psychological support would ensure those inside the border do not feel neglected and are aware that their wellbeing is the first priority of those outside the border that would endeavour to satisfy every reasonable wish of those inside.

Pre-planning would ensure that a basic set of contingency medical supplies and equipment of general use be available. Buildings would be surveyed and available for the rapid expansion of hospital capacity. Plans could be made for the rapid ramp-up of production of specialized equipment according to the needs of the particular pandemic. All these measures have already been used and proved so its mainly a matter of collecting them in a comprehensive plan with fast implementation when needed.

16.16.3 Back-up Reserves

Every sector of activity should be included in the planning to ensure any relevant capability is used when needed. Two examples are given from aviation. Cabin attendants are trained in basic health care. Obviously, they could not replace trained hospital staff in intensive care units. But with some more training, they could take over some simpler hospital tasks as surveillance of patients or help in simpler treatments, freeing the professional hospital staff to concentrate on more demanding tasks.

A second example concerns the industrial aerospace supply chain with a multitude of design and production skills and sophisticated programmable production facilities. These skills could be used to design medical equipment and plan the rapid ramp-up of production when needed. The combination of pre-stored general supplies and an array of pre-planned production ramp-ups would form the emergency plan to deal with pandemics.

16.17 Survival and Recovery

As the biggest crisis in the history of aviation, the COVID-19 pandemic has put in a survival and recovery state the main sectors: (subsection 16.17.1) starting with airlines, with the decline in passenger demand met by a fraction of the active fleet, and the remaining aircraft parked or stored (or to be disposed of) pending a traffic recovery that may take several years until new aircraft are needed; (subsection 16.17.2) continuing with aircraft manufacturers, facing cancelled orders, delayed deliveries and a lack of new orders until traffic recovers and older less efficient and/or more polluting aircraft have to be replaced; (subsection 16.17.1) filtering down the four tiers of the supply chain, that had been under pressure to lower prices and invest in increased capacity before COVID-19, finding afterwards a sharp decline in orders and revenue.

16.17.1 Airline Fleets

Before the COVID-19 pandemic, the long-haul traffic was softening with continuing strong demand in the short-haul leading aircraft to increase their fleets; the sharp decline after the pandemic forced airlines to rethink their fleet plans. The sharp decline in passenger demand required only a fraction of the fleet to remain active. Some older aircraft, with higher fuel consumption and/or emissions, were grounded with the expectation of disposal since by the time they could be flown again the economics would be unattractive and environmental restrictions unsustainable.

The total fleet minus active aircraft and those awaiting disposal, is grounded in one of two states: (i) parked, which allows quick return to service and has low initial costs, but higher maintenance costs over a longer time; (ii) storage, that has lower maintenance costs, but the higher initial cost and longer time to return to service. It is not easy for airlines to decide what part of the fleet to park or store, with low traffic levels and unpredictable ramp-up of recovery. No new aircraft will be required until traffic demand recovers, or existing aircraft have to be replaced by new more efficient and less polluting types.

16.17.2 Aircraft Manufacturers

Both Airbus and Boeing admit being in discussions with almost every customer or airline on revising the order book and delivery schedule, and not in a desirable way: (i) in some cases order cancellations cannot be avoided due to low traffic volume and expectations of slow recovery to

levels below pre-pandemic status; (ii) delivery delays are preferable to adjust to variable and hopefully improving traffic demand; (iii) new orders may wait 2-3 years from single-aisle and 3-5 years for twin-aisle as long-haul traffic recovers more slowly than short-haul.

Boeing and Airbus initial reactions to the COVID-19 have been to lower production rates by about 30% corresponding to the reduction in backlog and keeping the same period 5-8 years to fulfil all orders. In fact, twin-aisle production rates were already softening before COVID-19 and are cut to less than half afterwards. The main difference is in single-aisle where Airbus plans to ramp-up above 62 and Boeing plans to ramp-up over 52 (after ungrounding of the 737Max) have been revised to about 30 per month. Production rates may be adjusted temporarily to lowest possible economic level awaiting recovery.

