CANSO

EDUCATED GUESS

Interpreting traffic forecasting during the pandemic

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Contents

Synopsis

As the saying by George E.P. Box goes "all models are wrong, but some are useful". The severe impact of COVID-19 on aviation has led to a situation where traditional traffic forecasts are no longer valid.

In order to provide Air Navigation Service Providers (ANSPs) with a sense of what products are currently available, how they might be used by ANSPs and when longer term forecasts may be available, this paper provides a high-level overview of the current state of traffic forecasting.

Part A: Traditional forecasts	Considers the range of products normally available to support short-, medium- and long-term planning.
Part B: Forecasting during COVID-19	Provides an analysis of the products currently being made publicly available and how they can be used by ANSPs.
Part C: Forecasting post COVID-19	Looks at when ANSPs may be able to rely on a range of forecasting products once again, and how forecasting techniques might need to evolve.

It is clear that a lack of medium-term forecasts is a significant hindrance to the financial and capacity planning required to enable ANSPs to successfully navigate the current crisis. It may be some time after the pandemic before medium term forecasting is reliable again.

Acknowledgements

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Introduction

Understanding demand is critical to the cost-efficient delivery of capacity. ANSPs need accurate information on demand to plan staffing, capacity enhancements and revenues. They need information for the current day (sectorisation), for the next weeks (staff rostering) and months (staff levels) and years (calculation of revenues, need for additional capacity). This information is drawn from filed flight plans, airline schedules as well as short (1 year), medium (3 to 7 years) and long term (10+ years) traffic forecasts.

The COVID-19 crisis has led to an unprecedented fall in demand. The impact of COVID-19 is different to other crises that have affected aviation:

- Previous natural disasters, such as the Eyjafjallajökull volcano crisis of 2010, have caused severe short term, largely regional reductions with quick rebounds. Extant traffic forecasts remained valid after the event.
- Economic crises have caused moderate falls in traffic with a slow return to previous traffic levels. For example, following the 2008 financial crisis it took 10 years for traffic to recover. Whilst forecast models required recalibration, the forecasting methodologies remained largely valid, and sufficiently accurate forecasts were always available.
- Terrorist attacks or war have sometimes resulted in severe drops in traffic for periods of time within specific regions, with return of traffic once traffic restrictions were lifted and passenger confidence regarding safety returned.
- Previous pandemics have had severe but short impacts on traffic. The SARS outbreak in 2003 was the most serious in terms of impact on traffic volumes prior to COVID-19. At the height of the outbreak (May 2003), monthly Revenue Passenger Kilometres (RPKs) flown by Asia-Pacific airlines were 35% lower than their pre-crisis levels. Overall, in 2003, the loss of confidence and fears of global spread impacted both business and leisure travel to, from and within the region, resulting in Asia-Pacific airlines losing 8% of annual RPKs and $6 billion of revenues.

COVID-19 is different. The impact of COVID-19 is more severe – both in the level and duration of the disruption. It is a truly global and sustained event whose travel and economic impact will be felt for years. Furthermore, the pandemic has driven changes to consumer behaviour and business practices that fit no previous models, suggesting that the long-term impact of COVID on society in general and aviation in particular is not clear. As a result, the practice of forecasting has been upended and the traditional traffic forecasts available to ANSPs for planning are no longer valid.

In order to provide ANSPs with a sense of what products are currently available and when longer term forecasts may be available this paper provides a high-level overview of the current state of traffic forecasting.

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Part A: Traditional forecasts

Roles of forecasting

States, air navigation service providers, airports, airlines, aircraft manufacturers, suppliers, and other relevant aviation organisations all rely on air traffic forecasts to support accurate planning and resource allocation. For example, accurate traffic forecasts:

- Assist states in facilitating the orderly development of Civil aviation
- Assist in the process of planning for necessary airspace and airport infrastructure and staffing (air traffic control, airport terminal facilities and operations, access roads, runways, taxiways, etc.)
- Assist airlines in the short, medium, and long-term planning of equipment, crew, and route structures
- Assist aircraft manufacturers in understanding potential customer needs and planning for the introduction of new models.

ANSPs in particular are dependent on accurate forecasts to support many critical decisions, both on the day of operation and a decade into the future. To support these decisions, ANSPs relay on a variety of products – some developed in-house and others from public sources.

Use	Planning Horizon	Data Sources
ATFM Solutions Planning e.g. sectorisation, traffic orientation, ATFM measures	1+ days	Flights Plans
Operational capacity planning e.g. rostering	1+ weeks	Schedules
Staff planning	3+ years	Short Term Forecast
Financial planning	5+ years	Medium Term Forecast
Capacity planning	10+ years	Long term Forecast

Table 1 – ANSP planning dependencies

In Europe, medium term forecasts have a particular importance as they are central part of the European Union's "Performance Scheme.

1 https://www.boeing.com/commercial/market/commercial-market-outlook/

Available forecasts

Based on the time horizon, there are generally three types of forecasts[1]:

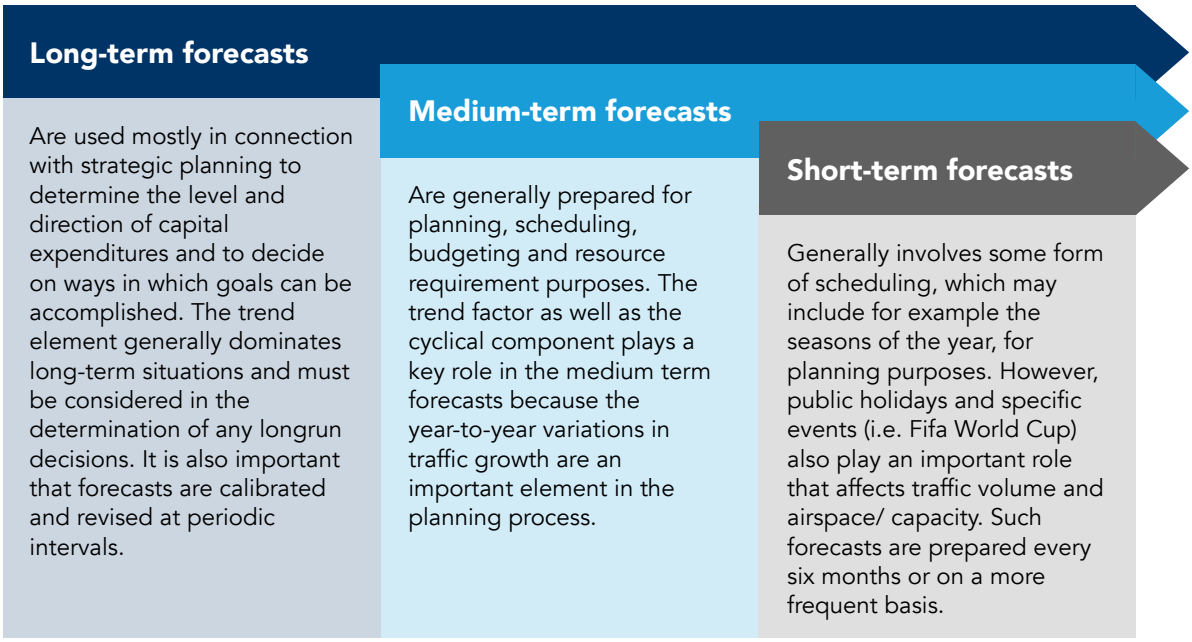


Figure 1 – Types of forecasts

Each forecast is based on a specific forecasting method – which can be divided into three broad categories[2]:

Quantitative	Mathematical model, heavily reliant on historical data and trends.
Qualitative	Judgmental, reliant on the judgement of experts and may be used to predict a significant change in historical patterns.
Decision analysis	Combination of the first two methods.

Table 2 – Forecasting methods

Depending on the scope and intended customer, forecasters develop their own specific methodologies which combine traditional methods and techniques (details in Annex 1) with further intelligence gathered from relevant data sources. These forecasting methodologies are constantly refined to improve accuracy.

Forecasters decide on the methodology to be used based on required output. Their consumers are interested in various information as they will use it for different reasons. For example, while airlines are mainly interested in the number of passengers, airports look at number of ground movements too, and ANSPs need to know the estimated number of flights they will have to control in order to ensure appropriate resource allocation.

So, each forecast provider uses a combination of methods and techniques depending on the scope, period, and data sources available to build their own specific and vigorous methodology. To further improve accuracy, all forecasts are based on a set of key assumptions which need to accompany the relevant forecast presentation.

Several forecasts are developed on a systemic basis and made available to the aviation community either for free or by subscription. Table 3 provides a summary of the key products. In addition, industry forecasts published by Boeing and Airbus provide insight in to the evolution of the commercial aircraft fleet.

