FLIGHT SCHOOL DECISION SUPPORT SYSTEM

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Project Overview

To deliver a system allowing flight schools to visualize the effects and improve the results of decision making in lowering the cost of operating aircraft at a flight school.

This system may be useful to flight training programs that are struggling to maintain operations, contributing to a perceived shortage in the number of pilots available to the aviation industry.

Agenda

Context

Problem and Need Statement

Stakeholders

System Requirements

Method of Analysis

Design

Results

Analysis

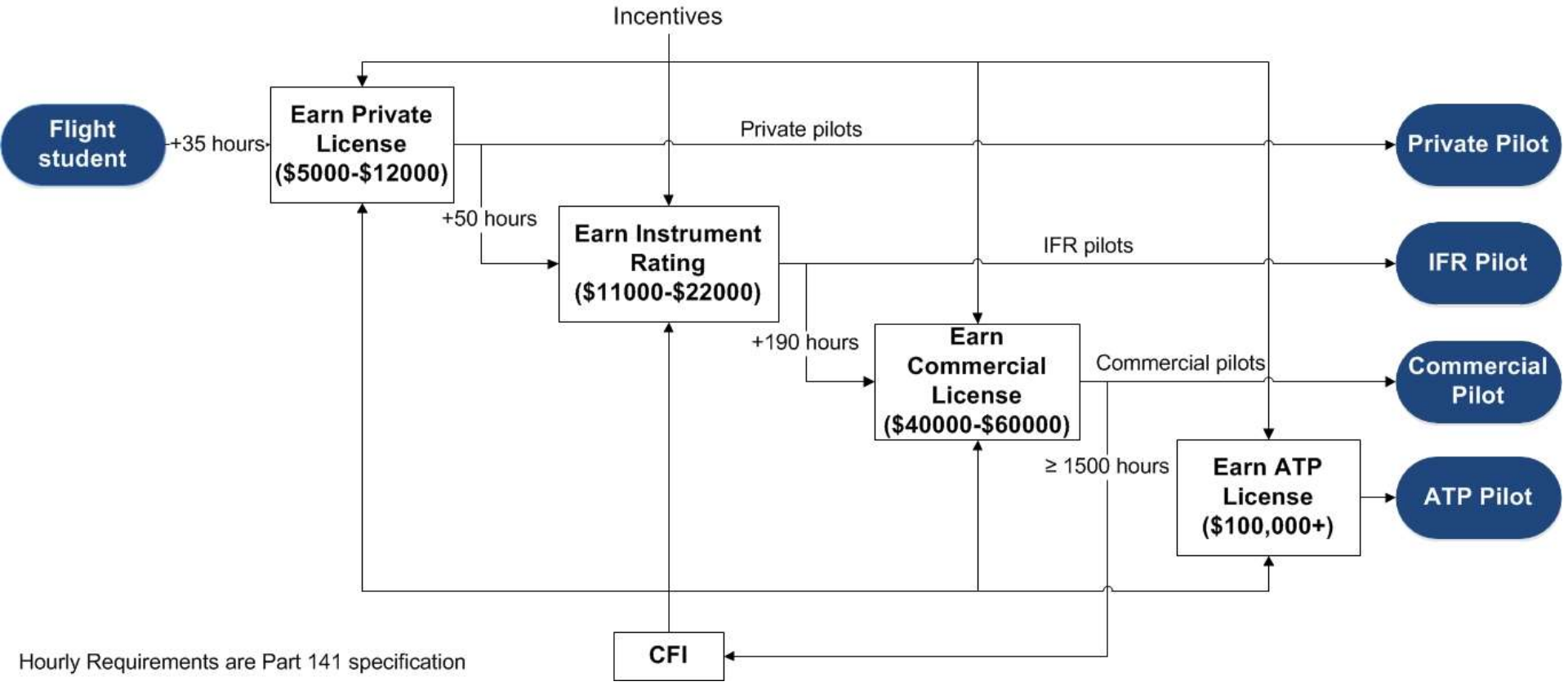
Conclusion

Why Help Flight Schools?

There exists a belief that the number of pilots needed by various industries is exceeding the supply and that a major hindrance to the creation of new pilots exists at the level of primary training.