16.17.3 Down the Supply Chain

Both Boeing and Airbus aggressively pursued plans to cut costs putting pressure on suppliers to reduce prices with single percent digit profit margins. At the same time suppliers were asked to make significant investments in increasing production capacity to meet the increasing demand for airliners. Thus, much of the supply chain was high on debt for expansion and low on liquidity from reduced prices when the COVID-19 pandemic suddenly hit with a sharp reduction in orders – very much an anti-climax.

The situation of thousands of companies in the supply chain depends on size, products they supply, and exposure to civil aviation. At one end tier 1 large engine manufacturers cannot be allowed to fail, and have to be rescued like aircraft manufacturers, since they are essential for recovery, and some of them have military contracts and non-aviation activities as a buffer. Down tiers 2 to 4 smaller companies may fail, leave the market, or be absorbed. Some with low exposure to civil aviation may survive by other means. Those which supply essential parts needed for recovery will be rescued if necessary by primes. Airbus and Boeing are thoroughly examining their supply chains in a 'reorganization' aimed at ensuring the survival of essential suppliers by sustaining orders, making capital available or taking over control.

16.18 Conclusion

The COVID-19 pandemic has had tragic consequences due to its unexpected rapid spread and lack of preparation to deal with the situation. These hard-earned lessons should be incorporated in an emergency plan to detect pandemics as early as possible and eradicate them quickly and effectively. Another set of preventive measures would be to adopt procedures that prevent contamination, for example, electronic or biometric screening that avoids the handling of documents at airports. The covid-19 pandemic has affected severely aviation prompting government intervention, sometimes in very different forms.

In the U.S. the CARES Bill provided more than 190 B$ for aviation in bail-out funds without long-term objectives and only short-term requirements that were not always fully met and generated controversies: (i) airlines were required not to furlough employees or reduce pay rates, but some tried to reduce working hours, thus decreasing monthly salaries and provoking protests in the corridors of congress; (ii) airlines and airports were required to keep domestic flight networks, but the rules affected differently small regional and large international airlines and there were funding discrepancies between large and small airports; (iii) industry received significant rescue funds, such

as 60 B$ for Boeing and 24 B$ for General Electric without strategic technological objectives. The CARES Bill covered only 6 months leaving open what happens after October 1, 2020.

In Europe national interventions did not exceed 15 B€, supplemented at the level of the European Union, and were applied based on case-by-case studies with significant economic and market constraints and long-term objectives of greater efficiency and reduced environmental impact: (i) airlines such as flag carriers received support packages up to 10 B$ requiring better economic and environmental performance together with other measures such as fleet reductions, loss of airport slots and closing of domestic routes; (ii) industry support strengthened the military contracts and covered all levels of the supply chain to enable the maturation of new technologies, like electrification and hydrogen power, to enable a future generation of up to 30% more efficient aircraft with environmental impact reduced by 25-75%.

The world military aircraft market (Figure 16.41) is about one-third to one-fourth of the civil aircraft market and thus only a partial buffer. On shorter routes up to 1000 Km in Europe high-speed rail (Figure 16.42) is a strong competitor for – continental distances above 1000 Km and transoceanic routes up to 2000 Km there is no credible alternative to aircraft in terms of speed and travel time, and indeed safety and efficiency.

