Assignment 3: Aircraft Performance Calculations

Date Due: February 15, 2023 Instructor: Trani

Problem 1

A low-fidelity Simulink-based aircraft runway simulator has been developed and it was demonstrated in class. The simulator for this analysis has been modified to approximate the runway performance characteristics of a Boeing 737-8 Max (see Figure 1). You can pick up the Boeing 737-8Max runway simulator at the website. Before using the runway simulator download the Aerospace Blockset from the Mathworks website and install it.

The simulator estimates the the takeoff safe speed using the block labeled “Takeoff Speed at Altitude (knots)” shown below. The takeoff speed of 150 knots if the takeoff speed at sea level conditions. The Takeoff Speed at Altitude is adjusted according to the density ratio if the airport elevation is other than sea level conditions.

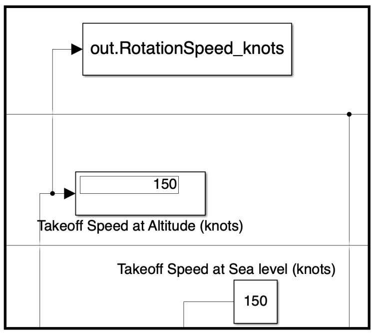
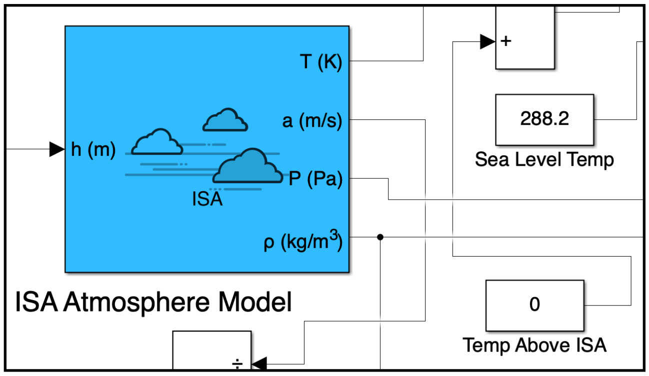


Table 1. Boeing 737-8 Max (A. Trani).
Boeing 737-8 Max with CFM LEAP-1B28B1 engines. 28,000 lbs. of thrust per engine (124,854 Newtons of thrust per engine).


a) Study the effect of temperature on the runway length required to reach the takeoff safe speed. Start with sea level conditions and estimate the runway length required. Create a table and repeat the runway length needed (to reach the



takeoff safe speed) for temperatures ISA, ISA + 10 degrees, ISA + 20 degrees, and ISA + 30 degrees. The temperature condition in the simulator is found in the block shown below (and labeled Temp Above ISA in degrees C.). For each simulation, you estimate the runway length required by inspecting the distance traveled versus speed plot. The runway length needed is the distance required to reach the takeoff safe speed labeled "Takeoff Speed at Altitude (knots)". For example, if the "Takeoff Speed at Altitude (knots)" is calculated to be 160 knots, the runway length is the distance traveled by the aircraft to reach the 160 knots. In the calculations use 81,000 kgs. as the aircraft takeoff mass.

b) Plot the runway length versus temperature above ISA and comment on the effect of temperature above ISA on runway length.

c) Study the effect of airport elevation on the runway length required to reach the takeoff safe speed. Start with sea level conditions and estimate the runway length required for airport altitudes 750, 1500, 2250, and 2,500 meters. In the calculations use 81,000 kgs. as the aircraft takeoff mass.

d) For part (c) comment on the reduction of the maximum (peak) takeoff thrust versus airport elevation. Estimate the percent of thrust loss from sea level to 2,500 meters.

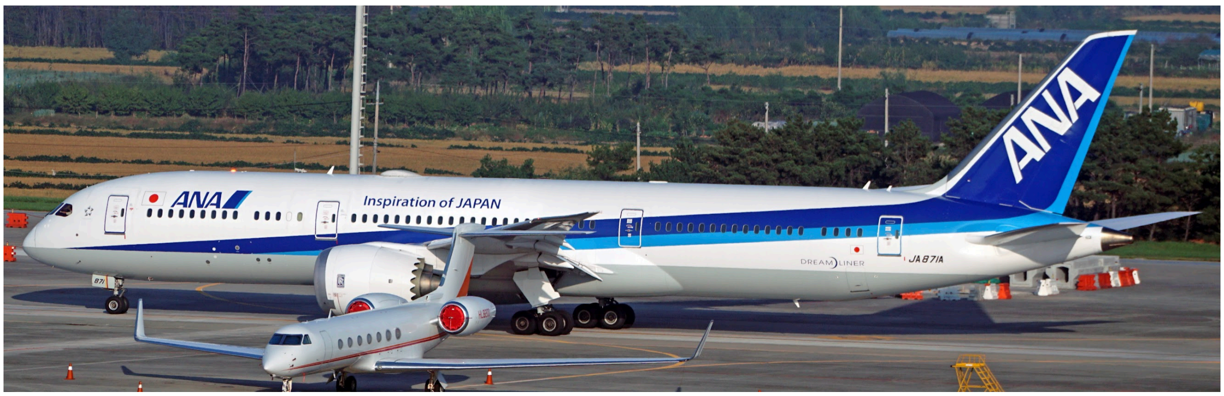
e) For part (c) comment on the reduction of the maximum acceleration versus airport elevation. Estimate the percent of the maximum acceleration loss from sea level to 2,500 meters.

f) Study the effect of aircraft mass on the runway length required to reach the takeoff safe speed. Start with a low takeoff mass of 65,000 kgs. Repeat the estimate of runway length using takeoff mass of 70,000 kgs., 75,000 kgs., and 80,000 kgs. Comment on the trends observed.

