# Effects of the COVID-19 Pandemic on the Aerospace Supply Chain

While the world-wide COVID-19 pandemic has passed, the effects on the aerospace industry linger, and will likely be felt for the next five years. During the pandemic, airlines were faced with sharply reduced passenger volumes, OEM constructors reduced their manufacturing tempo and avionics OEMs paused production. This disruption in both the labor supply and to the supply chain overall has had far-reaching effects on the industry.

As passenger volumes have largely returned to pre-pandemic levels, OEM constructors are faced with shortages due to these ongoing supply chain issues. This has delayed the delivery of new aircraft, disrupted the supply of materiel needed for MRO and repair activities and has impacted the ability of the industry to meet pent-up demand for air travel and transport of commercial goods. In addition, the normal demand for parcel and freight carriage in the absence of the usual capacity for passenger aircraft to carry a significant portion of this freight has caused unplanned demand for freight aircraft, primarily met with passenger aircraft conversions.

The result of this perturbation in the aerospace supply chain has been felt across the board, but is evident in its impact on the civil aviation market, particularly in terms of supply of new passenger aircraft. Backlogs are steadily increasing for all passenger airframe OEMs, while at the same time, 1st and 2nd tier suppliers to these OEMs appear to be second-guessing the airframers ability to ramp up production to meet publicly stated goals, leading to unexpected shortages of raw materials exacerbating already expected delays in delivery of aircraft. As of early 2024, the Airbus backlog stands at just over 8500 aircraft, while the Boeing backlog stands at just over 5600 aircraft. Assuming that suppliers can continue to meet the demands of Boeing and Airbus, this leads to a backlog of over 7 years to receive a new commercial aircraft ordered in mid-2024.

# The trend toward longer in-service lives for older aircraft

Commercial airline operators respond to world events and changing passenger demand to reshape their operations and fleets. During the economic downturn of 2008 and the COVID-19 pandemic, operators altered their aircraft fleet mix, in both cases, parking, returning to lessors, or selling segments of their fleets.

The timing of these moves has had interesting follow-on effects. For example, one of the unforeseen effects of the COVID-19 pandemic, its long-term impact on the supply chain, has substantially reduced the industry’s ability to ramp-up production of new aircraft to pre-COVID levels. As passenger volumes have returned to normal levels, the demand for new aircraft has outpaced the production capability of Airbus, Boeing and Embraer. As a result, airlines are keeping older aircraft in service longer than previously planned.

With more of these older airframes remaining in service than had been planned, these near-legacy aircraft are less likely to be equipped with capabilities meeting current airspace operational requirements or maintaining interoperability with the newest aircraft in the fleet. Additionally, these aircraft may have avionics that are nearing the end of their useful economic life, with maintenance becoming ever more expensive. This means that the industry will need to respond to aftermarket demand for retrofitting these aircraft with more modern technology.

# Supplier investment in OEM constructor programs

Another trend, is the increasing demand by OEM constructors to require a greater investment by key suppliers in the development and evolution of aircraft programs. Significant investment, buy-in, or risk sharing by these key partners result in a lengthier payback period for the suppliers. Where prior aircraft programs allowed for a payback period that spanned the first x-hundred aircraft, the payback period is now extended, perhaps, by 10-fold.

While suppliers benefit from an entrenched position, OEM constructors capitalize on these positions by demanding greater investments, de-escalation in prices and expectations of “free” upgrades to existing products in exchange for production continuity for the suppliers.

# SFE/BFE

Another method used by OEM constructors to reduce costs and to streamline supply chain complexity is to reduce the number of options available to aircraft purchasers. This has led to an increase in the relative percentage of Seller Furnished Equipment (SFE) supplied with aircraft on delivery

Previously, operators were given options to furnish avionics sourced directly from the operator’s supply chain. “Buyer Furnished Equipment” (BFE) options are becoming less prevalent as OEM constructors look to reduce the costs of certification and management of providing these options.

# Greater standardization in the cockpit/avionics

Further, OEM constructors are moving to greater standardization of avionics. This is driven by both supply chain and inventory savings and the greater integration of avionics by the system suppliers. The avionics OEMs have increased integration of their own products to increase their share of avionics real estate and to further enhance their own positions by warding off the availability of avionics component options for other sub-tier suppliers. If an avionic OEM tightly integrates, say, a radio function with the complete cockpit system, opportunities to supply an alternative radio function by different supplier vanishes.

# Tightly coupled avionics and other systems and components

Greater integration of avionics into complete cockpit system increases the span of products provided by single avionics suppliers. For example, autopilot functions are now supplied by the cockpit system supplier rather than being part of the basic aircraft. This simplifies the job of the avionics OEM and further solidifies their supply chain position. At the other end, sensors (pitot static, inertial, radio) functions are in-drawn by the avionics OEM to complete their system.

