CEE 5614 Analysis of Air Transportation Systems — Spring 2023

Assignment 6: Cost Models, Air Traffic, and Runway Operations

Solution — Instructor: Trani

Problem 1 Aircraft Development Cost Model

Use the aircraft cost development model and the Transonic Truss-Braced Aircraft file provided in class to answer the following:

a) Find the unit production cost if 1000 units of the aircraft are sold worldwide. Assume the maximum mach number at FL 370 is 0.73.

Cost development model using the following values:
OEW = 88,000 lbs (40,000 kgs)
Maximum speed = 419 knots (Mach 0.73 at FL 370)
Maximum sea level thrust = 24,000 lbs.
Cost per Airframe (1,000 units) = 90.43 million dollars.

b) Show a parametric plot of unit costs versus quantity produced from 400 to 1000 units.

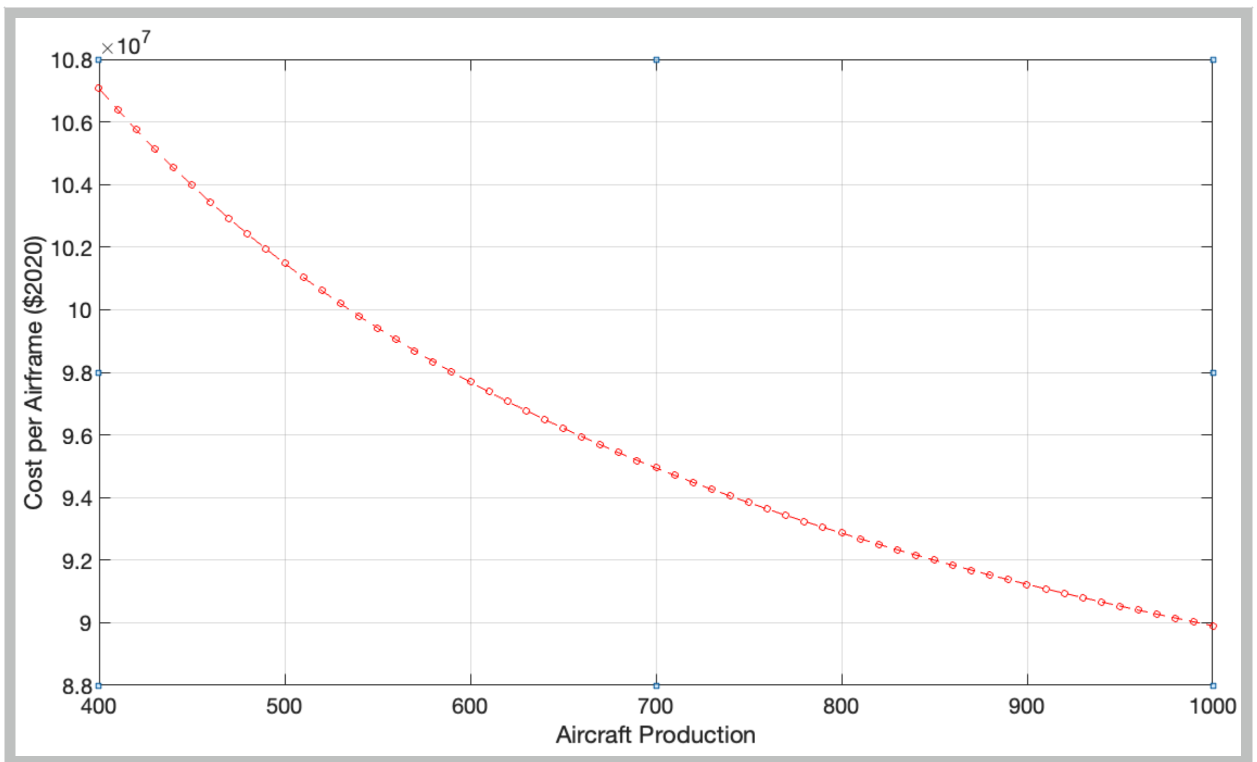

Figure 1. Unit Cost Development for TTBA Aircraft.

c) Assume a stretched fuselage version of the TTBA is produced with OEW at 43,000 kgs, Mach 0.72 and a more powerful engine with 27,000 lbs. of thrust (at sea level ISA conditions). Find the new unit cost for the same 1,000 units produced. Comment on the sensitivity of the unit cost to the parameters changed.

Cost development model using the following values:
OEW = 94,600 lbs (43,000 kgs)
Maximum speed = 419 knots (Mach 0.73 at FL 370)
Maximum sea level thrust = 27,000 lbs.
Cost per Airframe (1,000 units) = 95.5 million dollars.

The airframe unite costs increases by 5% with the higher thrust engine and the additional operating empty weight (OEW).

d) Compare the predictions of the model with list prices included in the class notes. Is the model reasonable?