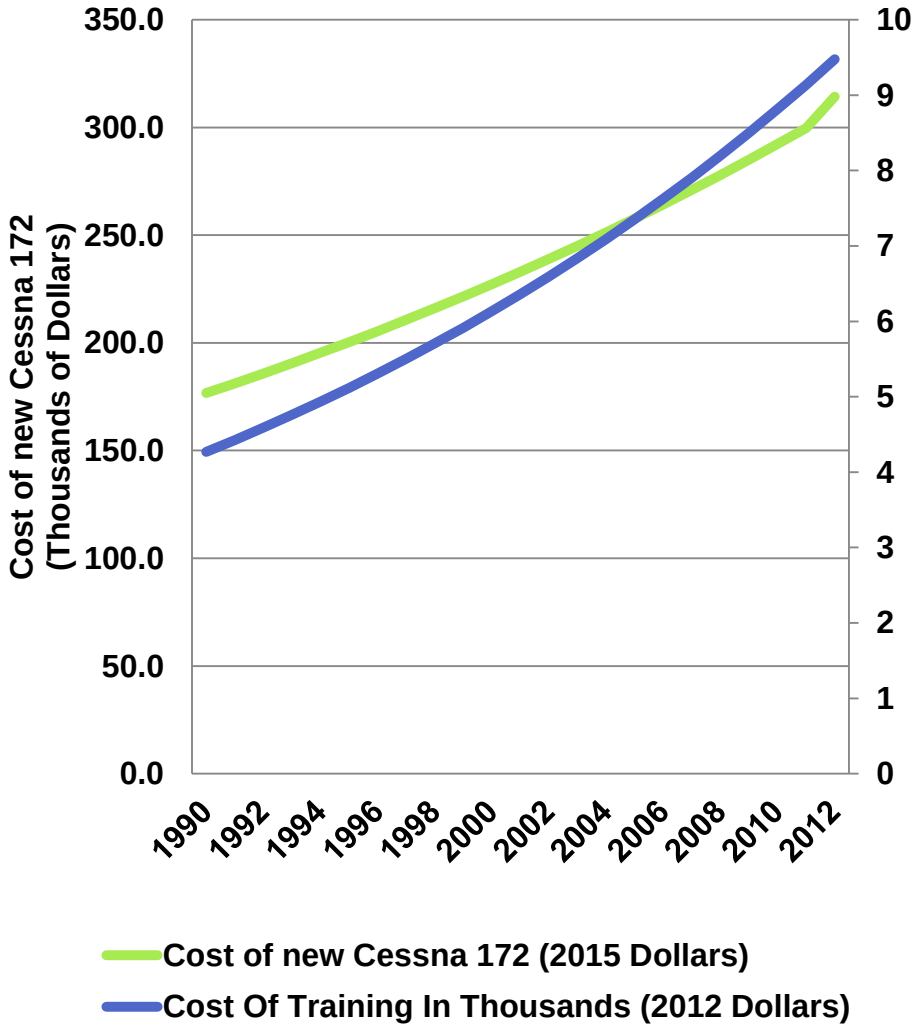
Primary training is the process by which student pilots are educated by Certificated Flight Instructors (CFI) at flight schools with the goal of earning a Private Pilot certificate, after which point they may continue training to eventually become Commercial or Airline Transport Pilots (ATP).

