APPENDIX M2

COVID-19 FORECAST SCENARIO DEVELOPMENT

1. FORECAST DEVELOPMENT METHODOLOGY

1.1 The methodology for developing the COVID-19 forecasts required using updated economic forecasts incorporating the impact of the pandemic and a series of assumptions made by the COVID-19 task group to inform the near-term recovery (see assumption matrices at the end of this appendix).

2. PASSENGER FORECAST DEVELOPMENT

2.1 Developing the passenger long-term traffic forecast (LTF) to account for both the short term impacts of COVID-19 and eventual long-term recovery required a combination of updated macroeconomic data and recent estimates of the pandemic driven demand shock (measured in changes to RPKs) to the aviation industry. Updated macroeconomic forecast data accounting for the impact of COVID-19 were sourced from IHS Markit, while passenger traffic outlooks accounting for the near-term effects of COVID-19 were sourced from IATA.[1] The following steps presented below were taken to combine the updated information and datasets to produce COVID-19 scenario forecasts.

2.1.1 **Incorporating updated macroeconomic data:** Country-level economic data forecasts pre- and post-COVID-19 were sourced from IHS Markit to measure the COVID-19 related changes in real GDP and population. These values were aggregated to the route group level and the difference in the growth rates between the pre- and post-COVID-19 outlooks calculated. This rate change (i.e. the difference in percent growth between the two outlooks for each year) was applied to the pre-COVID-19 OECD economic data by forecast scenario (i.e. mid, high and low economic outlooks). The passenger LTF was then re-processed using the updated economic inputs holding constant the model coefficient values to produce updated forecasts.

2.1.2 **COVID-19 RPK adjustment factors:** To accurately capture the near term impact of the COVID-19 downturn on the aviation industry and potential recovery paths, region based RPK forecasts were sourced from IATA. The RPK forecasts were indexed to 2019 to measure the expected drop in RPK demand in 2020 due to the pandemic, and the subsequent (expected) recovery back to 2019 RPK demand under the mid, high and low scenario forecasts.[2]

2.1.3 **Re-estimation of the Passenger LTF:** After the passenger LTF is re-processed using the updated economic inputs, the RPK adjustment factors are applied as a post-estimation process to guide the RPK forecasts during the COVID-19 impact period. Depending on the scenario (mid/high/low), the forecasted growth rates determined by the updated economic data are allowed to resume after the defined

[1] The official 2018 LTF was estimated using economic data sourced from OECD, however, updated OECD macroeconomic data was unavailable.

[2] The return to 2019 levels of RPK demand is detailed in the passenger scenario matrix, with expected global recovery in 2023, 2024 and 2027 for the high, mid and low scenarios, respectively.

COVID-19 impact period (e.g. under the high scenario forecast, RPK demand will reach 2019 levels by 2023 and will resume forecasted growth trends based on the updated economic inputs from 2023 onwards).

2.2 A comparison of the compound annual growth rates (CAGRs) between the 2018 LTF and three COVID-19 scenarios is presented in Table B1. Overall, the growth rates for the high COVID-19 scenario align with the underlying assumptions from the scenario matrix, whereby the domestic RGs recover at a faster rate relative to the international RGs. For example, for the high scenario the 10- and 20-year CAGRs for the domestic route groups are 3.9% and 4.2% respectively, compared to 3.4% and 4.0% for the international route groups. The difference between the mid and low scenarios are also broadly consistent and provide the expected bounding of the scenarios.

Table B1: Comparison of 32 Year Compound Annual Growth Rates

	International RGs				**Domestic RGs**			
CAGR	COVID-19: High	COVID-19: Mid	COVID-19: Low	LTF 2018	COVID-19: High	COVID-19: Mid	COVID-19: Low	LTF 2018
10 Year	3.4%	2.6%	1.1%	4.2%	3.9%	3.0%	1.4%	4.3%
20 Year	4.0%	3.5%	2.3%	4.2%	4.2%	3.6%	2.4%	4.2%
32 Year	4.2%	3.8%	2.9%	4.3%	4.1%	3.7%	2.8%	4.0%

2.3 Overall, the passenger forecasts are consistent with the COVID-19 assumption matrix, and the methodology and updated results have been agreed to by the COVID-19 Task Group members. Accompanying ASK forecasts were developed through updating the pre-COVID-19 load factor forecasts, using IATA data to inform the 2020 change, then estimating the subsequent recovery and return to long-run trend.

2.4 Extending the forecast through 2070 was done by utilizing the income coefficients from the 2018 ICAO LTF and applying a value that represents a potential equilibrium across all of the route groups (reflecting the idea that over time growth in developing and mature markets will converge). This value, which was within the range of the estimated LTF income coefficients, was then tapered over the initial 10-year portion of the forecast (based on one standard deviation from the ICAO LTF statistics) to reflect some slowing in the relationship between income growth and travel demand in the outer range of the forecast. The economic forecast trends used for this process were extrapolated from 2050 to 2070.

