ABIA 2040 Master Plan Analysis

Should the Austin-Bergstrom International Airport Expand?

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Austin-Bergstrom Airport

Background information about the AB Airport

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Predicting Traffic in 2020

Using our analysis to predict total airport passengers

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Breaking It Down

Diving deeper, and understanding our data

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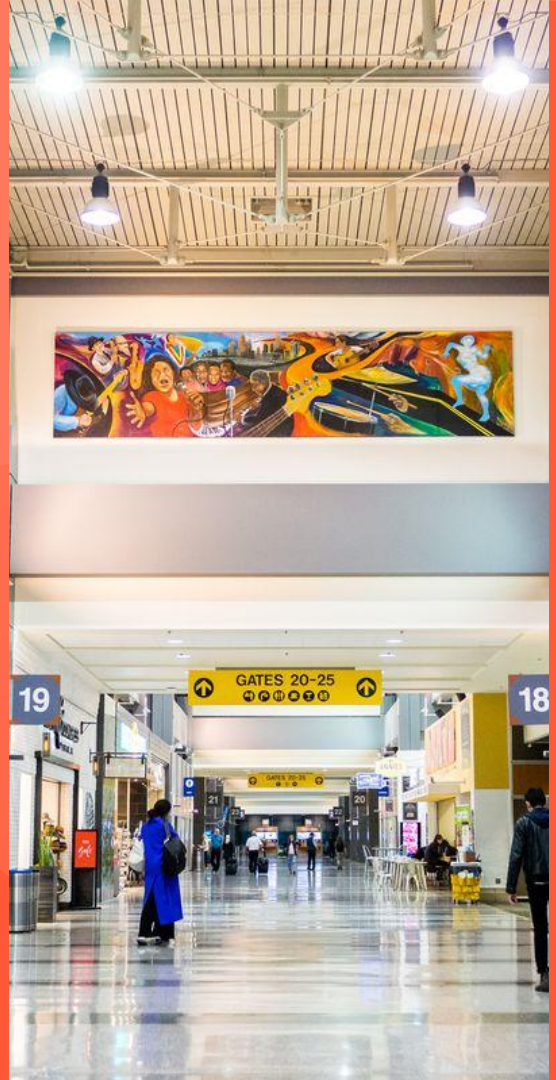
Tweaking and Concluding

Finalizing our results and making our conclusions

01. The Austin-Bergstrom Airport



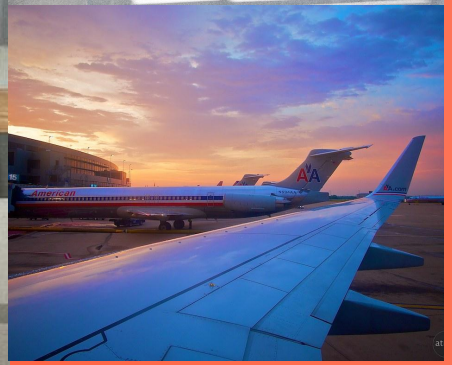
Recent Growth of ABIA

Increase of Population and Economic Significance

- Introduction of Nonstop Flights
- Passenger numbers
- Nonstop Service

2040 Master Plan

- 32 Gates
- 10,000 ft Runway
- Taxiway Improvements



15 Million

Current Airport Capacity

$4 Billion

Renovation Plan

Is the Upgrade Necessary?

"We’re going to have more demand for service, more travelers and more demand for space,”

"We’re going to need capacity at the airport and I don’t see those numbers slowing down."

—Walter Zaykowski

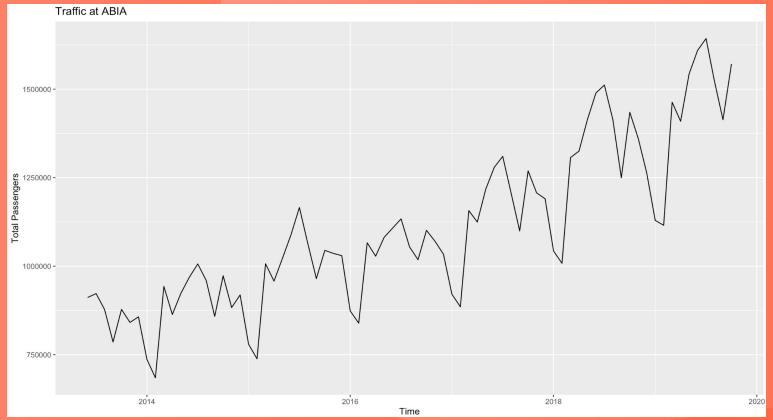
Let’s Explore!