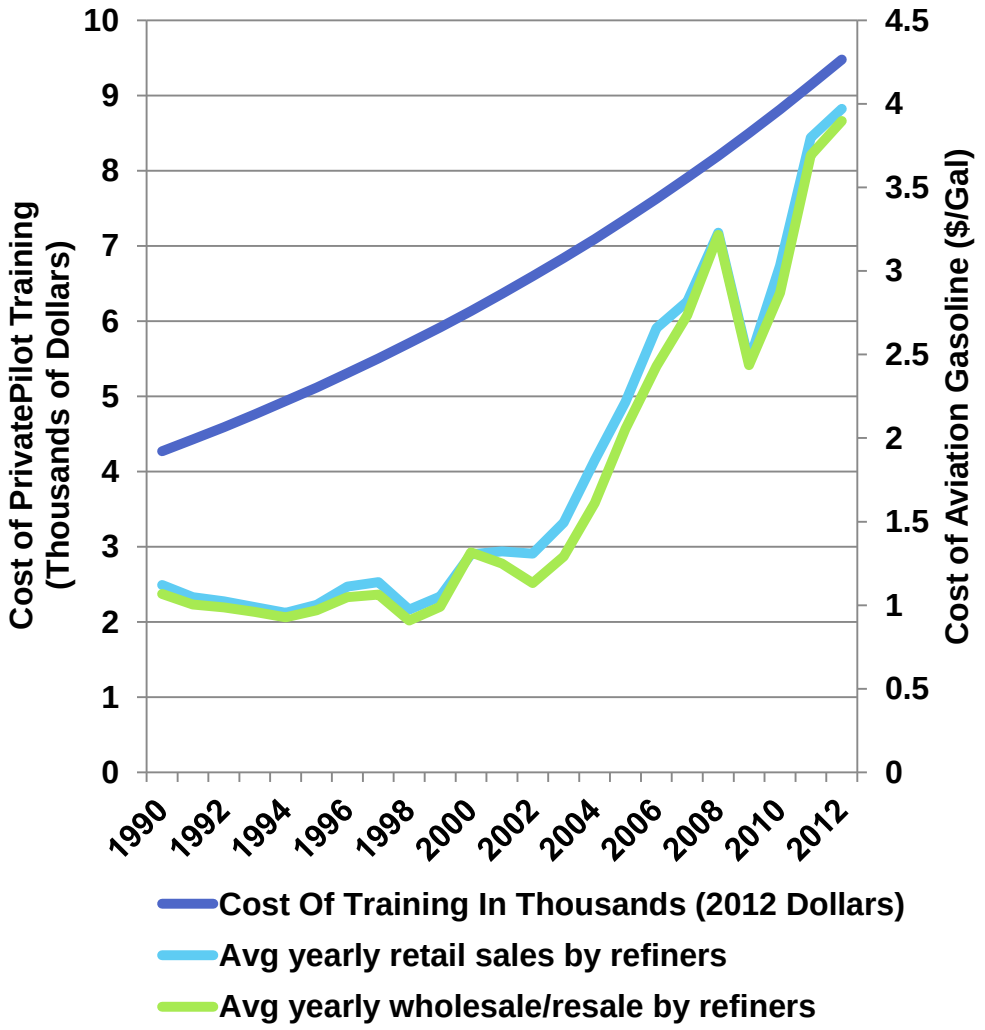
Pilot Training Life Cycle



Source: AOPA [4], Dulles Aviation

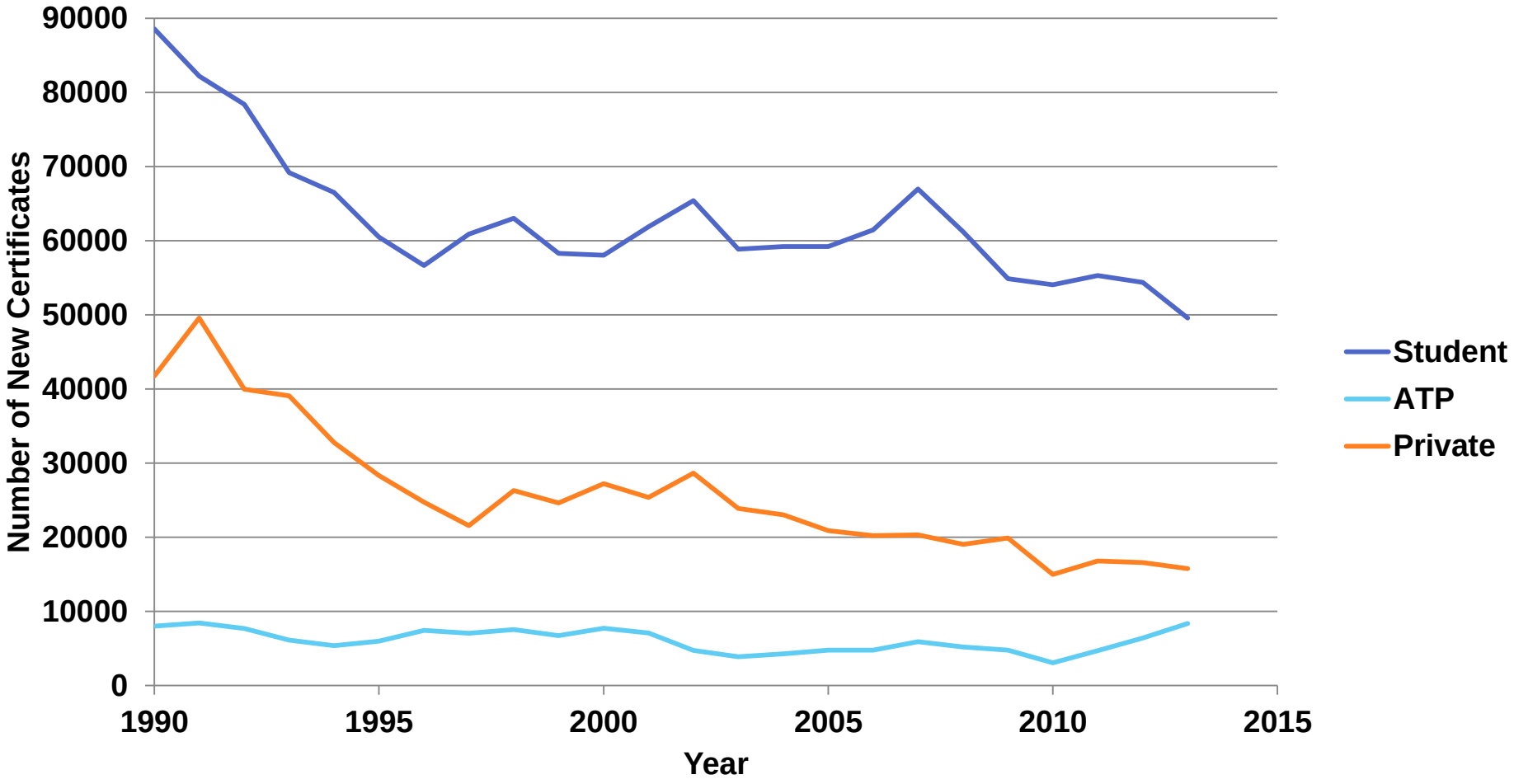
Higher Component Costs Increase Price of Training