This is clearly seen in the business aircraft segment as exemplified by the Garmin G1000, G3000 and G5000 systems, and the trend extends to commercial aircraft and helicopters as well, with Honeywell, Thales, Collins Aerospace and other OEMS offering integrated cockpits bound to particular aircraft types. This is a way for avionics OEMs to increase their content and to spread their risk-sharing across a greater number of individual components.

# Business Aircraft Technology/Market Trends

Similar to the commercial aircraft constructors, business aircraft OEMs are requiring similar risk-sharing partnerships from their avionics supply chain. These demands coincide with a goal of reducing the certification risk of offering multiple avionics options and to shift this burden to a single supplier for each given aircraft program.

The tempo of business aircraft programs is considerably faster than the development of commercial aircraft programs. As commercial OEM constructors strive to maintain commonality with prior aircraft series to assist operators in managing training costs, business aircraft OEMs are less burdened by this requirement. For example, Gulfstream has launched XX new aircraft programs (G600, G700, G800) in the last ten years. Textron Aerospace (Cessna, Beechcraft) have unveiled YY new aircraft programs (Latitude, Longitude, Denali, …)

Avionics systems commonality across aircraft models reduces costs for the OEM constructor, but differentiation of features and benefits distinguishes the capabilities of specific aircraft types. So, often capability differentiation occurs between aircraft models rather than options within a particular aircraft type.

In the business aircraft models then, bespoke interiors, enhanced passenger connectivity and passenger amenities are options available to the purchaser without changing cockpit avionics standardization.

The overall complexion of the avionics OEM supplier base is dominated by fewer major players. Often, the popularity of the supplier base goes through cycles where the dominance of one OEM changes. Currently, Garmin (G1000, G3000, G5000), Collins (Pro Line, Pro Line Fusion), Honeywell (Epic, PlaneView, EASy) are the major suppliers.

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| **Very-light jets** | |
| Cessna Citation Mustang | Garmin G1000 |
| HondaJet HA-420 | Garmin G3000 |
| Cirrus G2+ Vision Jet | Garmin Perspective Touch™ |
| **Light jets** | |
| Cessna Citation M2 Gen2 | Garmin G3000 |
| Cessna Citation CJ4+ | Collins Pro Line 21 |
| Embraer Phenom 300E | Garmin Prodigy Touch® |
| Pilatus PC-24 | Honeywell Epic 2.0 ACE |
| **Midsize jets** | |
| Embraer Praetor 500 | Collins Pro Line Fusion® |
| Citation Latitude | Garmin G5000 |
| **Super-midsize jets** | |
| Cessna Citation Longitude | Garmin G5000 |
| Bombardier Challenger 3500 | Collins Pro Line Fusion® |
| Dassault Falcon 2000LXS | Dassault (Honeywell Primus Epic) EASy |
| **Heavy jets** | |
| Dassault Falcon 8x | Dassault (Honeywell Primus Epic) EASy IV |
| Gulfstream G700 | Gulfstream (Honeywell) Symmetry Flight Deck |

# Upcoming enablers for aftermarket equipage growth

Continual evolution of equipage and operational capabilities in commercial and business aircraft has been the norm from the early days of civil aviation. This evolution process can be triggered for a number of reasons, primarily:

* New technology mandates
* Aircraft lifecycle extensions
* Operational improvements
* Safety improvements
* Efficiency improvements

In general, mandates are the most reliable to predict and the least difficult for decision-makers, since all users of regulated airspaces must play by the same rules. The other stimuli for aircraft upgrades tend to be basically economically driven, so these types of changes need to be cost-effective and cost-justifiable.

Currently, there are several market and operational drivers which are anticipated to drive aftermarket changes in the near future:

1. Performance Based Navigation
2. Controller Pilot Data Link Communication
3. Avoidance of GPS Spoofing
4. Single Pilot Cargo Operations

## Performance Based Navigation (PBN)

Performance Based Navigation, according to ICAO Doc 9613, Performance-based Navigation (PBN) Manual, 2008, “ICAO performance-based navigation (PBN) specifies that aircraft required navigation performance (RNP) and area navigation (RNAV) systems performance requirements be defined in terms of accuracy, integrity, availability, continuity, and functionality required for the proposed operations in the context of a particular airspace, when supported by the appropriate navigation infrastructure”.