An initial investigation into passenger traffic

Somewhat Upward Trend from February to July

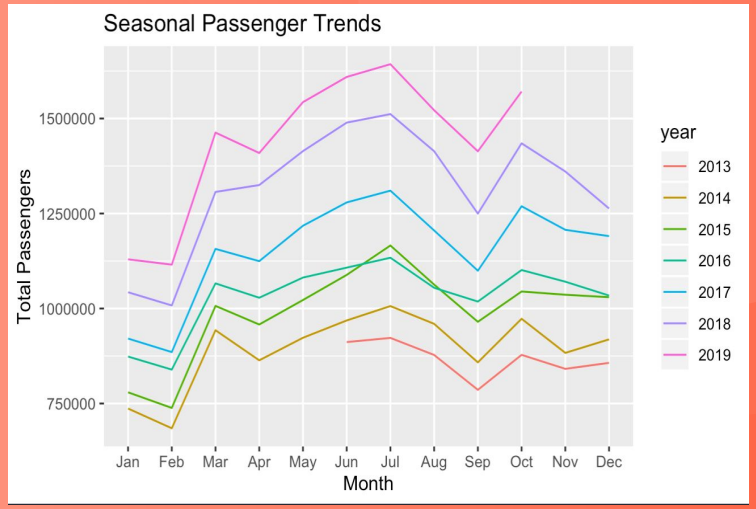
Decrease from July to February

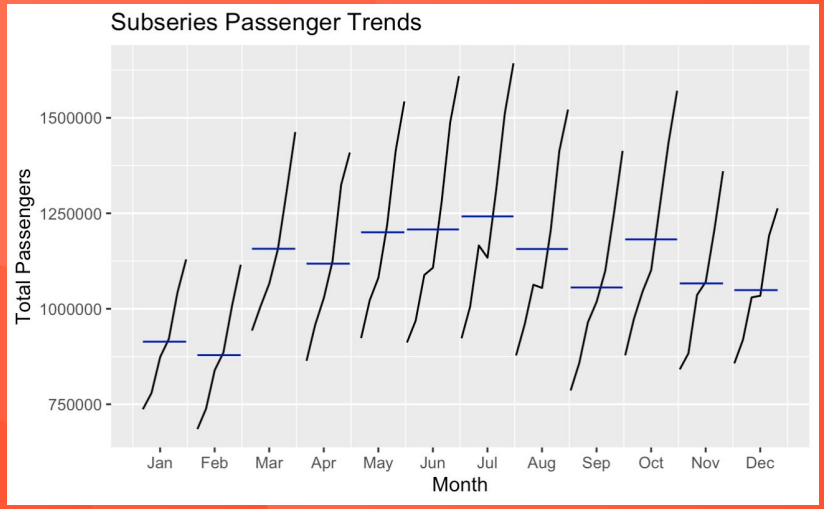
Total Passengers Increasing Over Time



Busiest Month: July

Emptiest Month: February

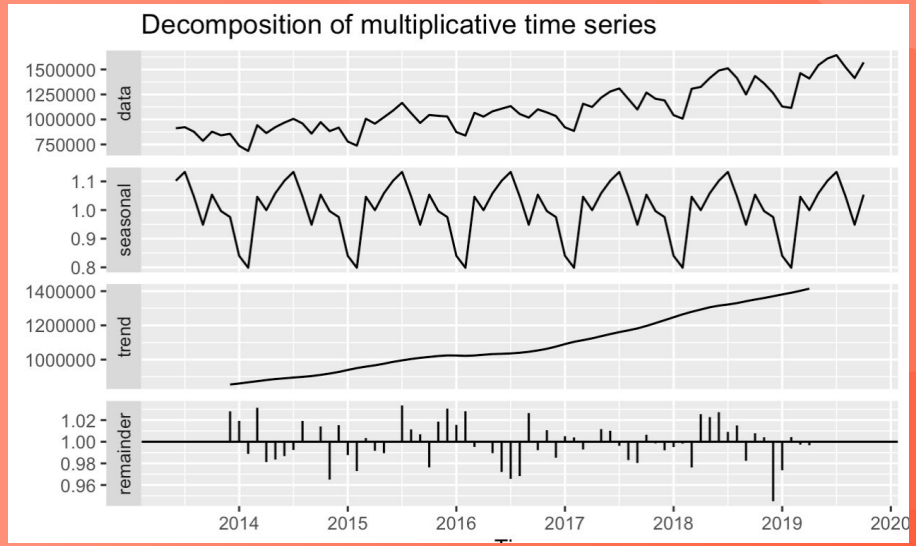




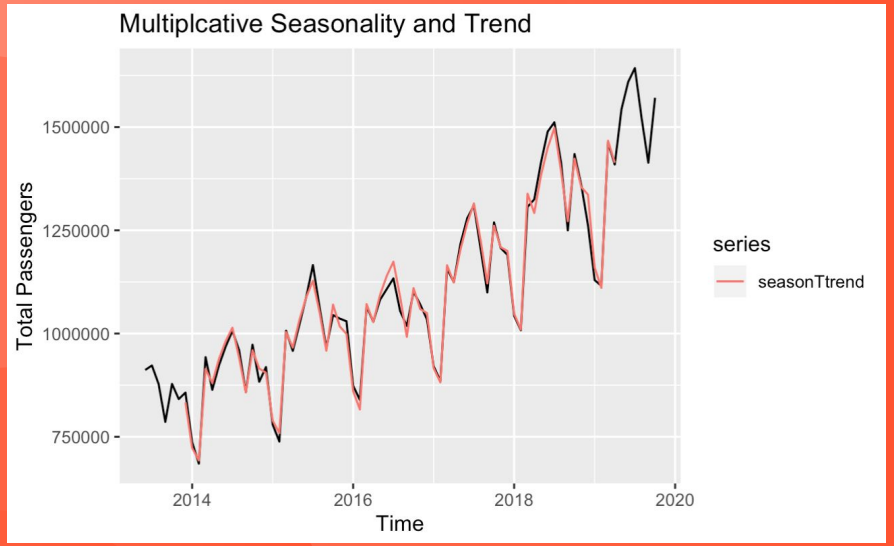
Upward Trend

Seasonality General Trend Captured

No Obvious Pattern in Residuals



Multiplicative Seasonality and Trend Captures Most of the Data

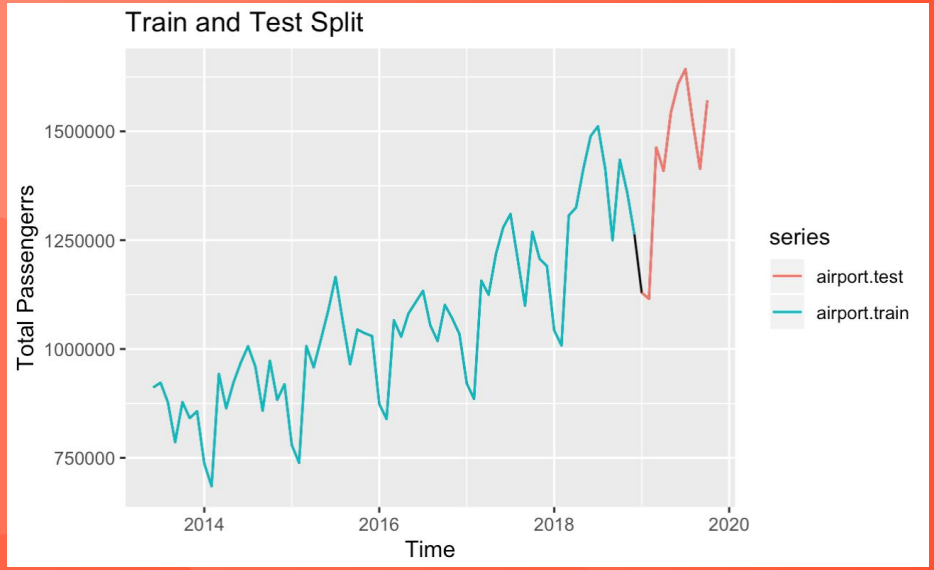


2020 Forecast

Using Models to Predict Airport Traffic

```
airport.train <- window(dft, end = c(2018,12))
airport.test <- window(dft, start = c(2019,1))
```

```
autoplot(dft)+
  autolayer(airport.train)+
  autolayer(airport.test)
```