Problem 2

An airline is evaluating two aircraft to operate flights from Austin–Bergstrom International Airport (AUS) Airport. The following table shows the aircraft proposed by Boeing. Two origin-destination pairs the airline would like to fly with the selected aircraft are: a) AUS-LHR and b) AUS-ICN. In your analysis use the latest version of the Boeing documents.

Table 1. Boeing 787-9 and Boeing 787-10 Considered in the Airline Evaluation.

Aircraft Considered
Boeing 787-9 with High-Thrust Rolls-Royce engines (see picture below). The aircraft has a maximum design takeoff weight of 561,500 lb. With 290 seats in a two-class layout. See other characteristics in the Boeing documents for airport planning and design.

Boeing 787-10 with High-Thrust Rolls-Royce engines. Aircraft maximum design takeoff weight is 560,000 lb. 330 seats in a two-class layout. See other characteristics in the Boeing documents for airport planning and design.

The design airport temperature used should be the average of the daily high temperatures of the hottest month of the year. Use the Climate Explorer website (https://crt-climate-explorer.nemac.org/climate_graphs) to find the mean maximum temperature of the hottest month of the year. More detailed information about the airport can be found at the AIRNAV database available on the web at: http://www.airnav.com/airports/ or visit the airport site.

a) Find the average stage length to be flown between each one of the critical OD airport pairs. In your analysis use the Great Circle Flight Path mapper link provided in our interesting web sites. Add 6% to the distances calculated to account for real Air Traffic route conditions and to account for possible weather deviations from the optimal Great Circle flight path.

b) Find the runway length needed for each one of the aircraft operating the critical route. Determine if AUS has enough runway length to support flights with all seats full.

c) Repeat part (b) assuming a load factor of 0.84 (84% of the seats used).

d) If the aircraft carries 84% of the seats full, can the flight carry additional belly cargo as payload?

e) Using the Payload-Range diagram of each aircraft, and using the longest route, find the Specific Air Range (SAR) parameter for each aircraft. Comment on the SAR values calculated.

f) Considering various factors such as payload, fuel economy, and potential of additional belly cargo, which aircraft is the best for this airline? Explain.

Problem 3

A new low-cost airline is evaluating The Airbus A220-300 to operate flights from a variety of airports including Washington, Reagan Airport (DCA) and Eagle County Airport (EGE). The airline would like your help to evaluate the A220-300 with the Pratt and Whitney PW1524G or with the lower thrust PW1521G.

Table 2. Aircraft Considered in the Airline Evaluation.

Aircraft Considered in the Analysis
Airbus A220-300 140 seat configuration. Maximum takeoff weight is 149,000 lbs.


The design airport temperature used should be the average of the maximum daily temperatures of the hottest month of the year. Use the Climate Explorer website (https://crt-climate-explorer.nemac.org/climate_graphs) to find the mean maximum temperature of the hottest month of the year. More detailed information about the airport can be found at the AIRNAV database available on the web at: http://www.airnav.com/airports/ or visit the airport site.

In your analysis use the latest version of the Airbus A220-300 documents for airport design (http://128.173.204.63/courses/cee5614/sites_ce_5614.html#Aircraft_Data).

a) Find the maximum range that the airline can fly from both airports at maximum takeoff weight. Evaluate the departure conditions for both engines and the usual airport design temperature conditions.

b) Do both airports have enough runway to support maximum takeoff weight departure operations?

c) Estimate the average fuel per passenger on a 2,000 nm (includes detour factor)for the aircraft.

d) Find the SAR for the same 2,000 nm trip.

e) Considering various airport operating conditions which aircraft engine would you recommend?

Problem 4

Use the data for the transport aircraft similar to the Boeing 737-800 (http://128.173.204.63/courses/cee5614/cee5614_pub/Boeing737800Jet_class.m) to answer the following questions.

a) Calculate total drag produced by the aircraft during a climb profile with an Indicated Airspeed of 240 knots at 1,200 meters above mean sea level conditions. Assume atmospheric conditions to be ISA. The aircraft weight is 72,000 kgs.

b) Repeat the process when the aircraft is climbing at 10,300 meters and an indicated Mach number of 0.76.

c) Estimate the instantaneous fuel consumption for each flight condition given in parts (a) and (b).

d) Comment on the observed trends.