Yes the model is reasonable. The cost of a Boeing 737-700 is slightly higher because it is heavier and faster than the TTBA aircraft.

e) Compare the cruise fuel consumption of the TTBA aircraft flying at Mach 0.72 and FL 370 with a Boeing 737-800 aircraft (http://128.173.204.63/cee5614/cee5614_pub/Boeing738_class.m) flying at Mach 0.76 and FL 370. In both cases assume the aircraft start the cruise segment with a mass 10% below the maximum takeoff weight. Perform the calculation at the TOC point. Comment on the answers obtained and put an economic context into the solution by estimating the annual savings at $2.75 per gallon.

At the TOC, we estimate the following fuel burns:
Fuel burn for TTBA at FL370 and Mach 0.72 is: 26.8 kg/min
Fuel burn for Boeing 737-800 class at FL370 and Mach 0.76 is: 45.6 kg/min

Problem 2 (Basic ATC and Runway Separations)

Answer briefly the following ATC-related questions.

a) An Airbus A321neo cruises at Mach 0.76 at FL 350 over Las Vegas (Nevada). Name the ATC service that oversees the flight.

Air Route Air Traffic Control Center (ARTCC)

b) For part (a), is the aircraft flying East or West. Comment.

Flying East according to the Hemispherical routes.

Aircraft Operating	On course degrees magnetic	Assign	Examples
Below 3,000 feet above surface	Any course	Any altitude	
At and below FL 410	0 through 179	Odd cardinal altitude or flight levels at intervals of 2,000 feet	3,000, 5,000, FL 310, FL 330
	180 through 359	Even cardinal altitude or flight levels at intervals of 2,000 feet	4,000, 6,000, FL 320, FL 340
Above FL 410	0 through 179	Odd cardinal flight levels at intervals of 4,000 feet beginning with FL 450	FL 450, FL 490, FL 530
	180 through 359	Odd cardinal flight levels at intervals of 4,000 feet beginning with FL 430	FL 430, FL 470, FL 510
One way routes (except in composite systems)	Any course	Any cardinal altitude or flight level below FL 410 or any odd cardinal flight level above FL 410	FL 270, FL 280, FL 290, FL 300, FL 310, FL 410, FL 430, FL 450
Within an ALTRV	Any course	Any altitude or flight level	
In aerial refueling tracks and anchors	Any course	Altitude blocks as requested. Any altitude or flight level	050B080, FL 180B220, FL 280B310

Figure 1. TTBA Aircraft Development. Source: https://www.faa.gov/air_traffic/publications/atpubs/atc_html/chap4_section_5.html

c) Find the minimum separation between two runways able to operate simultaneous instrument landing procedure arrivals with a Precision Runway Monitor (PRM) radar.

The FAA authorizes (on a special cases) simultaneous approaches down to 3,000 to 3,200 feet.

d) Use Google Earth and the FAA airport diagram to familiarize yourself with the runway configuration at Chicago O'Hare airport. Can runways 27R and 27L be operated independently for instrument approach arrivals? Comment on the rule used.

Yes, The runway spacing is more than 4300 feet.

e) Can ORD airport operate three simultaneous arrivals in Westflow (flying to the West) in instrument conditions? Name the runways selected in south flow operations.

Yes.

Problem 3 Basic ATC

An Airbus A350 flying over the North Atlantic at position 56 North and 45 West of Greenwich contacts ATC to request a flight level change.

a) Name the technology used by the pilot to contact ATC.

Cockpit Pilot Data Link System (CPDL-C)

b) What is the time latency specification for the message to go from pilot to controller and return to the pilot?

Typically the CPDL-C oceanic specification is 120-180 seconds (2-3 minutes).

c) Briefly describe what is the difference between SID and STAR routes used in air traffic control procedures in the terminal area.

SIDs are departure routes. STARs are arrival routes.

Problem 4 Performance-Based Navigation

Read the article on Performance Based Navigation (https://www.faa.gov/air_traffic/publications/atpubs/aim_html/chap1_section_2.html) and answer the following:

a) Explain the difference between RNAV procedures and PBN procedures.

According to the FAA AIM:

Required Navigation Performance (RNP)

"RNP is a statement of navigation performance necessary for operation within a defined airspace"

"RNP is RNAV with the added requirement for onboard performance monitoring and alerting (OBPMA)"

Area Navigation (RNAV)

"RNAV is a method of navigation that permits aircraft operation on any desired flight path within the coverage of ground- or space-based navigation aids or within the limits of the capability of self-contained aids, or a combination of these."

"RNAV includes procedures, such as SIDs and STARs"

b) For approach segments to an airport, what is the level of accuracy (RNP) expected?

0.3 to 1.0 nautical miles

c) What is the RNP value for enroute operations (domestic)

Two nautical miles.