Error - Trend - Seasonality (ETS)

Model 1

Multiplicative Error
Damped Additive Trend
Multiplicative Seasonality
AICc: 1680.79

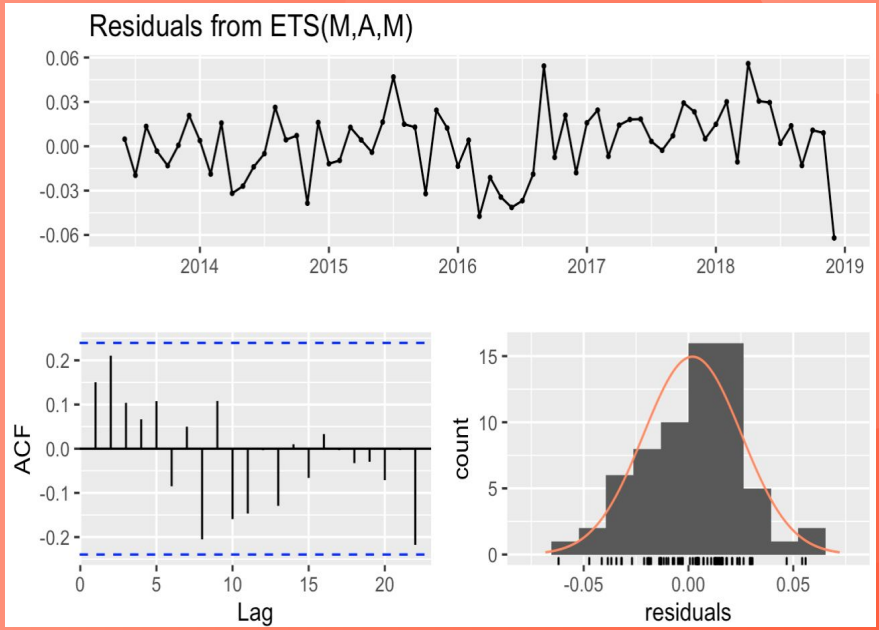
Model 2

Multiplicative Error
Additive Trend
Multiplicative Seasonality
AICc: 1680.82

	ME	RMSE	MAE	MPE	MAPE
Training set	1614.934	24727.44	18380.04	0.1052223	1.728210
Test set	84924.504	92784.53	84924.50	5.6942829	5.694283

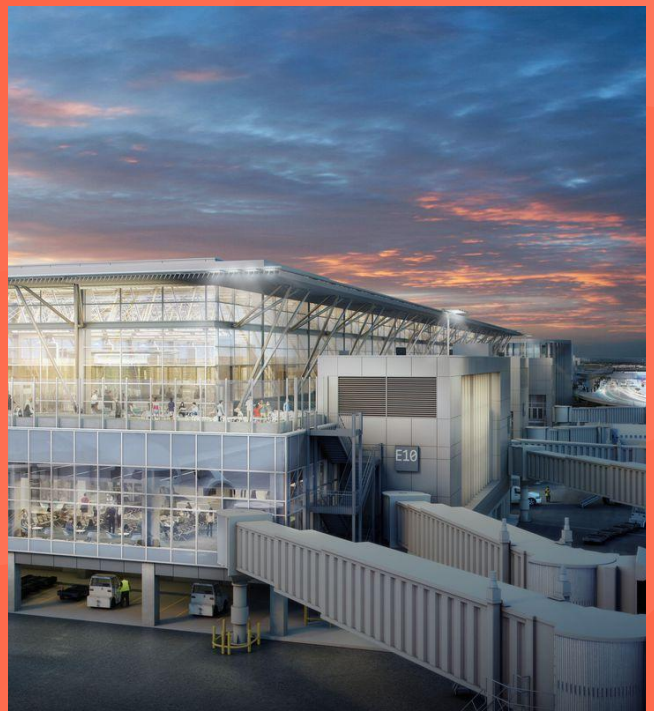
	ME	RMSE	MAE	MPE	MAPE
Training set	2364.661	26193.26	20237.65	0.1392747	1.873907
Test set	51076.351	58948.25	53252.57	3.4089422	3.601616

Analyzing our Test Residuals



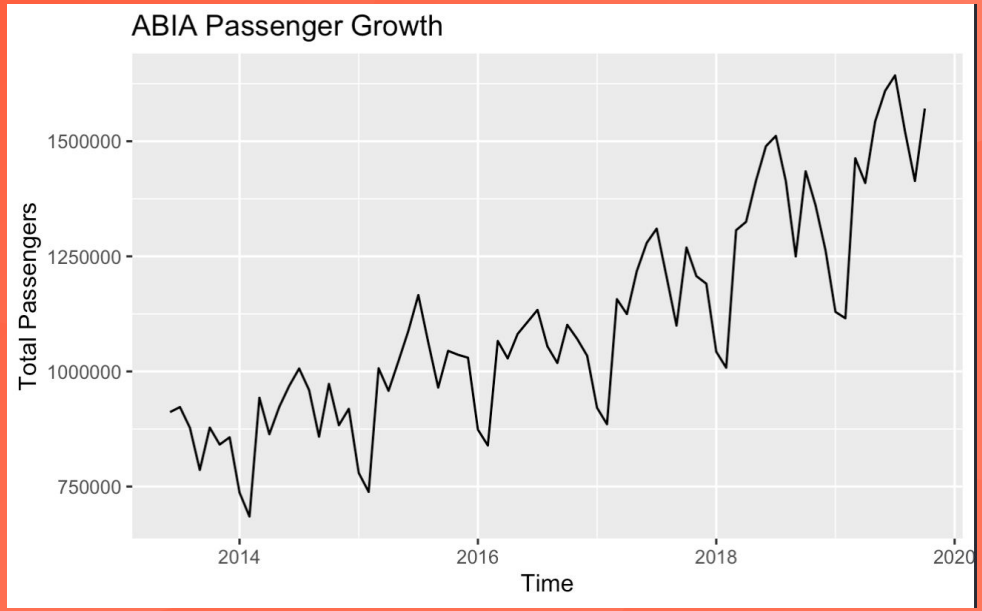

```
        Ljung-Box test

data:  Residuals from ETS(M,A,M)
Q* = 35.725, df = 24, p-value = 0.05835

Model df: 16.   Total lags used: 40


        Shapiro-Wilk normality test

data:  etsforecast2$residuals
W = 0.98159, p-value = 0.4231
```