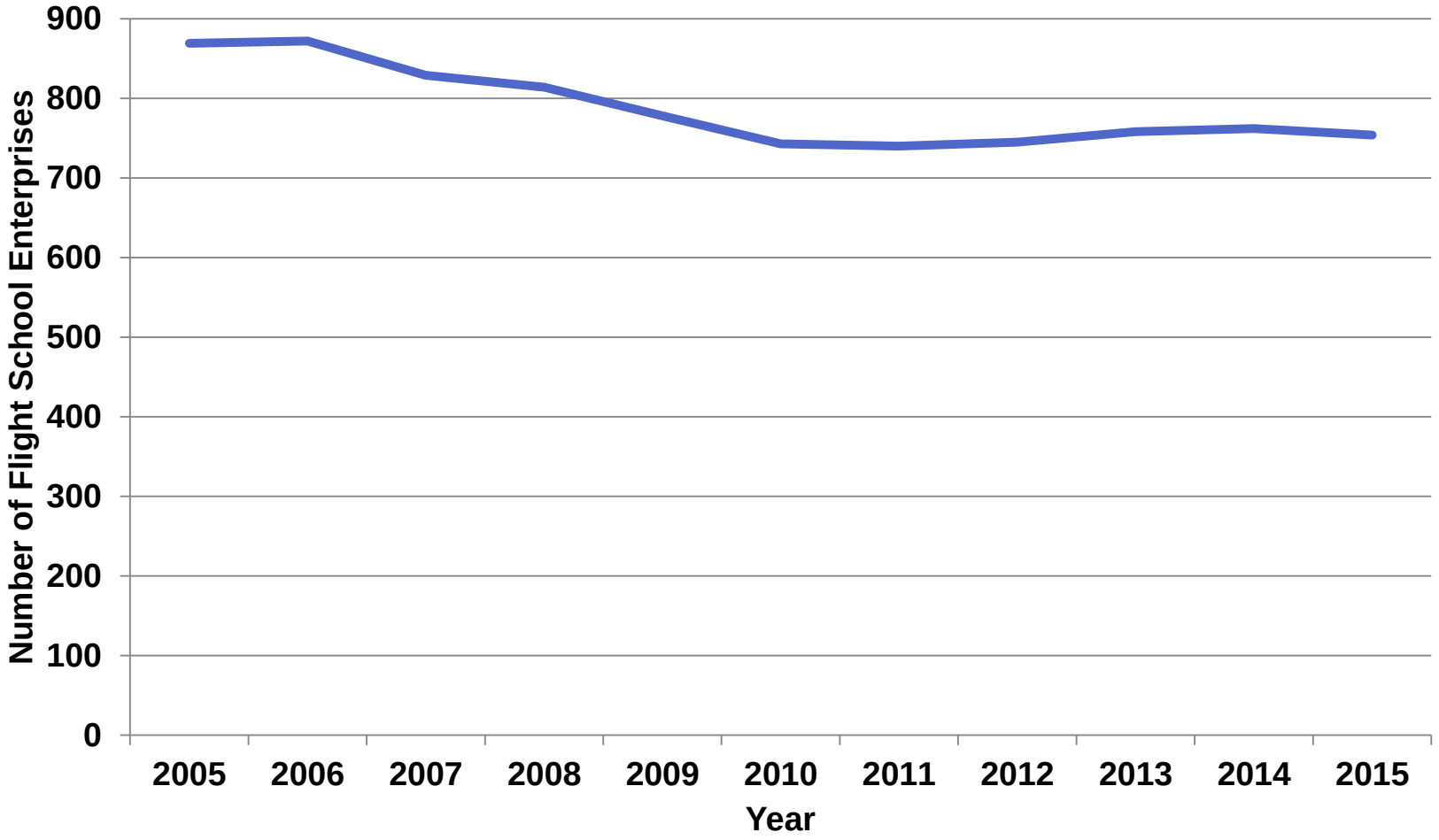
Source: University of North Dakota [1], Energy Information Administration [2], Smithsonian Air & Space [10], Cessna [11]

Pilot Throughput is Decreasing



Source: Federal Aviation Administration [6]

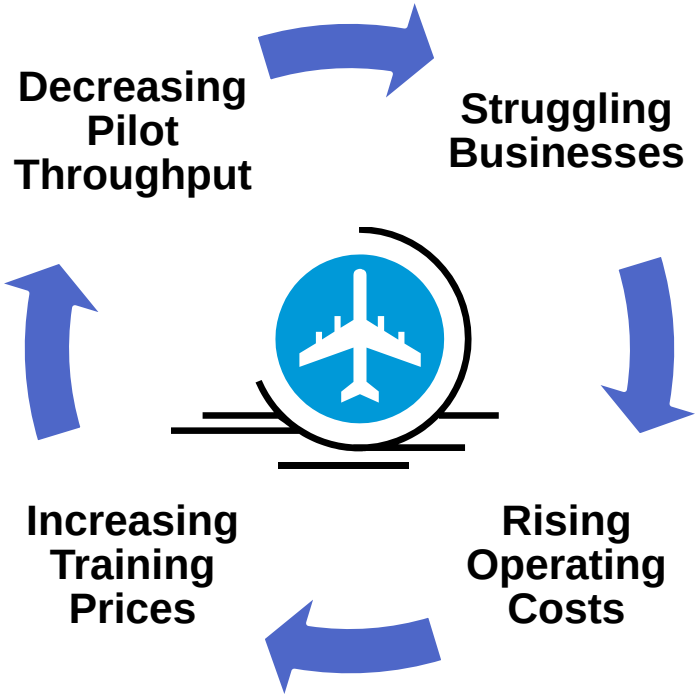
13% Decrease in Number of Flight Schools



Source: IBISWorld [5]