3. CARGO FORECAST DEVELOPMENT

3.1 The cargo COVID-19 forecast scenario methodology follows a similar logic to the passenger market, beginning with updating the region based economic forecast data to integrate the short and long run impacts to the regional economies. The pre- and post-COVID-19 economic data was sourced from IHS Markit, and the same process described for the passenger update was used to apply the changes in the growth rates to the previous OECD data. The cargo LTF domestic and international models were then re-processed (holding constant the previously estimated coefficients) to produce updated forecast scenarios based on the change in the economic outlooks. Finally, the recovery paths were adjusted during the post-COVID-19 impact period based on the freighter scenario matrix.

3.2 Cargo ATK forecasts were developed through updating the pre-COVID-19 load factors to reflect the 2020 downturn and recovery path back to long-term trends (using IATA data). The extension to 2070 was done through extrapolating economic forecasts to 2070 and then using the coefficients from the ICAO LTF model to forecast FTKs through 2070 by region.

4. BUSINESS JET FORECAST DEVELOPMENT

4.1 Development of the business jet COVID-19 forecast utilizes the FESG 2018 base year forecast, the estimated decline in operations in 2020 and economic forecast data from IHS Markit. The initial step involves creating and mapping together indices for operations and real GDP forecasts by region from 2018 through 2050. A correlation coefficient between operations and real GDP is calculated for each business jet region: North America, Europe, Africa, Asia Pacific, China, CIS, Latin America, Middle East and South Asia.

4.2 Using updated 2020 economic data and the correlation coefficients, the economic driven decline in 2020 operations is estimated. From here, the estimated 2020 operations decline is adjusted to match the total historical decline in 2020 operations, providing an approximation of the COVID-19 effect (e.g. lockdown, travel restrictions, etc.) on business jet travel. For example, for North America, the 2020 change in real GDP leads to an estimated 3.6% decline in operations, while historical data suggests a drop of around 20%. This suggests a COVID-19 adjustment at around 16.4%.

4.3 The IHS economic forecasts are used to trace out the near term recovery in operations (mid, high and low), through to the point where they return to 2019 levels (as detailed in the assumptions matrix). During the same period, the COVID-19 adjustment is linearly reduced to reflect increases in vaccination levels and reductions in cases and travel restrictions. Beyond this point, operations are forecast to return to a long-run trend based on the updated COVID-19 economic outlook. This process is performed for each business jet region.

4.4 After the operations forecast was finalized, growth in the in-service fleet was calculated using a ratio of in-service fleet per operation to guide this trend over the forecast horizon. The extension through 2070 was done by applying a moving average process to the economic forecast data, maintaining the underlying asymptotic trends in operations from the pre-COVID-19 forecast.

5. FLEET MIX

5.1 The COVID-19 task group examined whether current changes in the status of commercial aircraft would suggest making changes to the fleet mix for fleet evolution using the COVID-19 forecast. An examination of commercial fleet information showed a surge in stored aircraft in 2020 due to the sharp decline in demand as a result of the pandemic.

5.2 A further investigation of aircraft status indicated that there has been little change in retirement trends in 2020, with most of the change resulting from aircraft moving into storage. As a result the COVID-19 task group determined there was no clear precedent at this point in time for adjusting the fleet mix for COVID-19 fleet evolution through retirement adjustments, as the stored aircraft are positioned to return to the in-service fleet as demand picks-up.

6. FLEET FORECASTS AND FLEET EVOLUTION

6.1 The COVID-19 fleet forecasts (which are inputs for fleet evolution) are being developed using the Airbus and Boeing propriety forecast models. These models extend the traffic demand forecasts to generic fleet forecasts by route group, distance band and competition bin (for the business jet market the fleet forecast is produced by FESG). These are the dimensions required for as inputs to the MDG-FESG fleet evolution models. The base year for the COVID-19 forecast is 2018, which is unchanged from the CAEP/12 pre-COVID-19 traffic demand and fleet forecasts.

6.2 The FESG fleet evolution models—FLEET-Builder and the Aviation Assignment Tool (AAT) are used to develop the COVID-19 fleet evolution for environmental modelling. Apart from the COVID-19 fleet forecast, there are no other changes associated with inputs or assumptions used in the pre-COVID-19 CAEP/12 environmental version of the fleet evolution models.

6.3 For the LTAG study, a post-process fleet evolution approach was developed for introducing the Advanced Concept Aircraft (ACA) into the fleet. Using the COVID-19 mid fleet evolution run and based on specified entry into service years, and delivery market shares provided by LTAG, the ACA-T2 and ACA-T3 aircraft are introduced into the fleet at the market level (e.g. wide body, narrow body, etc.). The ACA aircraft

6.4 The steps for introducing ACAs into each respective market began with translating the aggregate level delivery market share into ASK (and ATK/operations) shares using the base fleet evolution dataset. As an example, at the market level this translates to an ACA introduced with 10% delivery market share receiving 10% of the associated ASKs (or ATKs/Ops) for aircraft at a specific entry into service year (EISY), with the remaining 90% allocated to the existing ATW aircraft.