Autoregressive - Integrated - Moving Averages



But First

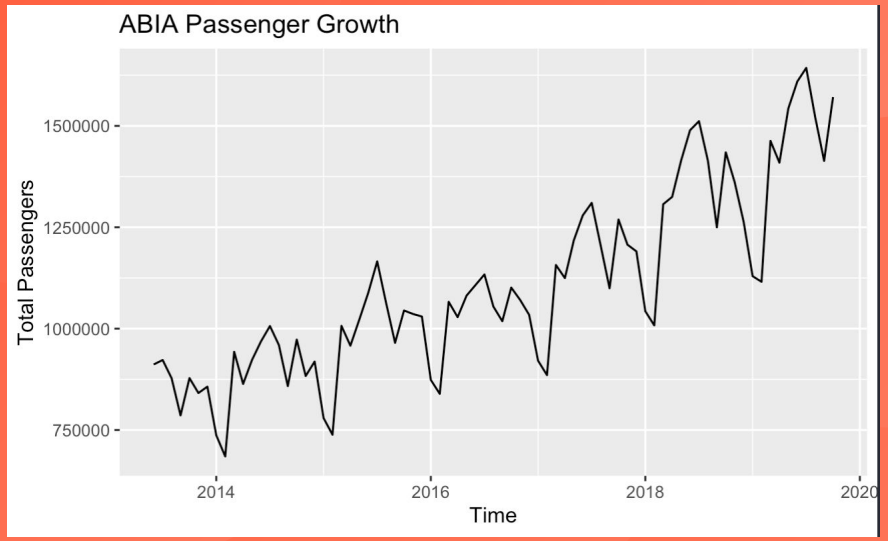
Stationarity Handling

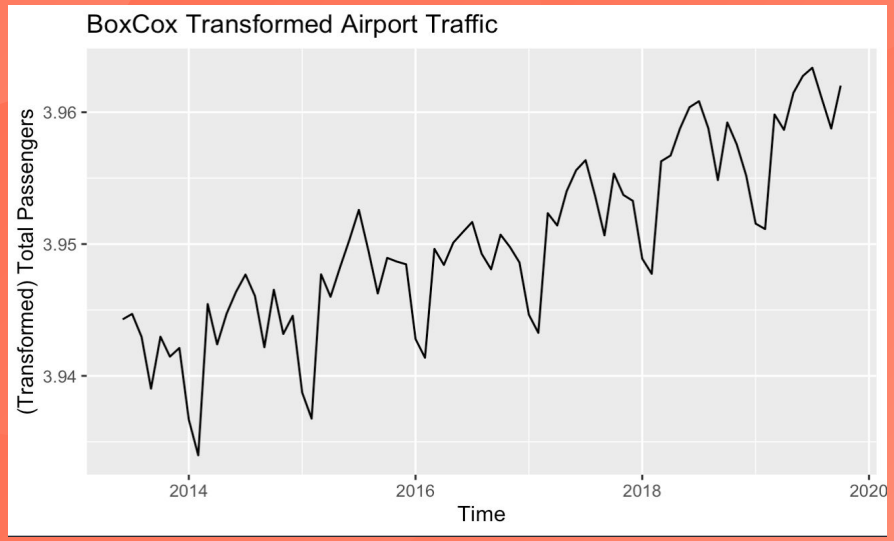


Stationalizing Our Data

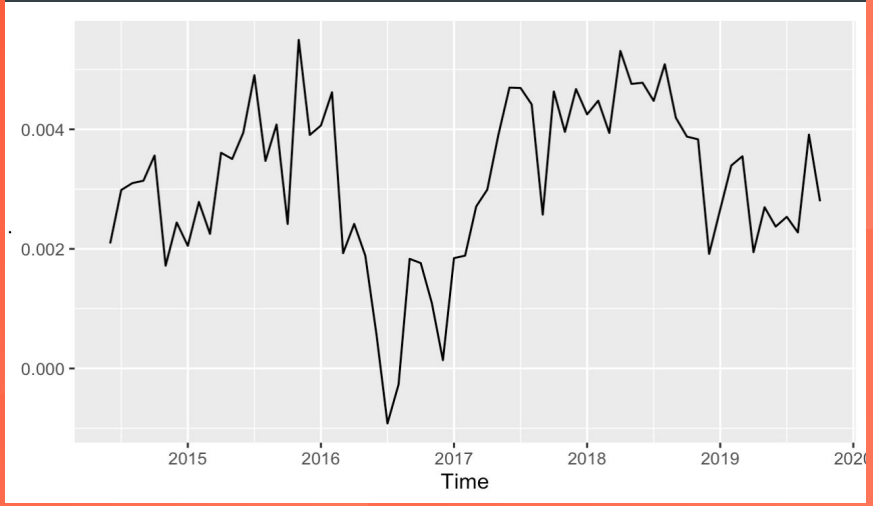
- Clear trend and change of mean
- Change in magnitude of seasonal variation

BoxCox Transformation





```
ndiffs(dftb,alpha=0.05,test=c("kpss"))
nsdiffs(dftb,alpha=0.05,test=c("seas"))
dftd1 <- diff(dftb,lag=12)
```

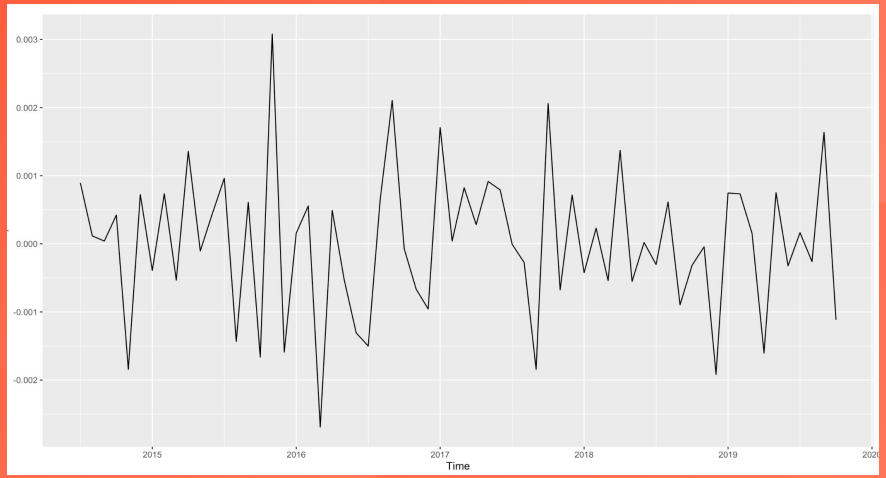



```
        Augmented Dickey-Fuller Test

data:  dftd1
Dickey-Fuller = -2.073, Lag order = 3, p-value = 0.5454
alternative hypothesis: stationary


######################
# KPSS Unit Root Test #
######################

Test is of type: mu with 3 lags.

Value of test-statistic is: 0.1918

Critical value for a significance level of:
                10pct  5pct 2.5pct  1pct
critical values 0.347 0.463  0.574 0.739
```