Problem Statement

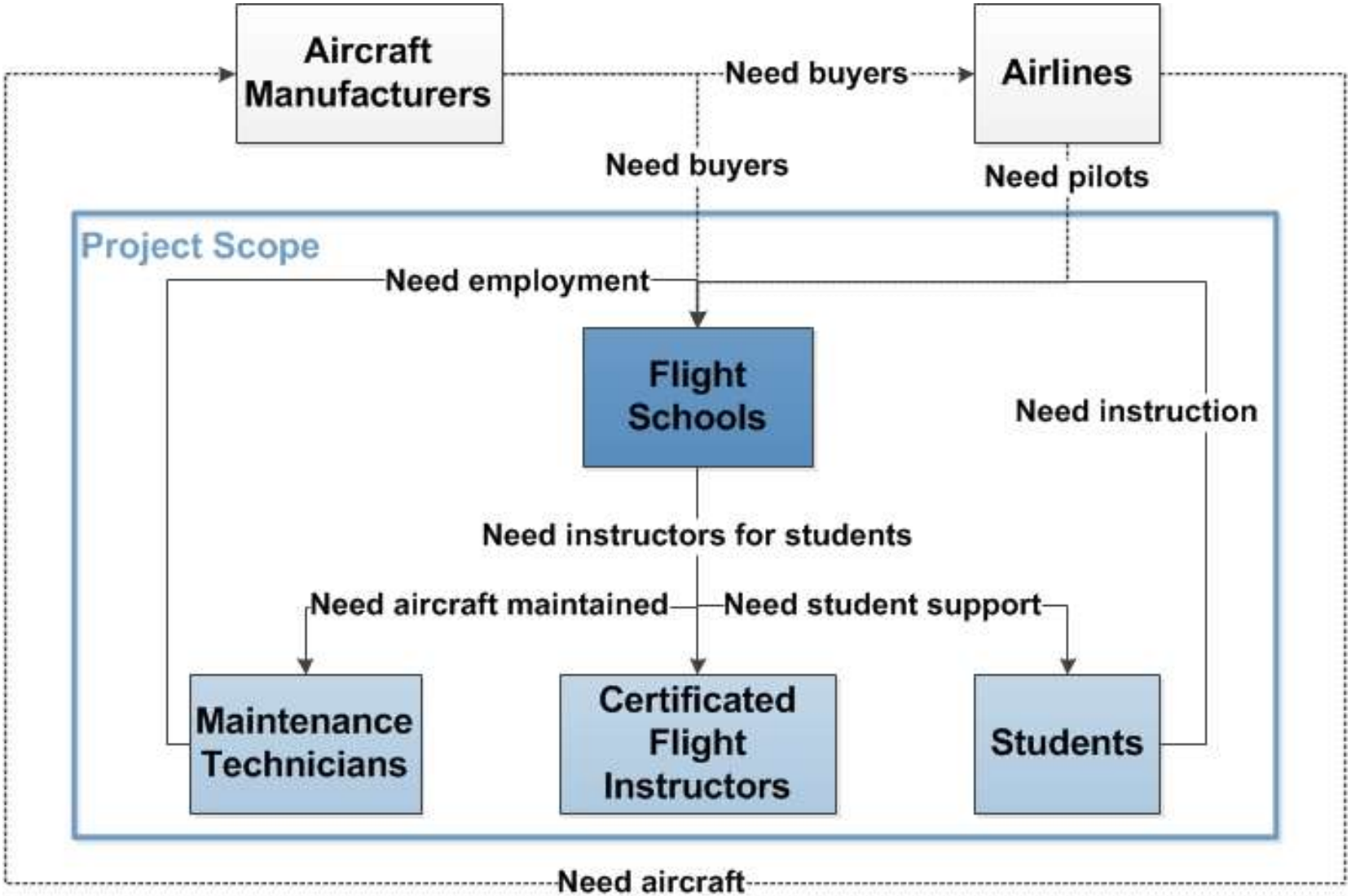
The hypothesis is **that the increased operating cost of aircraft is contributing to higher prices** at flight schools, leading to lost customers and struggling businesses.