2 https://www.airbus.com/aircraft/market/global-market-forecast.html

Forecaster	Forecast Type	Period	Updated	Last Published	Metric	Scope	Availability
ICAO	Mid-term	5 years	Yearly	December 2020	• PKP • FTK	Global / Regional / States	Public [3]
	Long-term	20 years	Biennially or Triennially	April 2018	• RPK • Growth	Global / Regional / States	Public [4]
IATA	Long-term	20 years	Biennially	April 2020	• Passenger numbers	Global / Regional / States	Subscription
ACI	Long-term	>20 years	Yearly	2019	• Passenger numbers • Aircraft movements	Global / Regional / States	Subscription
EUROCONTROL	Short-term	2 years	Monthly	Live	• Flight Movements • Service Units • Growth	EU / FAB / States	Public [5]
	Mid-term	7 years	Twice Yearly	October 2019	• Flights • Service Units	EU / FAB / States	Public [6]
	Long-term	20 years	3 to 5 years	September 2018	• Flights • Service Units	EU / FAB / States	Public [7]
FAA	Long-term	20 years	Yearly	July 2020	• Flights • ASM/ RPM • Passenger Enplanements	Regional / States	Public [8]
	Terminal Area Forecast	5 years	Yearly	2019	• Passenger Enplanements • Total Operations	Regional / States	Public [9]

Table 3 – Traditional Forecasts

Note: Depending on the provider, the forecasted aircraft movements/RPK may not include overflights, which may affect their utility for ANSPs who manage upper airspace. ANSPs may use trend and growth from these sources as guidelines and comparison to crosscheck if their own forecast is in line with the global/regional picture.

Part B: Forecasting during COVID-19

Who has been forecasting what, when?

In March 2020 it quickly became clear that existing traffic forecasts were no longer valid. Traditional forecasters stopped providing regular updates and started to publish "recovery scenarios". This section looks at the available products and how well they are performing given the challenges in the current environment.

Figure 2 illustrates the timeline of published forecasting information in 2020, showing that IATA led the way with their initial COVID-19 Impact assessment[9], quickly followed by the International Civil Aviation Organization (ICAO)[10]. Meanwhile, EUROCONTROL had a more conservative approach and only published their short-term traffic outlook one month later than the global forecast providers[11]. It is also worth noting that both the FAA and EUROCONTROL present weekly figures on actual traffic[3] which support an understanding of short-term trends.

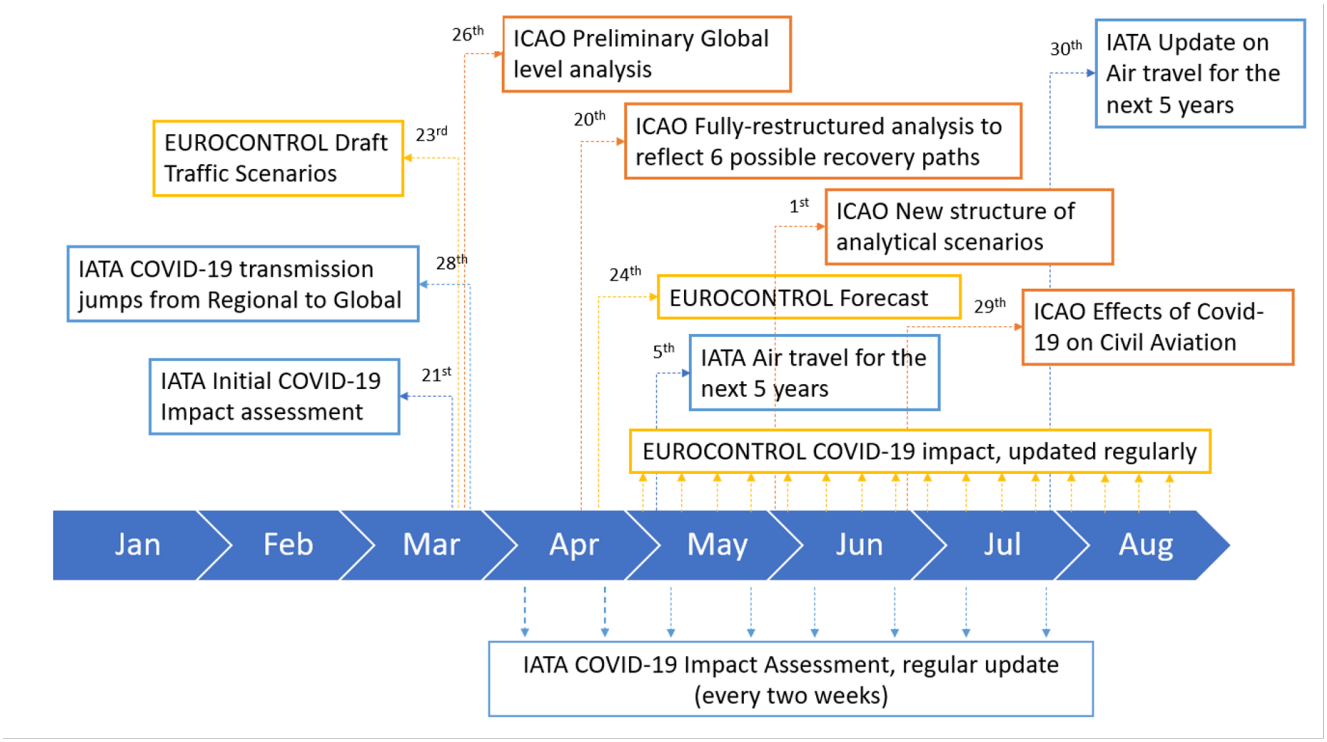


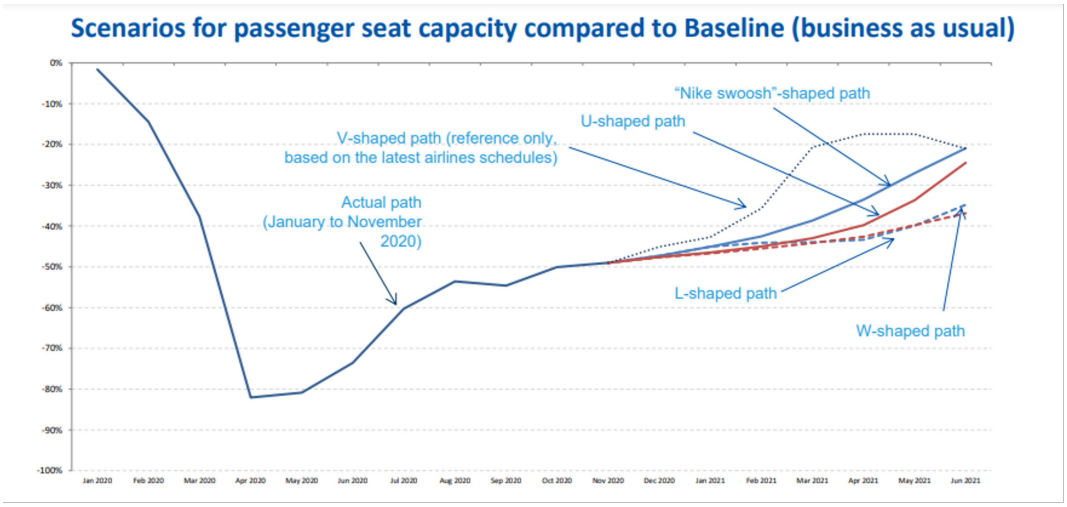
Figure 2 – Forecasting information timeline in beginning of the pandemic

The change in the frequency of updates highlights the high-level uncertainty within the forecasts [14, 15, 16, 17, 18, and 19]. The key products are summarised on the following pages.

3 For example: https://www.eurocontrol.int/covid19

ICAO

https://www.icao.int/sustainability/Documents/Covid-19/ICAO_coronavirus_Econ_Impact.pdf



Latest Publication	30 December 2020	**Scope**	Global, 2020 – June 2021
Publication	Effects of Novel Coronavirus (COVID-19) on Civil Aviation: Economic Impact Analysis [20]	**Value**	PSK

Scenarios

As overall severity and duration of the COVID-19 pandemic are still uncertain, four (4) different recovery paths under two (2) indicative scenarios are developed:

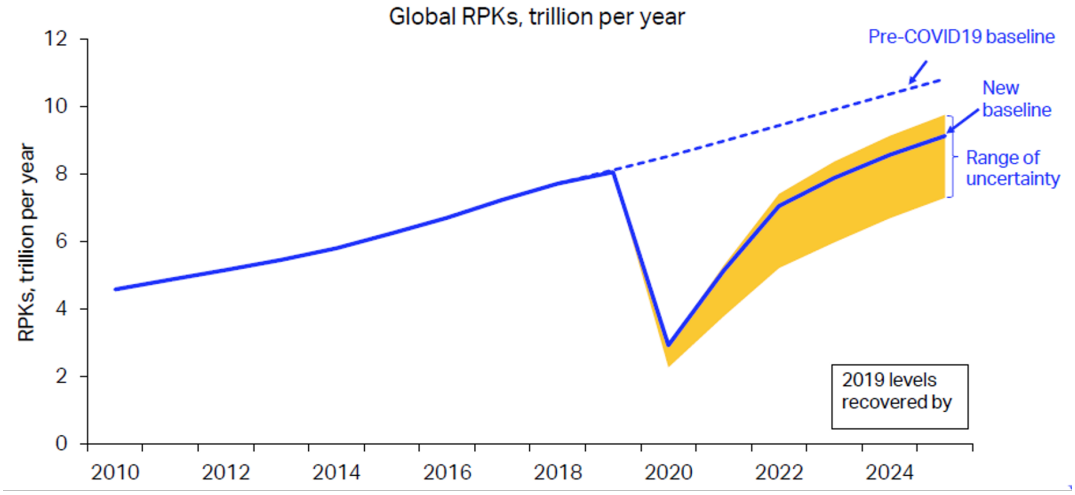
- Baseline: counterfactual scenario, in which the COVID-19 pandemic does not occur, that is, originally planned or business as usual
- Scenario 1: two (2) different paths (like Nike swoosh – and W-shaped)
- Scenario 2: two (2) different paths (like U- and L-shaped)
- Reference: information only, based on latest airline schedules (like V-shaped)

Underlying Assumptions

- International and domestic passenger traffic has separate scenarios/paths
- Scenarios/paths are differentiated in terms of supply and demand, i.e.
  - Scale of output or seat capacity change
  - Degree of consumer confidence that can be translated into demand or load factor as a proxy
- Supply and demand are influenced by:
  - Different timing and speed of recovery by region, international/ domestic, and intra-/inter-region
  - Global economic contraction
- No consideration is made to social distancing requirements on aircraft, etc.

IATA

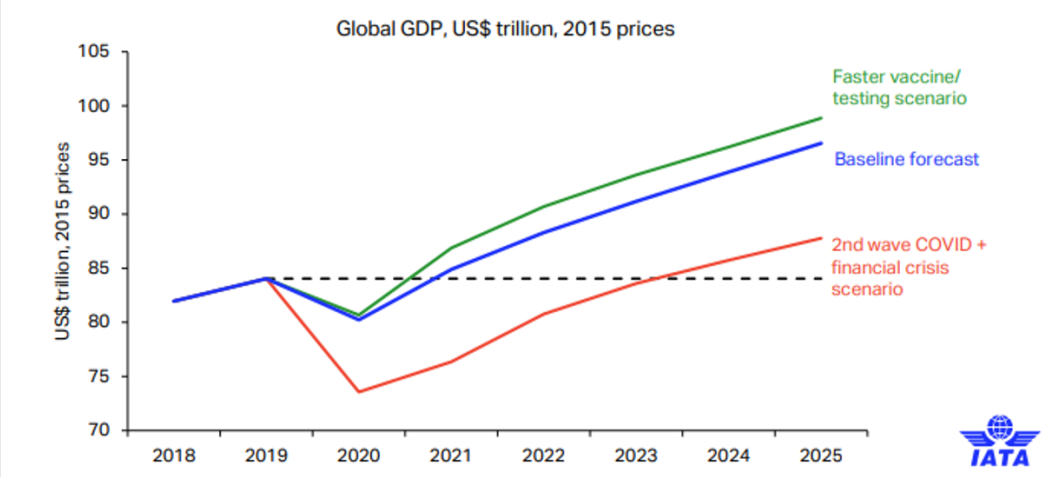
https://www.iata.org/en/iata-repository/publications/economic-reports/june-data-and-revised-air-travel-outlook/



Latest Publication	28th July 2020	**Scope**	Global, 2010-2025
Publication	COVID-19 June data and revised air travel outlook [21]	**Value**	RPK

Scenarios

The outlook for global GDP could take different paths and therefore IATA is exploring optimistic and pessimistic scenarios for the economy as below:

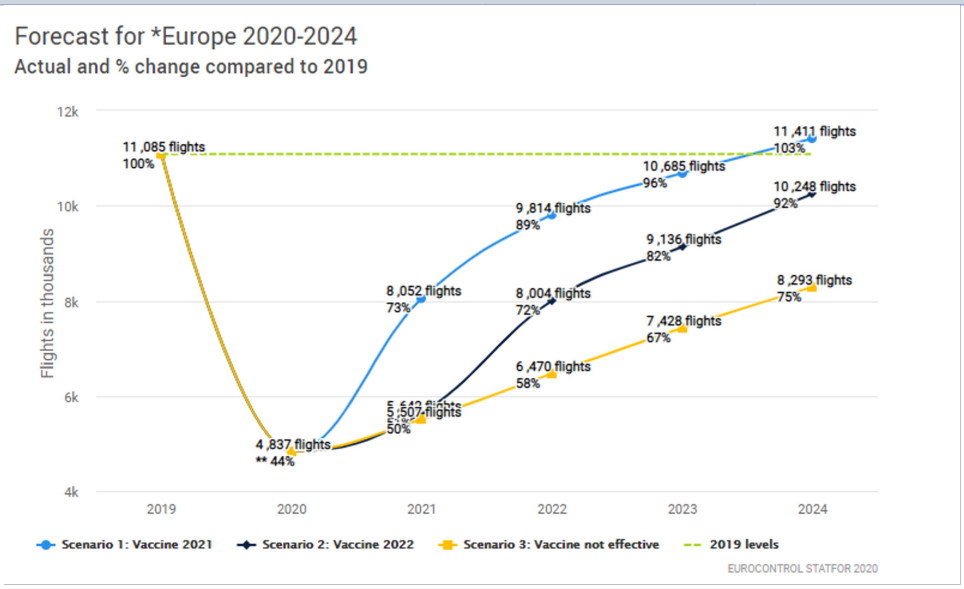


Underlying Assumptions

- Pandemic will gradually be contained and there will not be a second wave of COVID cases.
- Cautious behaviour of travellers will continue to affect travel demand at the start of 2021 and the recovery in business travel will come with a lag.
- The impact of COVID-19 on the global economy will be severe. Global GDP growth is expected to contract by 5.0% in 2020.
- COVID-19 will have a significant impact on international trade (13% decline) which has been suffering from the US-China trade war.
- 2020 will be the worst year in history for airlines (net loss of $84.3bn) and losses will continue in 2021, albeit to a lesser extent.
- Airlines in all regions are expected to record negative operating income in 2020.
- Revenues are expected to fall by more than demand as airlines are significantly discounting ticket prices to help stimulate travel.

EUROCONTROL

https://www.eurocontrol.int/forecasting

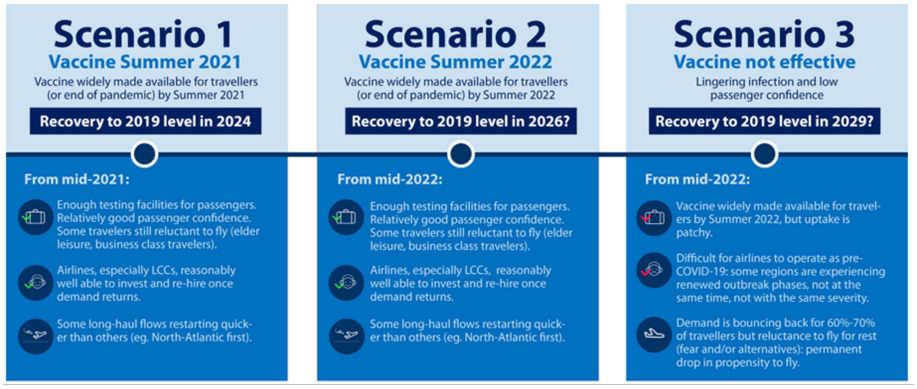


Latest Publication	November 2020	**Scope**	Regional (EU), 2020 – 2024
Publication	EUROCONTROL Five-Year Forecast 2020-2024 [27]	**Value**	Number of flights (%)

Scenarios

The 5 year forecast references 3 separate scenarios considering all possible risks and their relative impacts as follows:

- **Scenario 1 – Vaccine Summer 2021**
  Vaccine widely made available for travellers (or end of pandemic) by Summer 2021, with traffic only returning to 2019 levels by 2024.
- **Scenario 2 – Vaccine Summer 2022**
  Vaccine widely made available for travellers (or end of pandemic) by Summer 2022, with traffic only returning to 2019 levels by 2026.
- **Scenario 3 – Vaccine not effective**
  Lingering infection and low passenger confidence, with traffic only returning to 2019 levels by 2029.