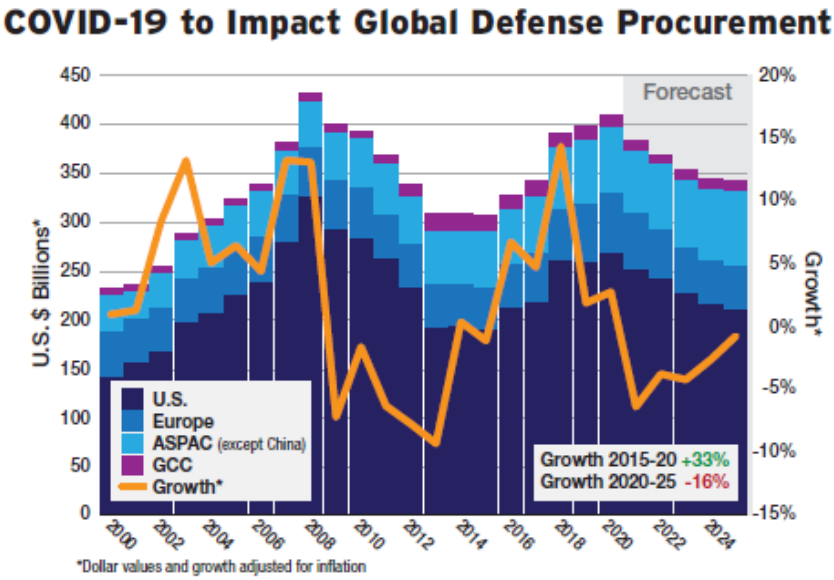

Figure 16.41 – COVID-19 to Impact Global Defense Procurement
(Source: https://aviationweek.com/)

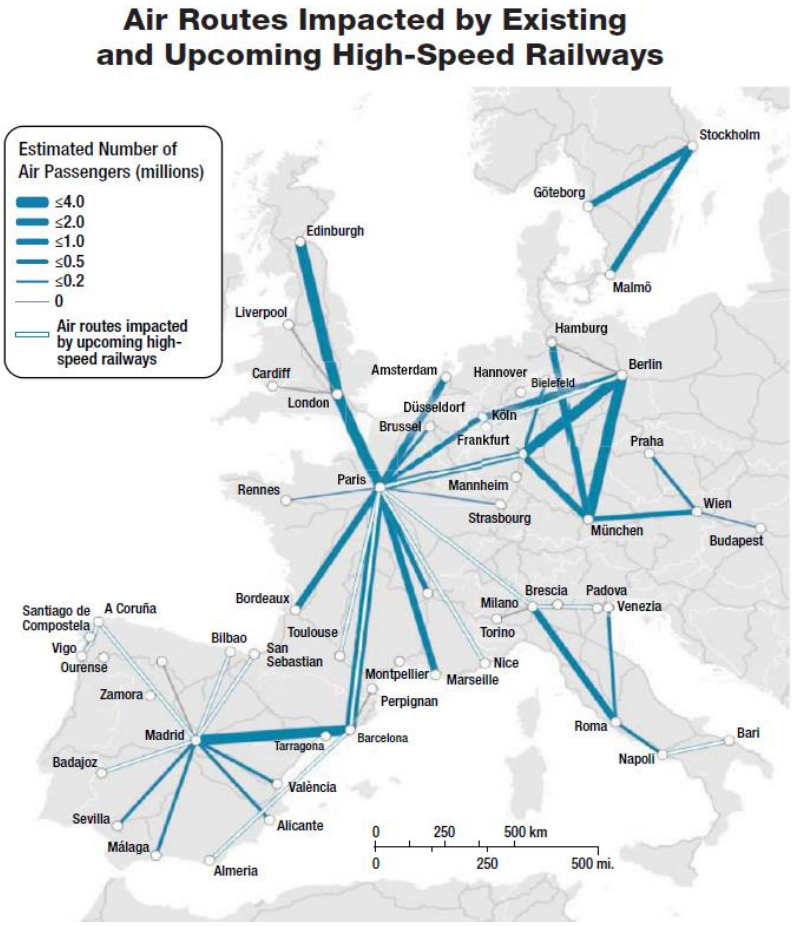

Figure 16.42 – Air Routes Impacted by Existing and Upcoming High-Speed Railways (Source: https://aviationweek.com/)