Need Statement

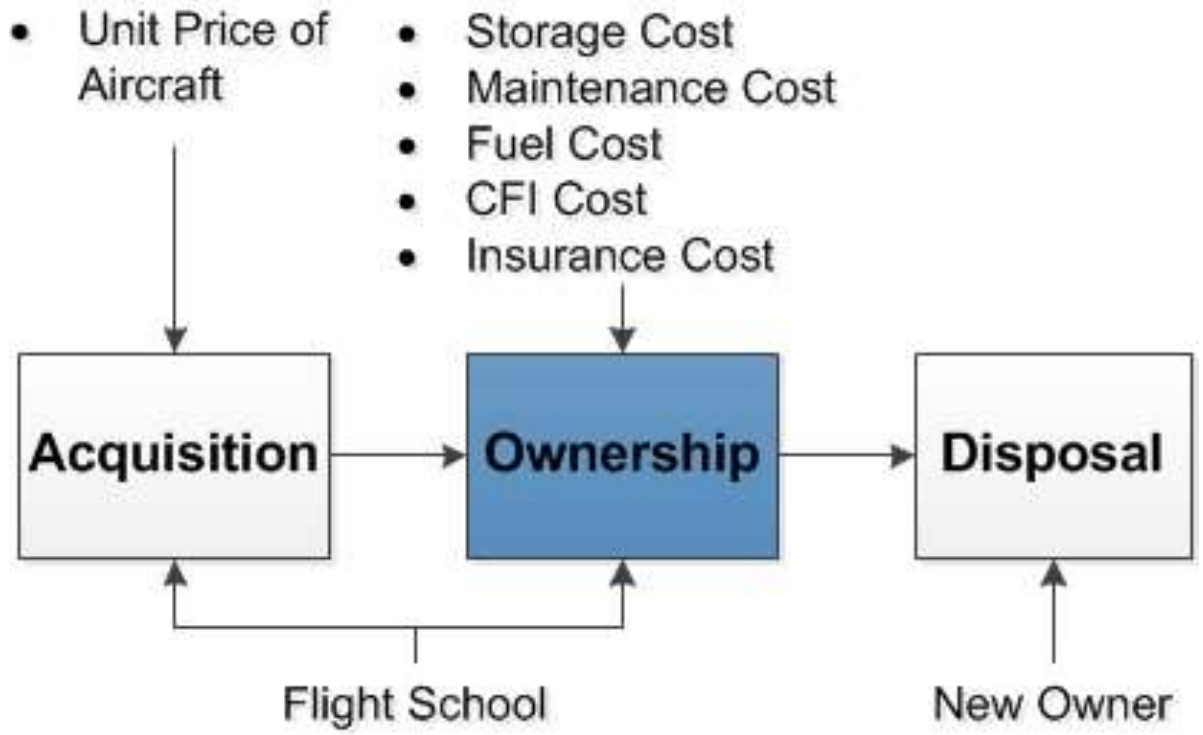
With the higher prices of obtaining a license resulting in lower pilot throughput at flight schools, **there is a need to assist schools in reducing the costs associated with operating the aircraft used in training new pilots.**

Stakeholder Relationships



Scope

The focus will be on private flight schools, with a concentration on the costs directly associated with flying a single-engine, primary trainer aircraft.



Mission Requirements

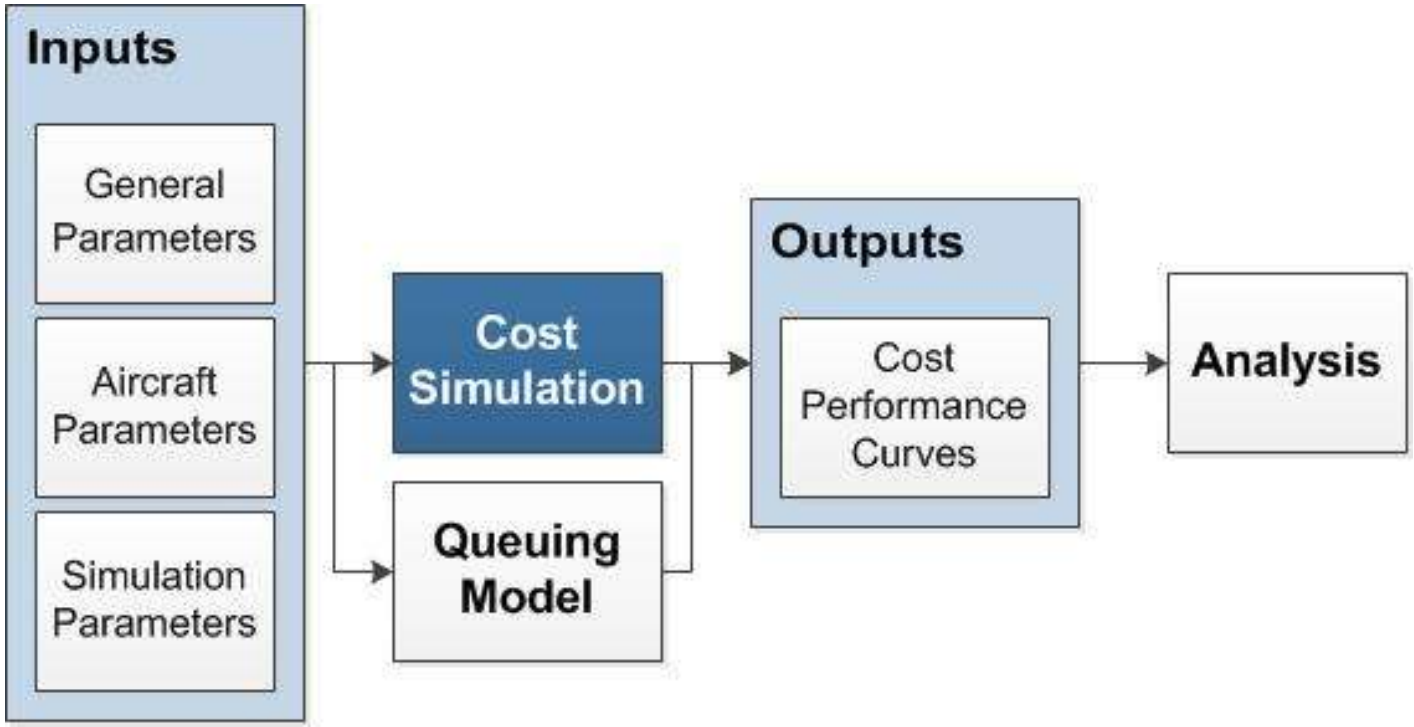
MR.1 The system shall provide a set of cost-performance curves for an array of selected aircraft