Simply stated, this means that an aircraft must be able to successfully navigate, and most importantly, successfully avoid conflict with other aircraft operating in the same airspace. The world’s Air Navigation Service Providers (ANSPs) have been advancing the technical state of the art on this subject for decades, incrementally reducing allowed separation between aircraft as sensor, guidance and flight control technology has advanced. This has allowed ANSPs to move, in a stepwise manner, away from a static sensor-based airspace management strategy toward a more dynamic use of available airspace, in order to support more traffic in the same physical volume while adapting to changes in the volumes and needs of traffic on an ongoing basis. The enabler for this evolution has been the deployment of global navigation satellite system (GNSS) equipment supporting position determination independent of ground-based sensors such as radar.

The original GNSS, the US Global Positioning System (GPS), was thus the first essential technology for development of PBN. GNSS systems are now evolving with deployment of satellite-based augmentation systems (SBAS), ground-based augmentation systems (GBAS) and ground-based regional augmentation systems (GBAS), while the introduction of Galileo and the modernization of the US GPS and the Russian Global Navigation Satellite System (GLONASS) will further improve GNSS performance. Similarly capable GNSS constellations are now being deployed in other parts of the world, including China and India.

In terms of avionics systems, apart from the GNSS sensors themselves, a number of aircraft avionics systems are involved, including navigational sensors, flight displays, flight management and guidance computers and related avionics systems. Recently manufactured aircraft, both commercial air transport and business aircraft, are generally well equipped for PBN operations, however, a significant upgrade strategy is expected for unplanned older aircraft that are now being retained in service.

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## CPDLC

Controller–pilot data link communication (CPDLC) supports data link communication between controller and pilot, supplementing and eventually replacing controller/pilot voice communication.

This service comprises clearance/information/request message elements derived from the voice-based practices currently employed by air traffic control procedures. The controller can issue level assignments, crossing constraints, lateral deviations, route changes and clearances, speed assignments, radio frequency assignments, and various requests for information. The pilot can then in turn respond to messages, to request clearances and information, to report information, and to declare/rescind an emergency. The pilot is, in addition, provided can request conditional clearances (downstream) and information from a downstream air traffic service unit (ATSU). A “texting” capability (resembling that of smartphones) is also provided to exchange information not conforming to defined formats. The controlling Air Traffic Services Unit can forward a CPDLC message to another Air Traffic Services Unit, typically the ATSU that is expected to receive the flight after handover.

CPDLC has been envisaged for several decades, with limited operational deployment, but has finally received…

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* 1. PM CPDLC
  2. North American experience
  3. European requirements

## GPS Spoofing

* 1. Largely ignored until…
  2. Look at what is happening!
  3. Solutions?

## Single pilot cargo operations

# Issue awaiting a solution – Clear Air Turbulence detection

Within the commercial aviation sector, clear air turbulence (CAT) events represent the single largest source of injury and claims exclusive of takeoff and landing incidents. Avoidance of airspace where CAT has been reported results in non-optimal flight altitudes, speeds, and routing resulting in additional direct operating costs.

The development of a reliable CAT sensor could provide an airborne indication and mapping of CAT regions allowing minimum diversion trajectories and rapid resumption of the planned flight path once the region of CAT is no longer a concern to the flight crew.

Several technologies offer possible paths of inquiry including lidar, infrared radar, RF detection of electromagnetic signatures in areas of convective activity, and ground-mounted microphones that pick up ultralow-frequency sound waves produced by clear-air turbulence, among others.

A viable solution could lead to fitment requirement for airborne solutions or ground-based sensor for terrestrial system.

# Electronic Flight Bags

Electronic Flight Bags (EFBs) provide a platform to add information and functionality to aid the flight crew without altering the avionics and certification of the aircraft. Initially, EFBs were contemplated as a way of reducing the amount of paper required in the cockpit. Approach charts (Jepp Charts), flight manuals, weather data and other information.

EFBs are divided into two broad categories: personal electronic devices (PEDs) such as iPads or tablets, and devices that can receive information from the aircraft avionics. The later are fixed installations (B787 for example) and the former are placed in mounts that allow for easy installation and removal.

# B737 Max Influence on Certification

The MCAS issues with the Boeing 737 MAX program have illuminated significant issues with the FAA oversight of aircraft certification. The FAA delegates significant authority to entities such as engineering organizations, certification consultants and manufacturers.

The B737 MAX problems illustrate the risks when there is insufficient oversight by the FAA of the manufacturer’s self-certification processes. However, the FAA lacks sufficient human resources to fulfill the certification needs for OEM constructors, avionics certification, and STC development.

Some level of external certification delegation will certainly be retained, but an over-reaction by the FAA may stymie certification throughput in the near-term.

# Military Procurement

# Supplier upgrade programs