First Difference

ADF & KPSS

```
dftd2 <- diff(dftd1)
adf.test(dftd2)
summary(ur.kpss(dftd2))
```

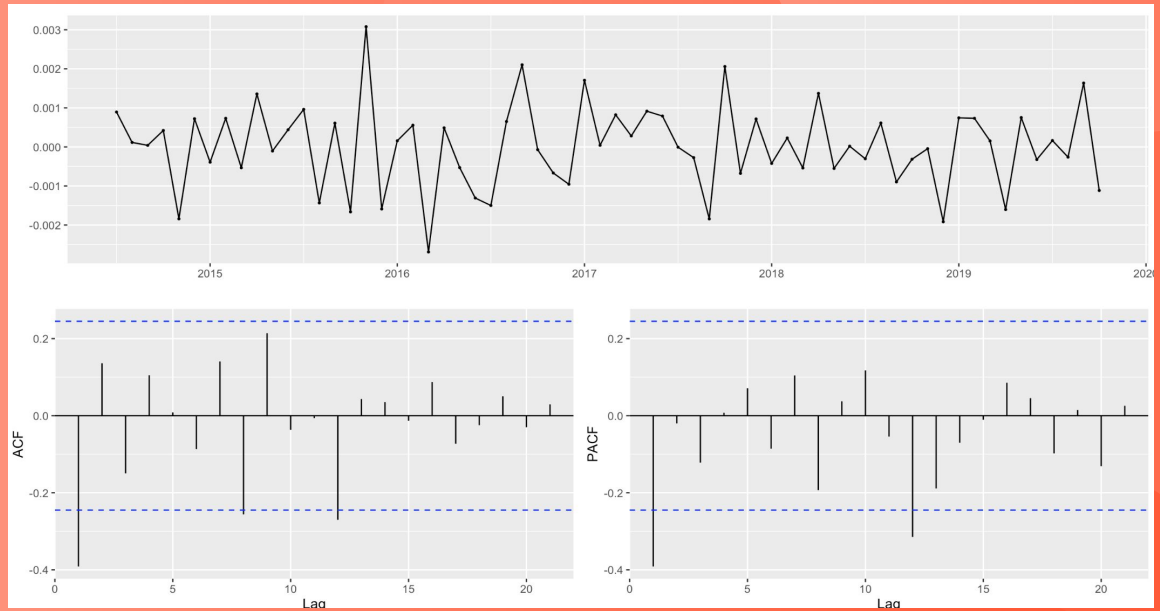



```
        Augmented Dickey-Fuller Test

data:  dftd2
Dickey-Fuller = -4.3535, Lag order = 3, p-value = 0.01
alternative hypothesis: stationary


######################
# KPSS Unit Root Test #
######################

Test is of type: mu with 3 lags.

Value of test-statistic is: 0.0645

Critical value for a significance level of:
                10pct  5pct 2.5pct  1pct
critical values 0.347 0.463  0.574 0.739
```

Second Difference

Stationary Data

Autoregressive - Integrated - Moving Averages (ARIMA)



Auto-Arima Model

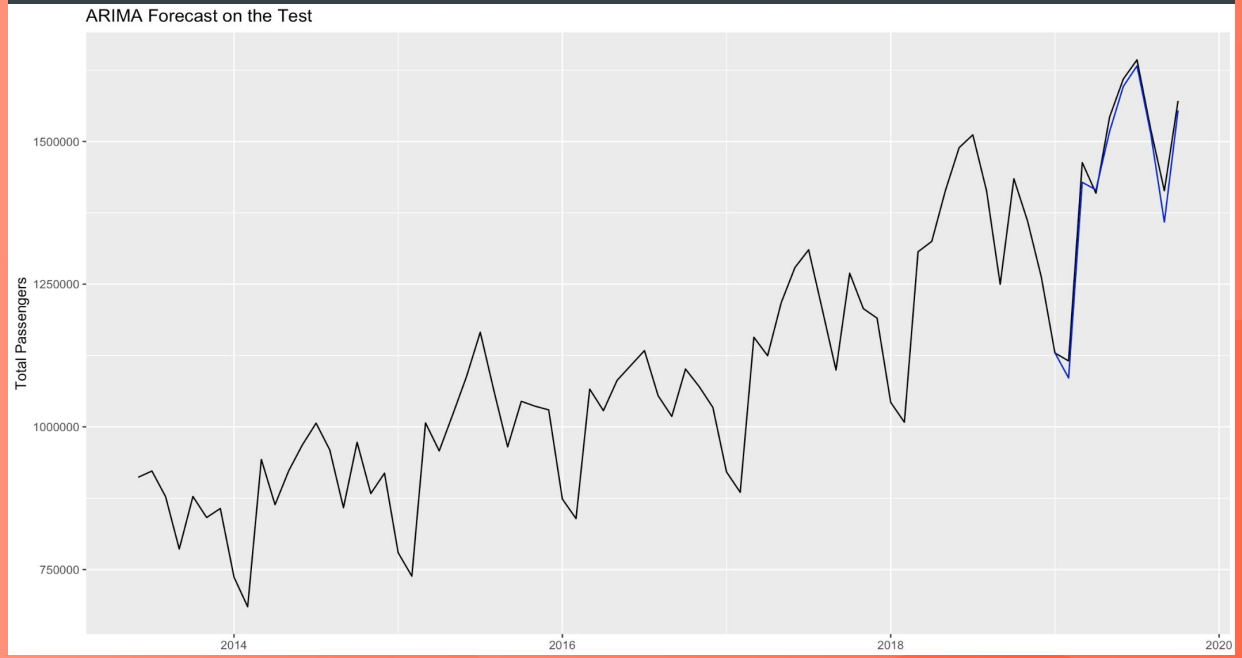
ARIMA(0,0,1)(0,0,1)[12]
Mean = 0
AICc = -709.04