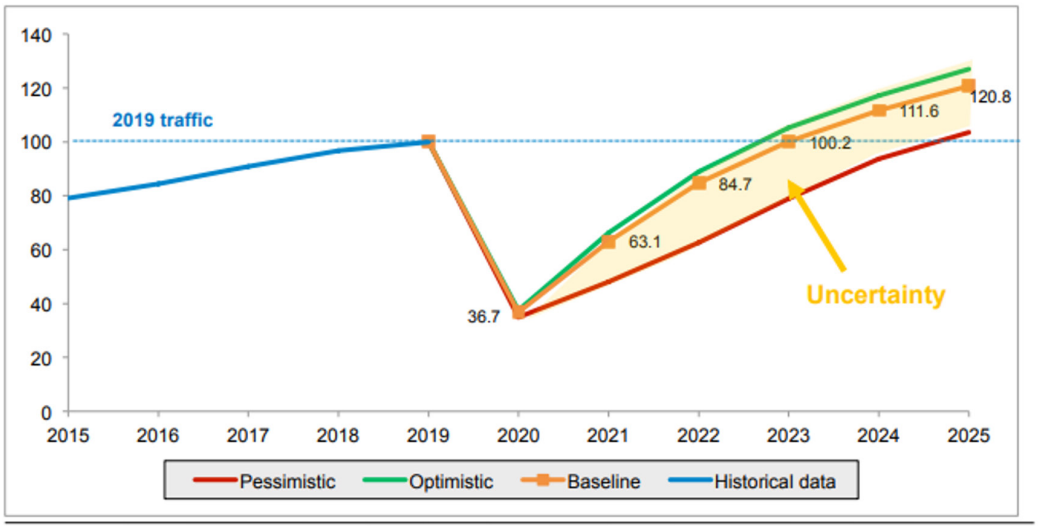
Underlying Assumptions

- Recovery is strongly dependent on how soon an effective vaccine is made widely available and by levels of public confidence
- Uses 23 October 2020 Oxford Economics Economic Forecast Cumulative Change in GDP growth
- Continued transport connectivity will be ensured post Brexit

ACI

https://aci.aero/wp-content/uploads/2020/12/Advisory_Bulletin_The_impact_of_COVID_19_on_the_airport_business.pdf

Chart 3: Short-term global passenger traffic projection (indexed, 2019 = 100)



* The business-as-usual (BAU) forecast represents the comparative baseline and is derived from the adjusted World Airport Traffic Forecasts (WATF) 2019–2040 considering latest insights provided by ACI Regional offices and other inputs.
** Estimated passenger traffic volumes scenarios based on a broad range of inputs provided by ACI Regional offices and industry experts

Source: ACI World

Latest Publication	8 December 2020	**Scope**	Global, 2020
Publication	ACI Advisory Bulletin [23]	**Value**	Number of passengers

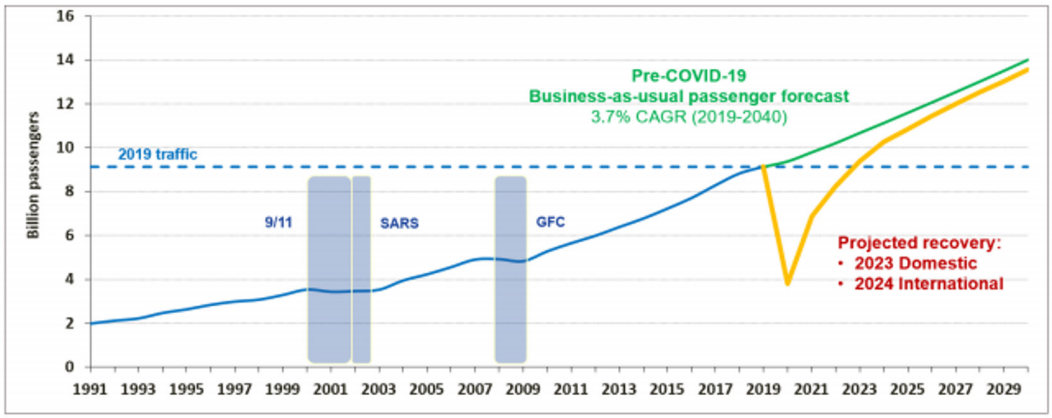
Scenarios

- ACI World estimated the impact of the coronavirus outbreak 2019 (COVID-19) on the airport industry in terms of potential losses in traffic and revenues based primarily on two key data elements: estimated traffic considering the latest COVID-19 statistics and unit revenues derived from the Airport Key Performance Indicators 2020, as total airport revenues are largely a function of traffic, while unit revenues have remained stable in recent years.
- Traffic estimates for Q1 2020 were generated using data collected by ACI World from airports for that period.
- The impact has been measured as a difference between the "business as usual scenario" (BAU) for Q1 2020 as well as year-end 2020 and the "COVID-19 scenario" with estimated traffic and revenues for Q1 2020 and year-end 2020, on a regional basis.
- The Q1 2020 traffic estimates, and hence the revenue figures, consider the seasonality patterns for the year 2019 calculated on a regional basis.
- The business-as-usual (BAU) forecast for 2020 represents the comparative baseline and is derived from the adjusted World Airport Traffic Forecasts (WATF) 2019–2040 considering latest insights provided by ACI Regional offices and other inputs. The BAU baseline represents a 3% growth in passenger traffic.
- The impact of COVID-19 on passenger traffic for year-end 2020 was estimated under the assumption that most containment measures and flight restrictions will be lifted by the end of summer 2020. This implies a difficult second quarter for the aviation industry, with a partial recovery in Q3 and Q4. However, the impact on passenger traffic is assumed to be long lasting, implying a slow and steady recovery possibly spanning far beyond the end of 2020.

Underlying Assumptions

Note: ACI included a forecast out to 2040 predicting that global traffic may take up to two decades to return to previously projected levels and cautioning that a structural change (in which traffic will never return to pre-COVID-19 forecasted level) is still a possibility.

Chart 4: Long-term global passenger traffic evolution until 2040 (in billion passengers)



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** Estimated passenger traffic volumes scenarios based on a broad range of inputs provided by ACI Regional offices and industry experts

Source: ACI World

How good were the forecasts?

The different forecasts use different parameters and underlying assumptions but tend to have similar looking predictions – suggesting a common bias based around airline expectations. To compare the products, a numerical comparison was undertaken. The full results, methodology and references can be found in Annex 2: Analysis of 2020 Forecasts.

COVID-19 has disrupted many data sources that feed traffic forecasts – including industry schedules, airline operations, airline fleets, aircraft seat capacity and industry traffic and fares. This means that many of the assumptions used to create forecasts no longer hold.

This is best illustrated by considering observed changes in airline behaviour during the pandemic.

Pre-COVID-19	**Post-COVID-19**
• Airlines published their schedules 6-11 months in advance • Schedule changes inside 4 months of departure were minor • Once crew assignments were in place, only day-of-departure operational issues would cause a flight cancellation • Airlines flew 98+% of their published schedule	• Airlines are waiting 4-8 weeks prior to departure • Changes are happening 1 to 2 weeks before departure, some cases days out • Cancellations are now happening 1 to 2 days out, for non-operational reasons

Table 4: Changes in airline behaviour during pandemic[4]

But the real issue affecting the accuracy of forecasts is the progress of the pandemic itself and States responses to growing numbers of cases and the emergency of new variants. Aviation forecasts are able to track positive plans of airlines to grow demand but can't predict when local flare ups in COVID-19 create tighter restrictions.

4 Source: Adapted from: https://www.cirium.com/thoughtcloud/aviation-data-quality-pandemic-forecasting/

How can ANSPs use the available forecasts?

Given the difficulty in developing accurate forecasts in the current climate, ANSPs should consult these products with caution, carefully assess underlying assumptions and use them as a trend guideline rather than a reliable data source. To minimise the potential eronous or misleading information, ANSPs should aim to identify more direct local data to support decision-making.

Sensible caveats for use of the current forecast products incude:

- Current forecasts should serve as a cross-check and ANSPs should try to focus on the specific sections that may apply to them;
- Identify which of the curves (e.g. W, U, L, etc.) might apply to each ANSP based on alternative available information (local passenger surveys, state masures, COVID-19 rates, etc.);
- Due to the rapid rate of change of external factors through 2020, ANSPs should recheck the available forecasts on a weekly basis to make sure no major changes are introduced and ensure continuous alignment between different data streams;
- Planning ahead process should be adapted to account for spontaneous changes and forecasts should be trusted for short-term outlooks rather than drive medium-term strategic decisions;
- ANSPs should note that some of the metrics provided may not be available in terms of traffic movements and may not account for overflights.

How can ANSPs produce local forecasts during COVID-19?

There are many factors out of industry's control and making it necessary to identify new techniques and strategies to understand the limits and sensitivity of forecasts, including the following techniques:

- ANSPs should think about providing separate forecasts for domestic and international flights (and/or overflights), which may be effected by travel restrictions and national passenger behaviour.
- For international flights, segregating city-pair traffic (routes or major flows) will allow ANSPs to forecast according to travel restrictions.
- ANSPs should liaise with key stakeholders that are leading the state vaccine deployment strategy in order to understand how to treat scenarios and refine them based on availability of vaccines. This should then be factored into determining how much of the traffic would increase/decrease due to each scenario.
- Flight schedules (seasonal slot allocation and other sources such as OAG & Innovata) can still be used for forecasting, but realiability drops significantly. To mitigate the variation due to last minute cancellations and change in flight scedules, a regional intelligence driven approach should be considered. For example, EUROCONTROL managed to provide more reliable traffic forecasts than most regional forecaters by coordinating well with airlines directly and not relying on the traditional sources.