MR.2 The system shall provide a utility analysis across a given set of qualities in each aircraft

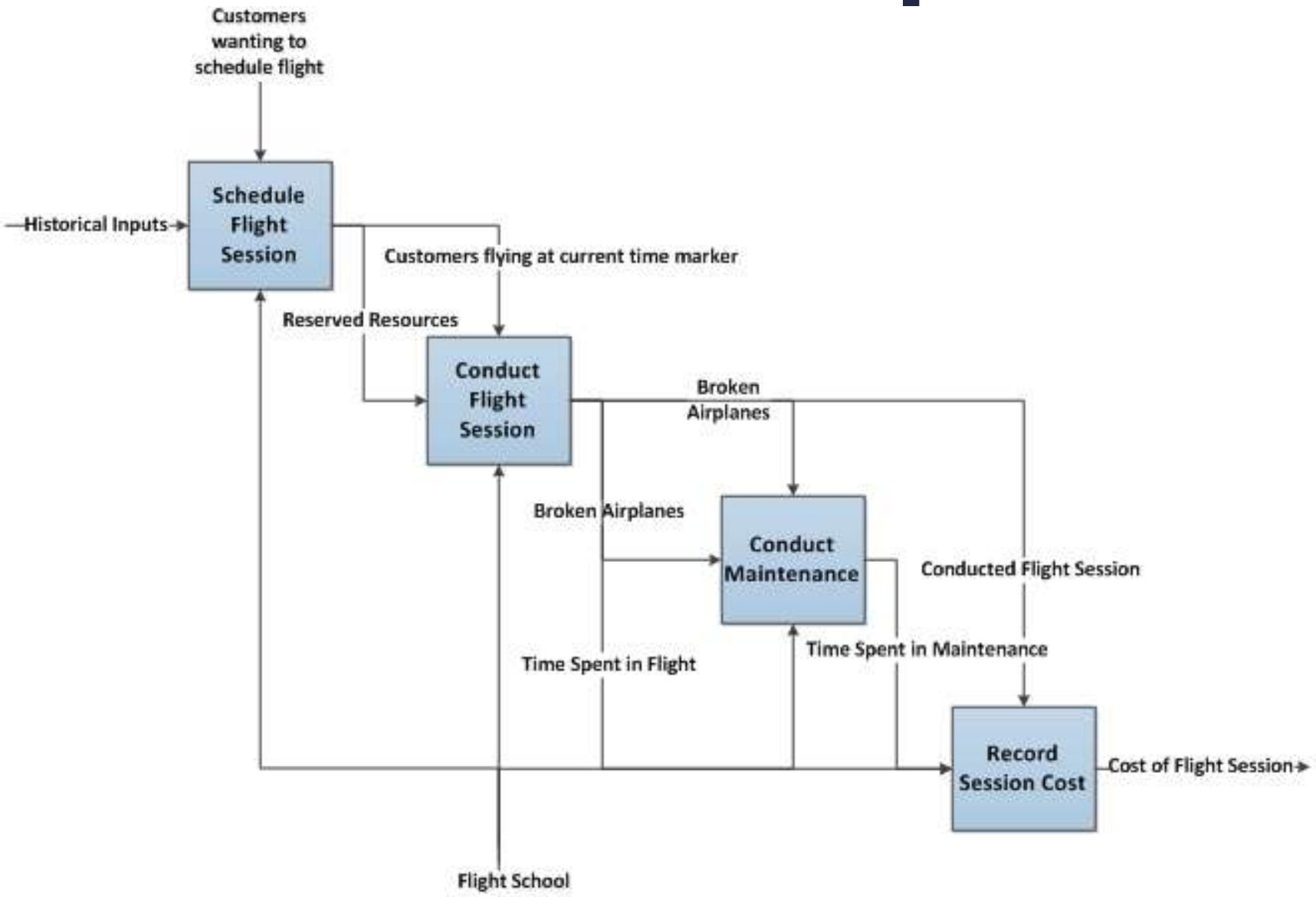
MR.3 The system shall recommend an aircraft that minimizes the cost of flight school operations

Method of Analysis

The operation of a homogeneous fleet of aircraft will be stochastically simulated and analyzed for cost performance trends measured against the size of and student demand placed on that fleet.



Stochastic Cost of Operations



Model Inputs

General Parameters

- Number of aircraft, instructors
- Hourly prices for services rendered
- Expected service inter-arrival time (time between flight sessions)
- Expected service duration

Aircraft Parameters

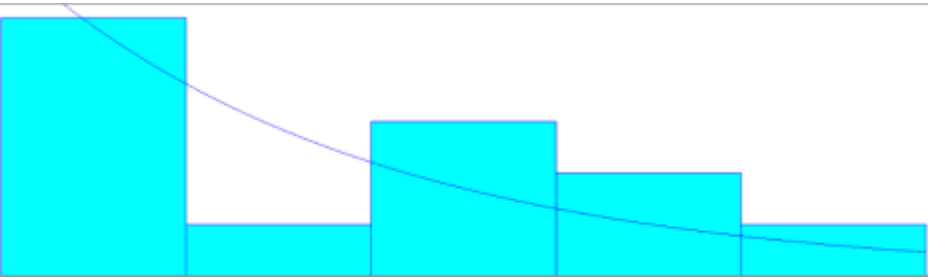
- Aircraft type
- MTBF
- MTTR
- Fuel consumption