Other Potential Models

```
auto.arima(dftd2,seasonal=TRUE,nmodels=10000,stepwise=FALSE)

Arima(dftd2, order = c(1,0,0), seasonal = c(0,0,1))
Arima(dftd2, order = c(0,0,1), seasonal = c(0,0,1))
Arima(dftd2, order = c(1,0,0), seasonal = c(1,0,0))
Arima(dftd2, order = c(0,0,1), seasonal = c(1,0,0))
                    etc...
```

```
auto.arima(dftd2,xreg=fourier(dftd2,K=6))
auto.arima(dftd2,xreg=fourier(dftd2,K=5))
auto.arima(dftd2,xreg=fourier(dftd2,K=4))
auto.arima(dftd2,xreg=fourier(dftd2,K=3))
auto.arima(dftd2,xreg=fourier(dftd2,K=2))
auto.arima(dftd2,xreg=fourier(dftd2,K=1))
```

```
flightarima <- Arima(flightrain, order=c(0,1,1), seasonal=c(0,1,1), lambda = l)
flightaforecast <- forecast(flightarima, h=length(flightest))
```



	ME	RMSE	MAE	MPE	MAPE
Training set	-6045.18	69313.06	30190.03	-0.5917838	2.908232
Test set	18649.17	25295.40	19876.56	1.3143867	1.402315

ARIMA (0,0,1)(0,0,1)[12]

RMSE: 25295.40

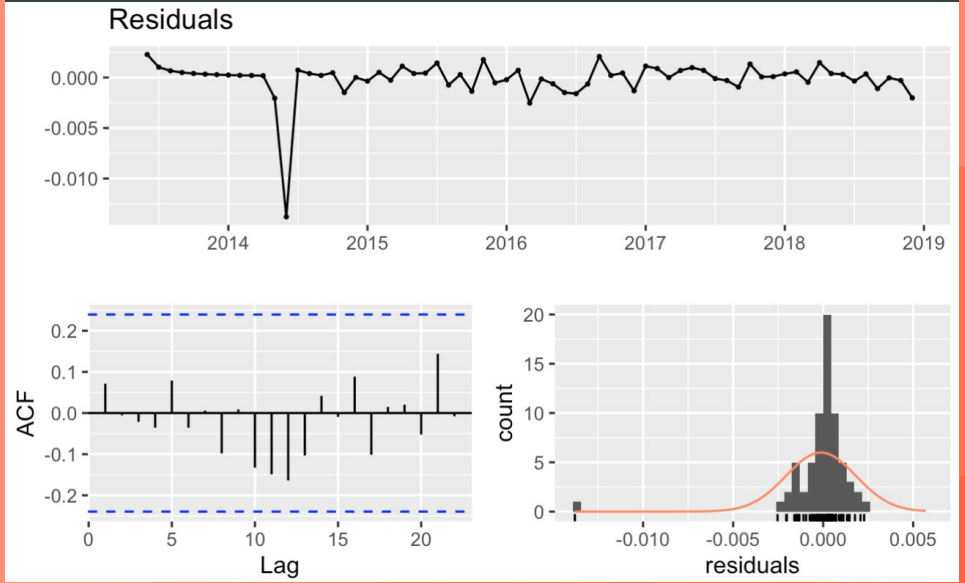
MAPE: 1.314

ETS:

RMSE: 58948.25

MAPE: 3.4089

```
checkresiduals(flightaforecast)
shapiro.test(flightaforecast$residuals)
```

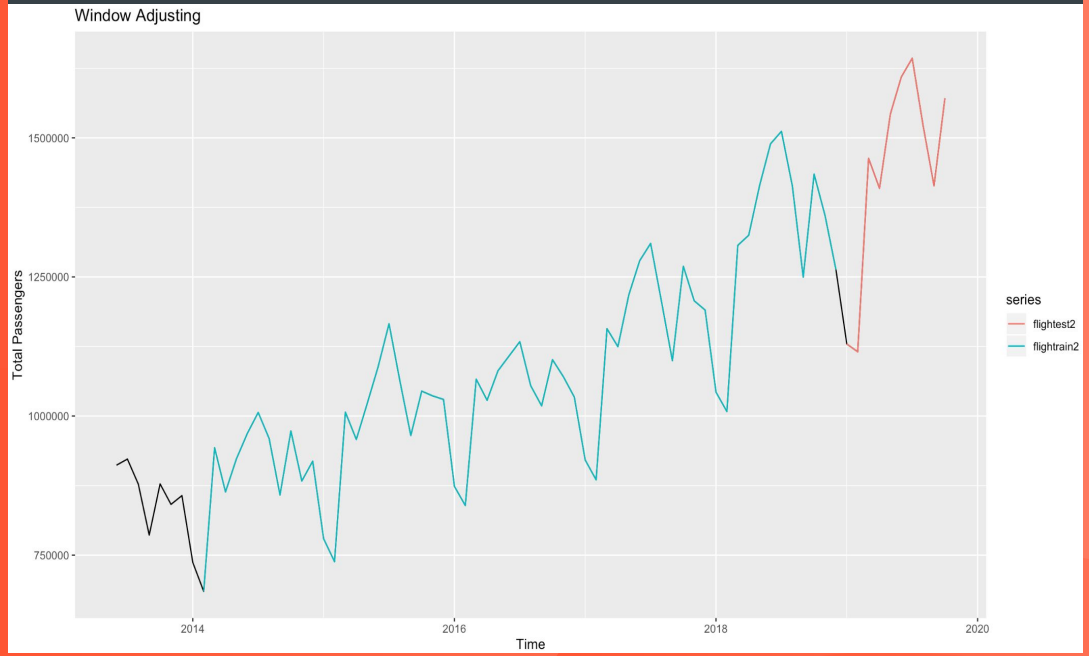



```
        Ljung-Box test

data:  Residuals from ARIMA(0,1,1)(0,1,1)[12]
Q* = 8.2427, df = 11, p-value = 0.6914

Model df: 2.   Total lags used: 13


        Shapiro-Wilk normality test

data:  flightaforecast$residuals
W = 0.53012, p-value = 2.571e-13
```