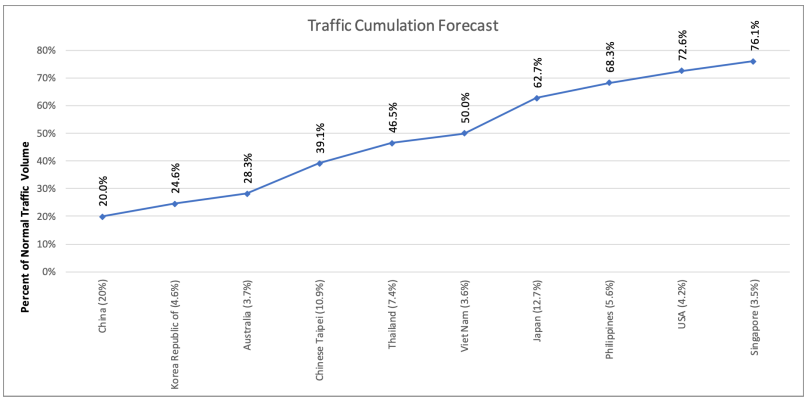
Alternatively, ANSPs may develop alternative approaches to forecasting during the pandemic. A promising approach developed by METRON is described in the table below.

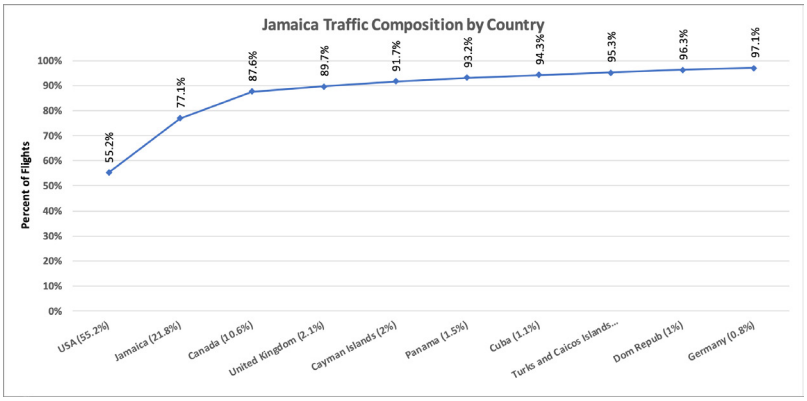
METRON Approach to forecasting impact of COVID-19

The METRON approach was developed to support regional State level forecasts based on examination of historical traffic and travel constraints imposed by States. METRON has published regular updates for CANSO meetings and works with specific ANSPs.

The main assumptions are:

- Use of a V-shaped recovery – specifically, traffic demand will resume if and when State authorities allow it.
- Provision of upper and lower envelopes around itsforecast (best-case and worst-case scenarios).
- Forecast the rate at which traffic will rebound, and where it would be coming from but without placing time values on exactly when the rebound occurs, except that:
  - Countries/territories with more rapid COVID recovery will accept/send traffic sooner which determines the ordering on the horizontal axis (see graph below).
- Forecast suggests a steady traffic growth, rather than a surge, as countries/territories resume traffic.
- Timing of how long this will take is difficult to determine and METRON continues to refine its approach





Rationale:

- Global forecasts may not reflect upcoming trends for a given ANSP – hence a need to decompose traffic forecasts and recent trends by specific country or region.
- In the long run, traffic demand composition (i.e., contribution from other countries or regions) will be inclined to restore itself to pre-COVID conditions, though it is a question of timing – which ones will restore first, and by how much.
- Traffic demand is largely driven by the following factors:
  - Rate at which airlines can resume operations, which is often faster and more ambitious than what States will allow.
  - OAG largely reflects airline intentions, but must be tempered with recent airline tendencies to over/under schedule, then adjust.
  - Number of new COVID cases in each country or region. In turn, this will dictate the rate at which each State authority will allow travel to/from other countries or regions.

Part C: Forecasting post-COVID-19

The ongoing second wave in COVID-19 cases, the emergence of new strains and subsequent reestablishment of flight restrictions highlights the lack of stability with the current forecasts. It is clear that accurate medium-term forecasts will not be available in the short-term.

So the critical question remains: when will the industry enjoy the wealth of products previously available? The answer has three elements:

- When will traditional models be valid?
- How will traditional models need to be recalibrated?
- How much traffic will have been lost?

When will traditional models be valid?

It is clear that demand remains severely curtailed by the coronavirus and in particular travel restrictions imposed by states. "Business as usual" is dependent on:

Factor	Risk	Potential Impact
Availability and Effectiveness of Vaccine	The approval and availability of vaccines will dictate the pace of aviation recovery. With vaccine deployment underway, there is renewed hope that normal life will return in Spring/Summer 2021, although there is some uncertainty about the effectiveness of vaccines against new variants.	High
State Travel Restrictions	As vaccination rates climb, States will lift travel restrictions as the local population gets covered. If the vaccine is available only in a limited number of countries, there is a possibility that quarantine or travel restrictions may remain for an extended period.	Medium
COVID-19 Constraints limiting Airport Capacity	The aviation infrastructure is not designed for operating with social distancing – new capacity constraints (e.g. queueing capacity at airports) may become apparent as traffic returns to more normal level.	Low

Table 5 – Novel factors

At the time of writing, vaccine deployment is underway and spooling up in some countries. Widespread innoculation however remains unlikely before 3rd quarter 2021, suggesting that traditional forecasting models will not be valid before 2022.

How much traffic has been lost?

The following table summarises the current predictions for traffic level at the end of 2020 compared to 2019. IATA has suggested that 2019 traffic may return between 2024 and 2029 depending on the success of vaccination programmes across the world.

Forecaster	Full year 2020	Potential Impact
IATA (RPK) [20]	-66%	2024
ICAO (number of passengers) [21]	-59%	N/A
ACI (number of passengers) [22]	-64.2%	2023
EUROCONTROL (Number of Flights) [28]	-55%	2024 / 2026 / 2029

Table 6 – Recovery forecasts

How will traditional models need to be recalibrated?

We could assume that traditional forecasting models will be used to forecast traffic from 2022 onwards based on unconstrained use of the infrastructure (albeit with more permanent losses of capacity if airports are forced into bankruptcy and airlines are forced to reduce the number of pilots, crews and aircraft to keep their companies afloat). But these forecasts will need a new set of assumptions to take account of the longer-term impacts of COVID-19 – ranging from the loss of GDP (a key factor in most forecast models) to growing awareness of environmental issues and change to public perception of travel – will we continue to use Zoom for our business meetings?

This range of new assumptions required is going to lead to higher uncertainty in the forecasts – which of course leads to the issue of deciding how to cope with high and low scenarios.

Factor	Risk	Potential Impact
Environmental Pressure	Linked to passenger behaviour, environmental consciousness and flight shaming can be factors driving global lifestyle change. This was mostly dormant before COVID-19 but has potentially been accelerated by the pandemic and environmental report showing the benefits of lockdown highlighting human impact on the environment. Furthermore, planes flying half empty may become unacceptable due to environmental impact.	Medium
Economic Impact	GDP projections traditionally play an important role in medium to long term air traffic forecasting. However, the weight of the economic impact might be reduced for a significant period due to remaining concerns of public health safety.	Medium
Business Travel	The need for business travel has been extremely reduced during the pandemic and there is high uncertainty associated to the extent this will be restored in the upcoming years.	Medium
Public Confidence	Public confidence in traveling by air has been significantly impacted. Surveys show that passengers consciousness regarding their intention to return to their usual travel plans has been continuously shifting. As an example, IATA found that a sizeable portion of the surveyed population would wait up to half a year or even a year to return to flying again. But looking at Asia and their experience with domestic traffic recovery, one may argue confidence in flying may not be a decisive factor and would rather be a cumulus of previously discussed factors that will consequently further affect traffic recovery.	Low

But risk mitigations can drive opportunities. Can the aviation industry accelerate the wide implementation of environmental measures and the advent of environmentally friendly technologies such as efficient aircraft or cleaner fuel? Would the traffic downturn during COVID-19 help enable the implementation of some new concepts and technologies? For example, many ANSPs are using this low-traffic period to trial direct routing, Free Route Airspace and CCO/CDO which can all contribute to flying being more efficient and environmentally friendly.

If there is enough advancement in sustainability by the aviation industry itself, it could improve the public's perception and balance against the "flight-shaming" movement.