6.5 The LTAG fleet evolution ensures ASKs, operations and ATKs are consistent across the base forecast and the integrated scenarios and maintains the FESG retirement process from the base mid fleet evolution run. Any ACA related range restriction are also accounted for by this process.

Table B2: Passenger Assumption Matrix

Commercial Passenger Market							
Scenario/Assumption	**Vaccine**	**Global Economic Activity**	**Regional Variation**	**Route Variation -- Domestic/International**	**Business Travel Demand**	**Return to 2019 RPKs**	**Return to pre-crisis Trend (levels)**
Optimistic	Announced early 2021 Available/wide spread use mid/late 2021	V-shaped recovery -- back to 2019 levels in early 2021	--Solid and sustained global recovery --Asia (China) pick-up quickly in 2021 --Recovery in traffic tracks economic growth (NA/EUR follow Asia)	--Domestic traffic responds quickly particularly in U.S./Europe/Asia (China) --International lags somewhat (2022) --solid income growth drives leisure travel	-- Business Travel growth resumes late 2021 --Returns to normal levels in 2022 -- Drives solid recovery in both markets (B2B and conferences)	2023	Yes -- around 2030
Central	Announced mid-2021 Available/wide spread use early/mid 2022	Return to 2019 levels in late 2021/2022 (running behind the optimistic outlook)	-- Recovery lags economic growth (some behavioral changes/lower incomes) -- Resumption in domestic traffic first -- International lags --China/Asia leads the recovery, followed by NA and EUR	--Domestic traffic growth resumes in 2022 U.S./Europe/Asia (China) --International lags (2023) -- Lower incomes reduce leisure travel	--Business Travel growth resumes in late 2022/2023, but never fully returns to normal levels (i.e. some permanent reduction due to substitutes -- Zoom, etc.)	2024	No -- permanent shift due to substitution of online technologies for business and changes in household vacation/travel patterns
Pessimistic	Announced early 2022 Available/wide spread use late 2022/early 2023	Return to 2019 levels by 2023/2024	--Recovery lags economic growth (more prevalent behavior changes/lower incomes) -- resumption in domestic traffic slow to gain traction --International lags further behind --China/Asia and developing nations lead recovery. NA and EUR lag.	--Domestic traffic resumes growth in 2024 Asia (China) --International lags (2025) -- Lower incomes reduce leisure travel	--Business travel does not fully recover --Permanent and sustained loss in domestic/international travel as a result.	2027	No -- permanent shift due to substitution of online technologies for business and changes in household vacation/travel patterns

Table B3: Freighter Assumption Matrix

Freighter Market					
Scenario/Assumption	**Vaccine**	**Economic Activity**	**Regional Variation**	**Return to 2019 FTKs**	**Return to pre-crisis Trend (levels)**
Optimistic	Announced early 2021 Available/wide spread use mid/late 2021	V-shaped recovery -- back to 2019 levels in early 2021	Regional variation will depend upon differences in regional economic activity -- Pacific/Asia & Asia/Middle East will lead, followed by North America/Europe	2021	Yes
Central	Announced mid-2021 Available/wide spread use early/mid 2022	Return to 2019 levels in late 2021/2022 (running behind the optimistic outlook)	Regional variation will depend upon differences in regional economic activity -- Pacific/Asia & Asia/Middle East will lead, followed by North America/Europe	2022	Yes
Pessimistic	Announced early 2022 Available/wide spread use late 2022/early 2023	Return to 2019 levels by 2023/2024	Regional variation will depend upon differences in regional economic activity -- Pacific/Asia & Asia/Middle East will lead, followed by North America/Europe	2023	Dependent upon economic forecast

Table B4: Business Jet Assumption Matrix

Business Jet Market					
Scenario/Assumption	**Vaccine**	**Economic Activity**	**Regional Variation**	**Return to 2019 Ops**	**Return to pre-crisis Trend (levels)**
Optimistic	Announced early 2021 Available/wide spread use mid/late 2021	V-shaped recovery -- back to 2019 levels in early 2021	Recovery driven by regional economic variation and largest markets -- North America, Europe and China. Variation affected by stock market performance, investment, purchasing managers index, and the US$ exchange rate.	2022	Long-run trend influenced by long-run economic trends
Central	Announced mid-2021 Available/wide spread use early/mid 2022	Return to 2019 levels in late 2021/2022 (running behind the optimistic outlook)	Recovery driven by regional economic variation and largest markets -- North America, Europe and China. Variation affected by stock market performance, investment, purchasing managers index, and US$ exchange rate.	2023	Long-run trend influenced by long-run economic trends
Pessimistic	Announced early 2022 Available/wide spread use late 2022/early 2023	Return to 2019 levels by 2023/2024	Recovery driven by regional economic variation and largest markets -- North America, Europe and China. Variation affected by stock market performance, investment, purchasing managers index, and the US$ exchange rate.	2024	Long-run trend influenced by long-run economic trends