Tweaking our Results

Modifying the training period to enhance accuracy

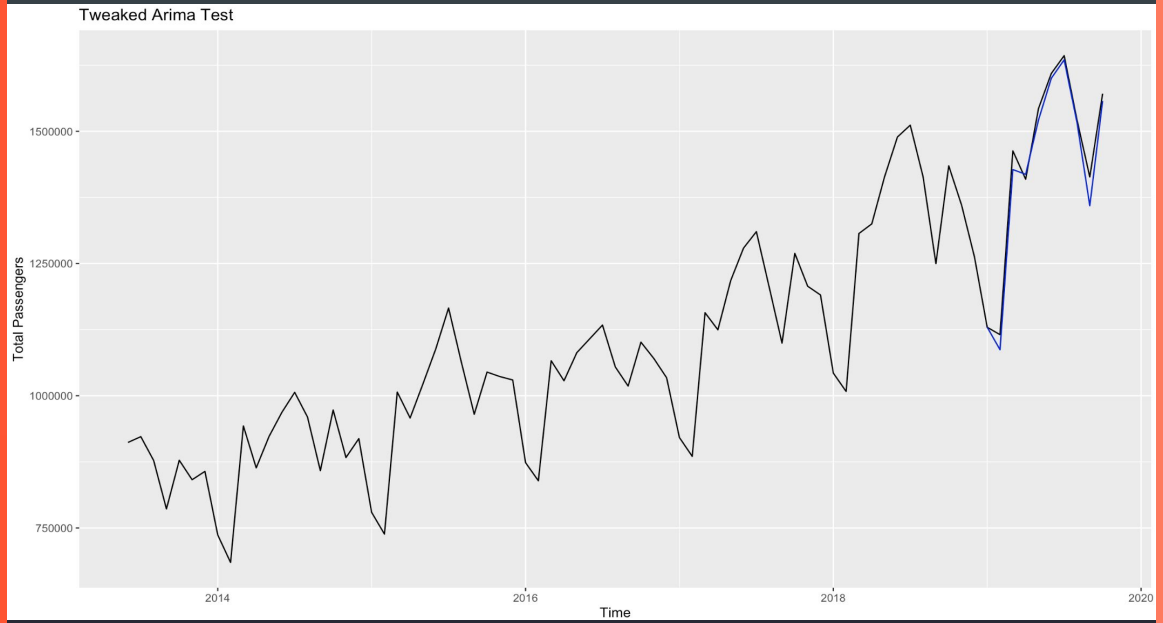
```
flightrain2 <- window(dft, start=c(2014,2), end=c(2018,12))
flightest2 <- window(dft, start=c(2019,1))
```



Assessing the Relevance of the First Year

Testing Over the Same Period of Time

```
flightarima2 <- Arima(flightrain2, order=c(0,1,1), seasonal = c(0,1,1), lambda=l)
flightforecast2 <- forecast(flightarima2, h=length(flightest))
accuracy(flightforecast2, flightest)
```



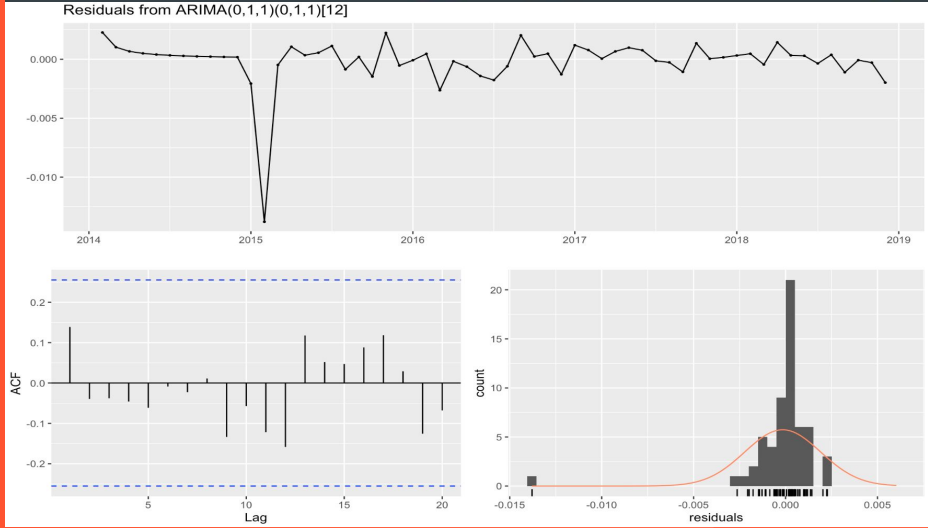
	ME	RMSE	MAE	MPE	MAPE
Training set	-4863.655	56148.48	29848.90	-0.6581834	3.042124
Test set	16607.255	24384.51	18504.91	1.1791834	1.314146

Use of same ARIMA Model

Significant Reduction in Prediction Errors

Previous RMSE: 25295.40

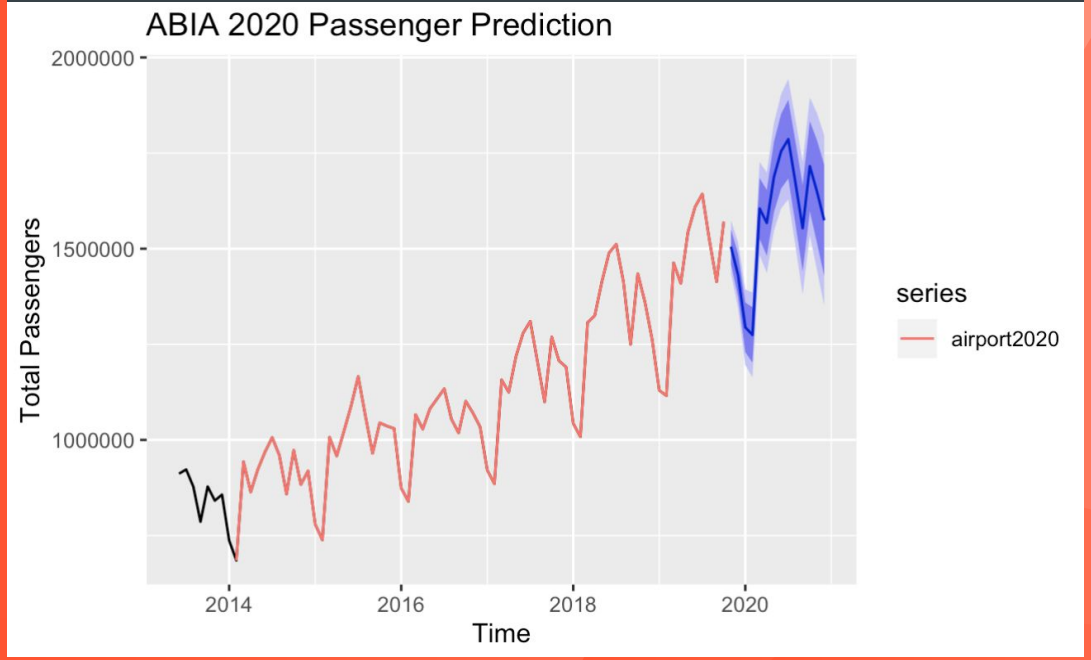
```
checkresiduals(flightforecast2)
```




```
shapiro.test(flightforecast2$residuals)
```

```
        Ljung-Box test

data:  Residuals from ARIMA(0,1,1)(0,1,1)[12]
Q* = 6.3844, df = 10, p-value = 0.782

Model df: 2.   Total lags used: 12


        Shapiro-Wilk normality test

data:  flightforecast2$residuals
W = 0.54166, p-value = 2.692e-12
```

```
airport2020 <- window(dft, start=c(2014,2))
pred2020 <- Arima(airport2020,order=c(0,1,1), seasonal=c(0,1,1), lambda = l)
pred2020f <- forecast(pred2020, h = 14)
```