Conclusions

Traffic Forecasting is a significant undertaking. It is performed globally, regionally, and nationally. Traffic Forecasters use a range of techniques to provide the aviation community with a wealth of different products that really do drive critical decision-making in the industry. They are so important that, even in relatively stable times, forecasting errors can cause significant disruption.

ANSPs are currently relying on limited short-term forecasts, or scenario products, with no real view of the medium term. At the same time decisions are required on how to effectively reduce costs without limiting medium term capacity or damaging long term reform.

It is critical that medium term forecasts are available to prevent short-termism creating long-term structural issues.

The forecasting models will necessarily evolve over time and will be self-correcting – as we move through pandemic recovery, we will learn which modelling assumptions are valid and which are not. Two other novel elements of forecasting that would need to be included are (1) forecasts of how COVID-19 will move through society, as this will, in turn, dictate travel restrictions (or relaxation of) from State authorities, and (2) addition of some more economic modelling, based on past recovery trends for airline industry, and overall economic recoveries.

Annex 1: Forecasting methodologies

Depending on the scope and intended customer, forecasters use methodologies which combine traditional methods and techniques (details below) with further intelligence gathered from relevant data sources. These forecasting methodologies tend to evolve and be refined to continuously improve accuracy [2].

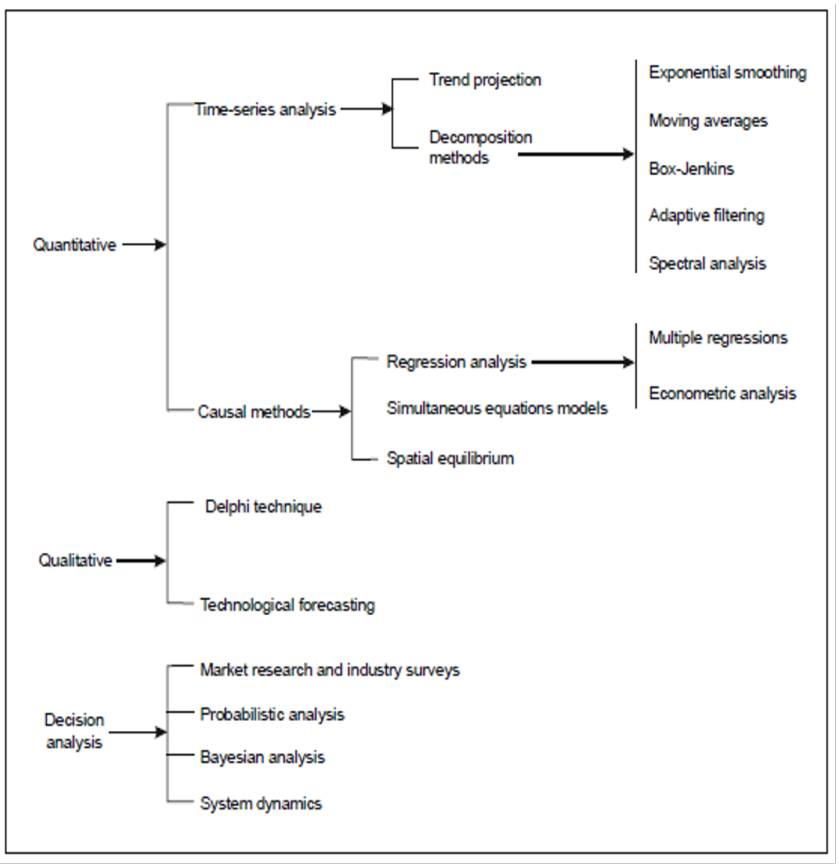


Image 1 – Alternative forecasting techniques

Quantitative forecasting

Quantitative forecasting methodologies rely on historical data and trends. The challenge with this type of forecasting becomes easily apparent as the first two quarters of 2020 have been a break in such trends with little to no previous supporting data. The SARS event in 2003 was initially thought to be an indicator of the type of curve civil aviation might follow on its recovery path, but new levels of complexity must be considered due to the global and fast spread of the virus in a very different socio-economic context.

Data availability

A key initial step in the model-building process is the measurement of the variables chosen for inclusion in the model. As mentioned previously, it may become evident at this stage that certain variables can be rejected due to lack of available data. For some variables, the data may not be directly available in an appropriate form but can be derived from several sources or by careful estimation.

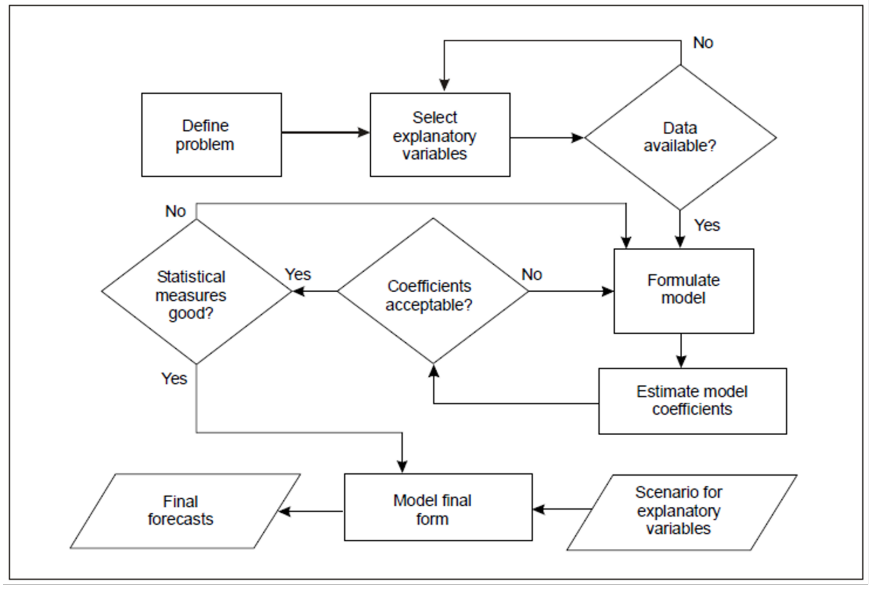
Data for the dependent variables, such as passenger traffic in terms of passengers or RPKs and freight traffic in terms of freight tonnes or Freight Tonnes per Kilometre (FTKs), are normally available from the airline, airport or the State that needs the forecast. They are also normally available in the ICAO statistical databases. This data may be supplemented, as required, using International Air Transport Association (IATA), Airports Council International (ACI) or other sources such

as airline flight schedule data from OAG. Data for the independent or explanatory variables related to airline operating economics are also available from the ICAO databases, supplemented as required, using other sources as mentioned earlier. Data for socio-economic variables and demographics may be available from the publications of the International Monetary Fund (IMF) and the United Nations national accounts and other economic services.

Accurate measurement of the price of air travel is complicated by the various fares that are available. A single measure of price may be calculated as an average of the various fares, weighted by the number of passengers using each fare. In general, passenger yield, i.e. passenger revenue per passenger-kilometre, can be used as a measure of price. Ideally, the average weighted fare for a particular route group or region concerned is more appropriate; however, the average yield can be considered as a suitable substitute or proxy variable to reflect the price of air travel.

A special problem with economic and financial data is whether to use current or constant money values to measure monetary quantities. The normal practice is to work with constant money values by adjusting the time series of financial data for simultaneous changes in the purchasing power of the currency.

Consider, as an example, a model of the demand for passenger travel on a network of routes, which includes a measure of income (for example, GDP) of the country or region and the passenger yield as explanatory variables. The data for the variables in current values can be divided by consumer price indices for each of the years concerned to obtain a constant (or "real") price series. The advantage of this approach is that it removes the effect of fluctuations in the inflation rate.



Development of an econometric model — Source: ICAO Forecasting Manual

Forecasting errors

Traditionally, there are four potential quantitative forecast errors:

a. a specification error, which results when the incorrect functional form is chosen or a key explanatory variable is left out of the model, or if the model structure varies over time.

b. a conditional error, which occurs when predictions of the inputs to the model are not accurate.

c. a random error, which is due to sampling and randomness associated with the data; and

d. **an exogenous error, which is unrelated to any of the inputs or specifications but is due to an external event of a unique character, such as a war or terrorist attack.**

By looking at these four categories when considering 2020 forecasts, it can be agreed their accuracy is highly affected by exogenous errors due to unpredictable coronavirus pandemic.

Qualitative forecasting

Quantitative forecasting techniques discussed so far assume that a number of historical observations are available, and they represent some underlying pattern. Qualitative forecasting methods are used when such data is sparse or not available. These methods can also be used in an assessment of how new technological or other developments would affect the forecast. The state-of-the-art in qualitative forecasting methods is not nearly as well-defined as in quantitative analysis. These methods are largely intuitive. They rely heavily on the judgement of experts and may be used to predict a significant change in historical patterns or, due to lack of sufficient historical data, for a quantitative analysis.

Therefore, as judgement plays an important part in qualitative analysis, providing reliable forecasts based on expert opinions can be problematic during the most dramatic economic impact on civil aviation. However, qualitative forecasts can assist support in providing a set of possible scenarios rather than a clear exact forecast. (ICAO Scenarios)

Delphi technique

For example, Delphi technique is a special procedure for forecasting by consolidation of opinions on the future. It has two steps. A selected group of qualified people are first presented with a questionnaire in which they are requested to indicate a most probable course of development in the activity being forecast. The initial returns are then consolidated, and the composite response returned to all contributors giving them the opportunity to revise their original assessments in light of prevailing opinions among other experts. The Delphi technique is a practical means of bringing together information from many experts and moving towards a consensus among them.

Decision analysis

Potentially the most suitable analysis methodology for the current context is decision analysis, which is essentially a combination of both quantitative and qualitative analysis methods. In decision analysis, the analyst's judgement is used in preparing forecasts for a particular area of expertise in combination with some statistical or mathematical techniques including subjective inputs of probabilities. Decision analysis is helpful in the assessment of uncertainty and in risk analysis. Examples of forecasting methods within this category are market research and industry surveys, Bayesian analysis, probabilistic analysis and system dynamics.

Probabilistic analysis

The notion of forecasting the value of some variable in the future is based on the fact that there is some uncertainty associated with that variable. In cases where the amount of uncertainty is large, it would be desirable to have a range of values associated with that variable and to assign probabilities to the outcome of a variable or the forecast itself.

Air traffic distribution models

Air traffic distribution models are normally used to forecast traffic demand between designated airport pairs, city pairs and/or country pairs. The socio-economic factors, demographics and other relevant factors including the economic characteristics of the cities themselves for the market concerned should be taken into consideration. Also, supply-side factors such as the level of service available between origin and destination can also come into play.

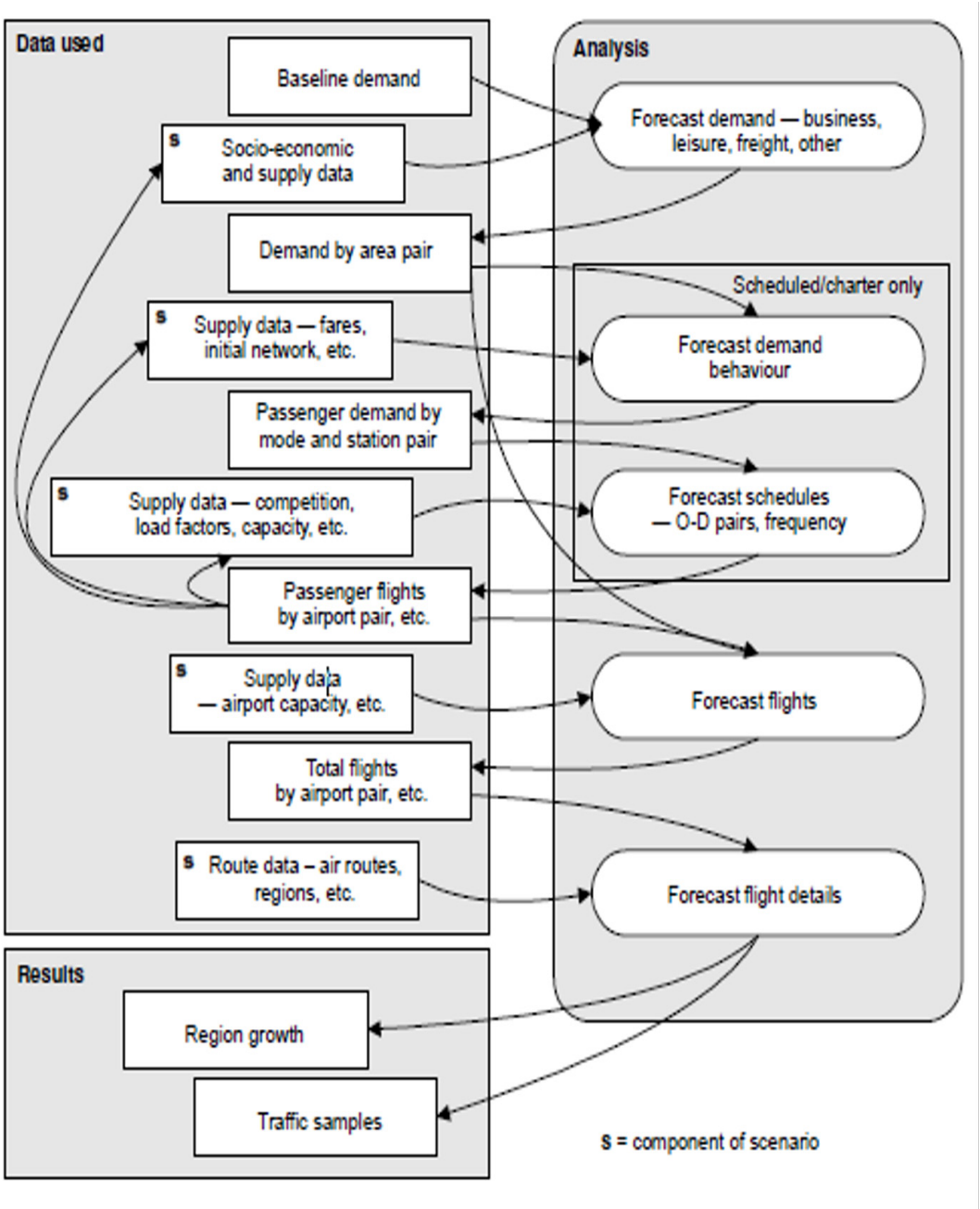
Normally, demand between the two cities is directly proportional to the population of the two cities concerned and inversely proportional to the square of the distance between them. Population is used here as a measure of attractiveness of the cities, and the distance as a measure of impedance (resistance). This is a very simplistic approach, and the gravity model in its simplest form implies that if there is a two-fold increase in population, this will result in a four-fold increase in demand.

But given the current context, demand distribution changes rapidly and passenger behaviour has not yet reached a clear direction. Uncertainty and continuous geo-political decisions regarding country-to-country border rules and air travel

corridors affect consumer behaviour towards flight bookings. People no longer plan or book holidays months in advance as they are conscious of the unpredictable pandemic resolution, but they might be prepared to purchase holiday flight tickets on a short-term basis. The affordability of booking ad-hoc holidays however is another factor to be considered when projecting further demand calculations.

Medium-term forecast analysis components

To provide further context of how such methods and techniques are combined to create accurate methodologies for each forecaster, ICAO has published a mid-term forecast analysis overview based on EUROCONTROL's approach in 2006.



Overview of medium-term forecast analysis components, EUROCONTROL

Source: ICAO Forecasting Manual

Air traffic forecasting parameters

Consumers of Air Traffic Forecasts are interested in various information as they will use it for different reasons. For example, while airlines are mainly interested in the number of passengers, airports look at the number of ground movements too, and ANSPs need to know the estimated number of flights they will have to control in order to ensure appropriate resource allocation. Similarly, Air Traffic Forecast Providers aim to produce and support different end users of their product, feeding the relevant information to fulfil their primary end users' needs.

Therefore, when looking at multiple forecasts, global or regional, we see they are measured and presented using different measurement units such as: Revenue Passenger Kilometre (RPK), Available Seat Kilometre (ASK), Freight Tonne-Kilometres (FTK), Number of Flights, Aircraft Movements, Number of Passengers.

While these parameters are self-explanatory, two of the most commonly used ones are ASK and RPK. ASK refers to available capacity deployed by scheduled carriers on all its routes whereas RPK performed refers to number of seats for which the carrier has earned revenue, in relation to the distance travelled. ASK is normally the supply side parameter used to assess the capacity growth in the market whereas RPK is the demand side parameter used to assess the revenue generated by airlines from passenger traffic.

Annex 2: Analysis of 2020 forecasts

The below analysis aims to compare the main global and regional forecasts or scenarios available during the COVID-19 pandemic in order to get a better understanding of the information available and its accuracy.

The key assumptions are:

- For this accuracy assessment, we compared IATA and ICAO forecasts against actual global data.
- Similarly, for the regional assessment we plotted EUROCONTROL's and ICAO's public predictions for 2020 to highlight the variation. We also compared their forecasts against relevant regional actual data.
- ACI's quarterly projection was included and compared with the other regional data for Europe published by EUROCONTROL and ICAO.
- All percentages are given with respect to 2019 – it was found more relevant to compare to data we already have from 2019 than to compare it with the 2020 scenario; this way we shall obtain a more accurate picture of the situation
- Different metrics used in forecasts will give roughly the same numbers – as forecasts use RPK – passenger revenue * number of kilometres or number of flights or number of seats
- Number of seats is proportional to passenger revenue; in case of seats capacity, being a relative percentage to 2019, it gives a similar value to RPK (in absolute value, the two metrics might not be directly proportional, but the decrease in number of flights gives roughly the same decrease in RPK).