The 2020 Forecast

Back to the 2040 Master Plan

Using our prediction to assess expansion validity

2020 Passenger Traffic

```
for (i in 3:14){
  sum2020 <- sum2020 + pred2020f$mean[i]
  sum2020l <- sum2020l + pred2020f$lower[i,2]
  sum2020u <- sum2020u + pred2020f$upper[i,2]
}
```

17,279,124

Lower Bound

95% Confidence Interval

19,135,319

Mean Prediction

20,991,514

Upper Bound

95% Confidence Interval

2020 Passenger Traffic

15 Million Passengers

Current Yearly Capacity

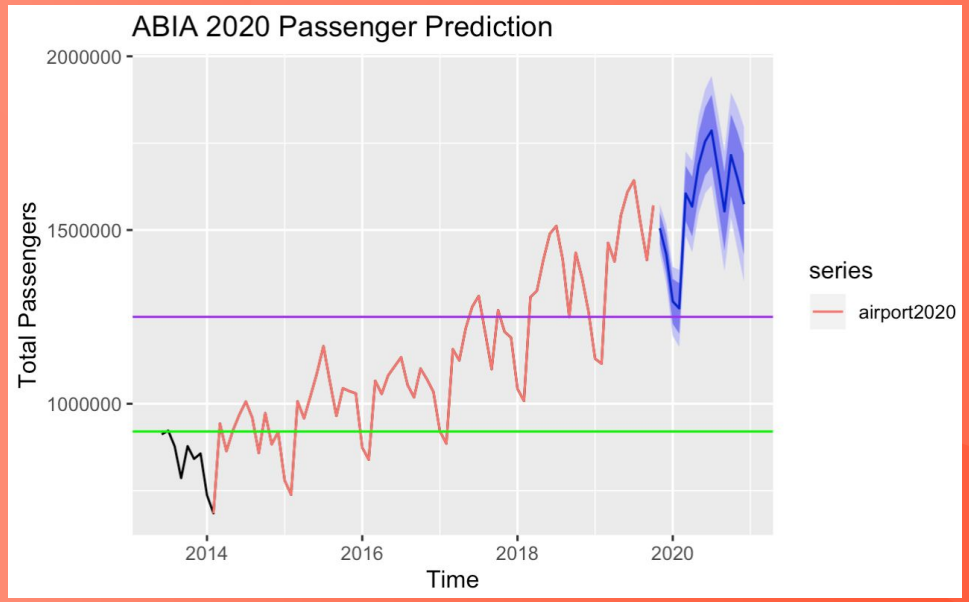
Between 17-21 Million Passengers

Are Predicted to use the ABIA in 2020

Original Airport could Facilitate around 11 Million Passengers Yearly

1.7X the Current Capacity is Expect to use ABIA in 2020

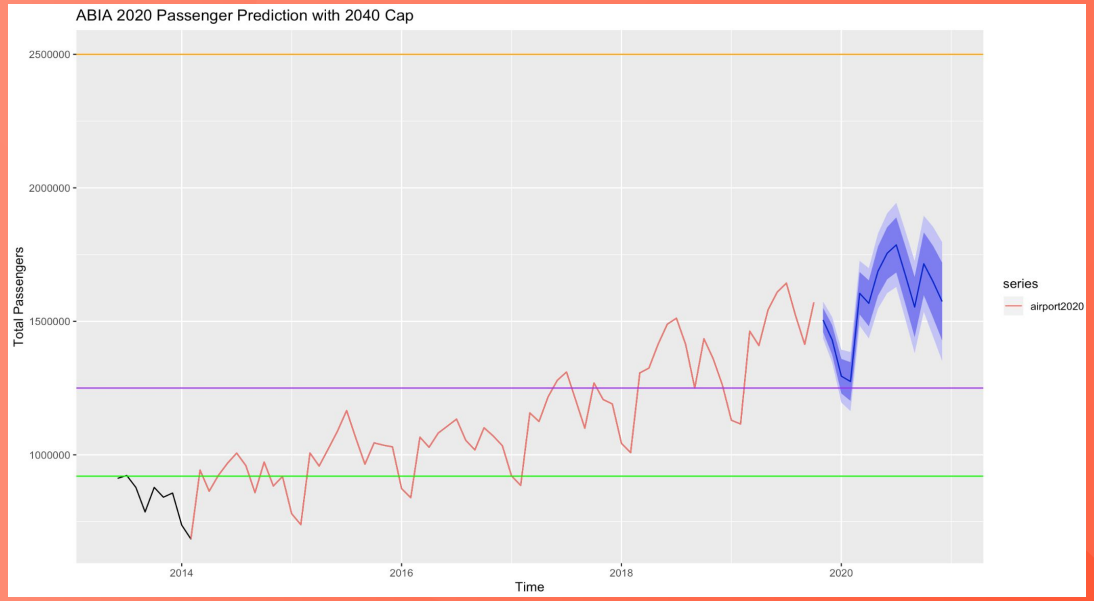
2020 Passenger Traffic



920,000 Average Monthly Passenger at Original Capacity

1,250,000 Average Monthly Passengers at Current Capacity

2040 Master Plan Capacity



2040 Master Plan Average Monthly Passenger Capacity

2,500,000 Passengers/Month

Conclusions

Current Airport Capacity

Is not enough to handle the projected total passengers for 2020

2040 Plan

Is not only valid but very necessary to manage the influx of passengers

Thanks!

Do you have any questions?

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