These assumptions helped us overlap the forecasts in order to find the most similar models and the path that was mentioned before. This way, we were also able to take a range of possibilities.

In order to compare the main global and regional forecasts or scenario available during COVID-19 pandemic (as of August 2020), we plotted them together as summarised in the table below:

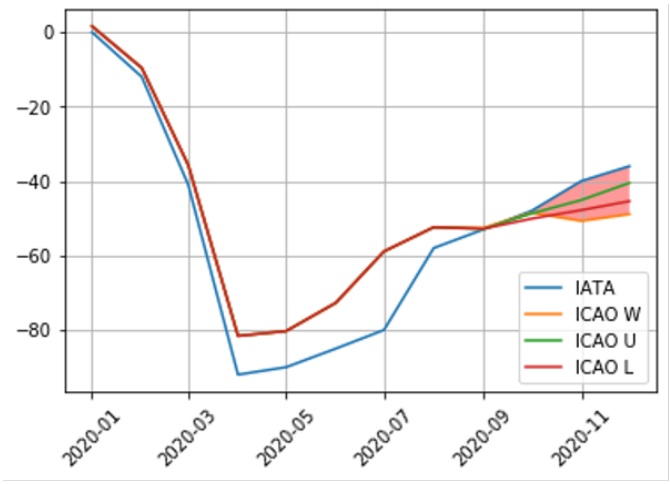


Figure 3 – Current global forecasts/ scenarios

As the different paths can be visualised in Figure 3 – Current Global Forecasts/ Scenarios, one can observe the variation of the different recovery paths forecasted by the key providers. Therefore, to get an indication on accuracy and relevance of the different forecasts, we compared all scenarios with actual published data from April, May, June and mid-July in order to obtain an understanding of accuracy to date.

To do so, we took the average absolute difference in percentage points (i.e. for IATA, the differences were 2.4%, 1.8%, 1%, 4%, 7%, 9% and 11% respectively, resulting in the average error being 5.2%). Figure 4 below is showing global forecast/ scenarios and associate errors in a graphical representation:

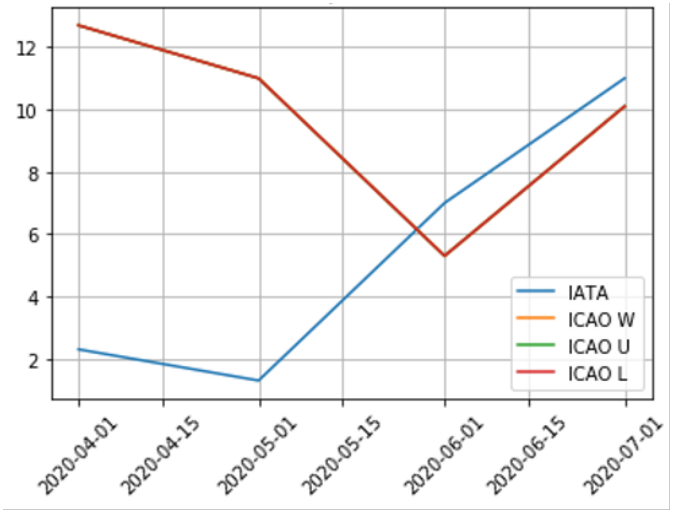


Figure 4 – Global forecasting error

Similarly, we looked at EUROCONTROL and ICAO and their regional forecasts as per Figure 5.

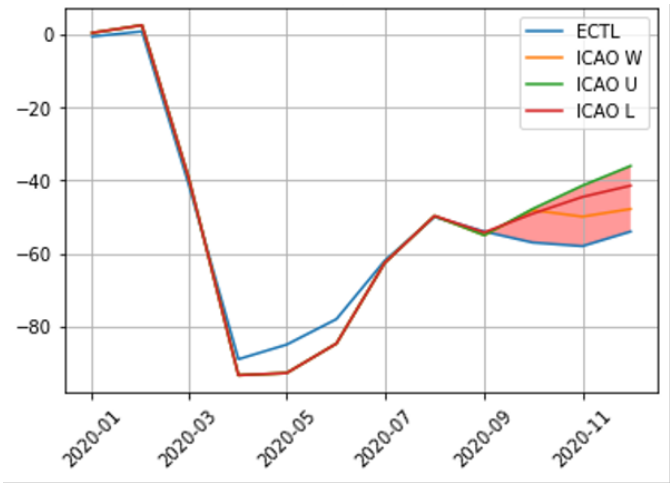


Figure 5 – European forecasts

Looking at ACI's quarterly European forecast, we also plotted the previous scenarios in order to visualise the variation between their models and they are shown in Figure 6 below:

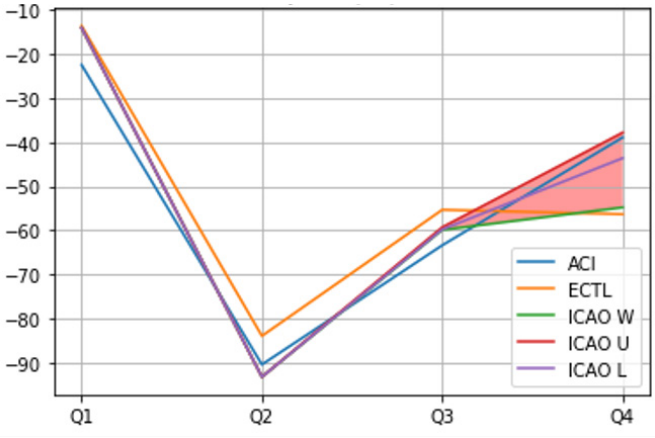


Figure 6 – European quarterly forecast

Figure 7 below shows the Error variation between EUROCONTROL's forecast and the actual air traffic data recorded for the April – August time period.

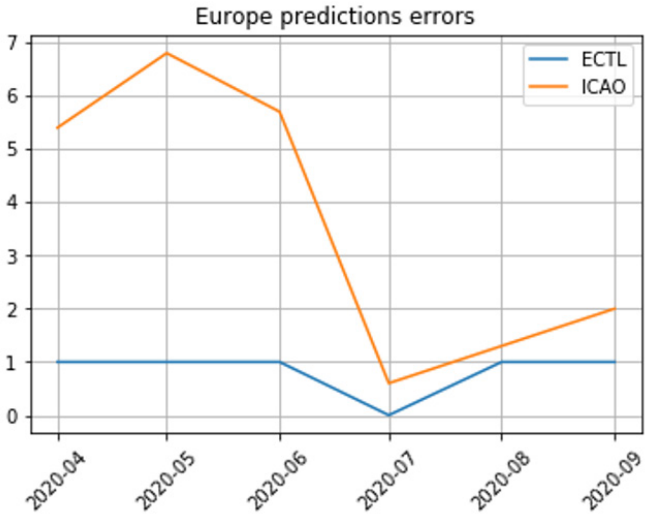


Figure 7 – European forecasting error

The graphs clearly show that ECTL error was very small compared to all other forecasts, and a key factor that contributed to EUROCONTROL's accuracy is that they have "memorised" the data based on actual airline bookings. Furthermore, providing a forecast for a region with geo-political similarities and limited traffic behaviour is very different to predicting the air traffic evolution world-wide. Thus, EUROCONTROL's average forecast accuracy error is only 0.8%.

ECTL, IATA, ICAO U/L have the highest accuracy over the past four months. ICAO U/L and IATA offer the best range of possibilities; however, starting from August, ICAO U and ICAO L will follow different paths, that will give a smaller range and a better prediction on what will come IF, AND ONLY IF the assumptions remain valid throughout the entire recovery period.

Taking a range of possibilities is a safer more pragmatic approach because it reduces the sensitivity to unexpected changes. Providers can reduce the range of forecasted scenarios as more actual data becomes available.

While there might exist more complex methods of comparing accuracies, we used this method to get a better understanding of the air traffic forecasting products during the COVID-19 pandemic aiming to support Forecast-data users get an informed overview of the projected short-term air traffic picture.

Forecasts analysis limitations

During this analysis, a set of limitations was identified as follows:

- Some scenarios are dependent on others; IATA and ICAO predictions take into consideration ECTL's scenario, while ECTL's scenario considers the views of IATA and ICAO => meaning that if one is wrong, the error will be distributed and incorporated in the others, leading to the introduction of a bigger error than expected.
- The data available to produce current forecasts/ scenarios is not extensive enough to provide an accurate prediction; therefore, depend to some extent on the experience of the analysts.
- Human behaviour is unpredictable and can significantly affect these predictions
- There is no previous experience with a similar global pandemic to support robust assumptions; the current COVID-19 outbreak has a much bigger global impact on all industries, including aviation, than the SARS in 2002.
- They are sensitive to unexpected changes – example: a new wave of COVID-19 is not taken into consideration

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