Simulation Parameters

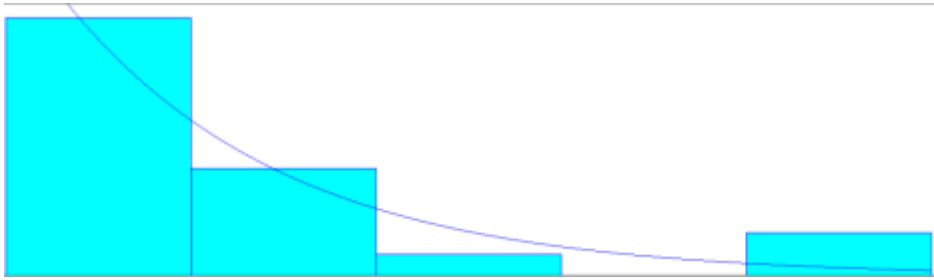
- Simulation duration
- Number of repetitions

Input Analysis – Maintenance

	Symbol	Distribution	μ (hours)	Square Error
Mean Time Between Failures	MTBF	Exponential	463*	0.044
Mean Time to Repair	MTTR	Exponential	53*	0.055



MTBF

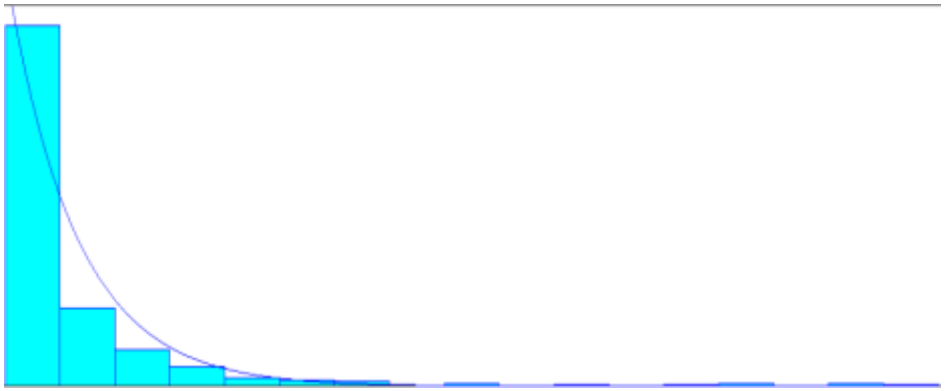


MTTR

***Derived from historical data from one year of two Cessna 172 M flight data from one real flight school**

Input Analysis – Flight Sessions

	Symbol	Distribution	μ (hours)	Square Error
Interval Between Flight Sessions	μ	Exponential	4	0.030
Flight Session Duration	λ	Exponential	1.5	0.003



Interval Between Flight Sessions

Flight Session Duration

Assumptions

The simulation of flight operations is subject to the following constraints:

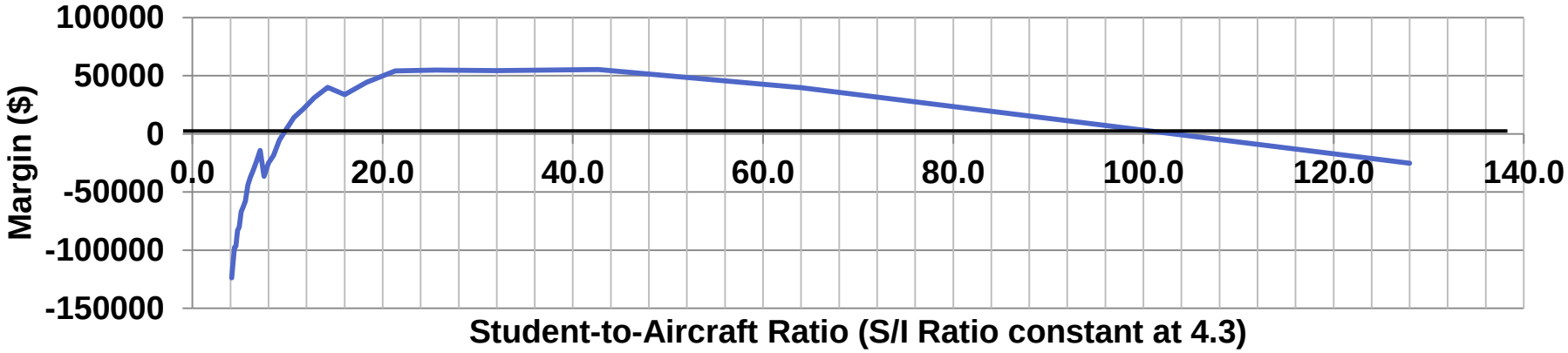
- Flight schools provide service 24/7
- CFIs provide service 24/7
- No queuing delay
- Demand for service is static
- All operations and costs involve student flights
- Maintenance rates are uniform across aircraft types

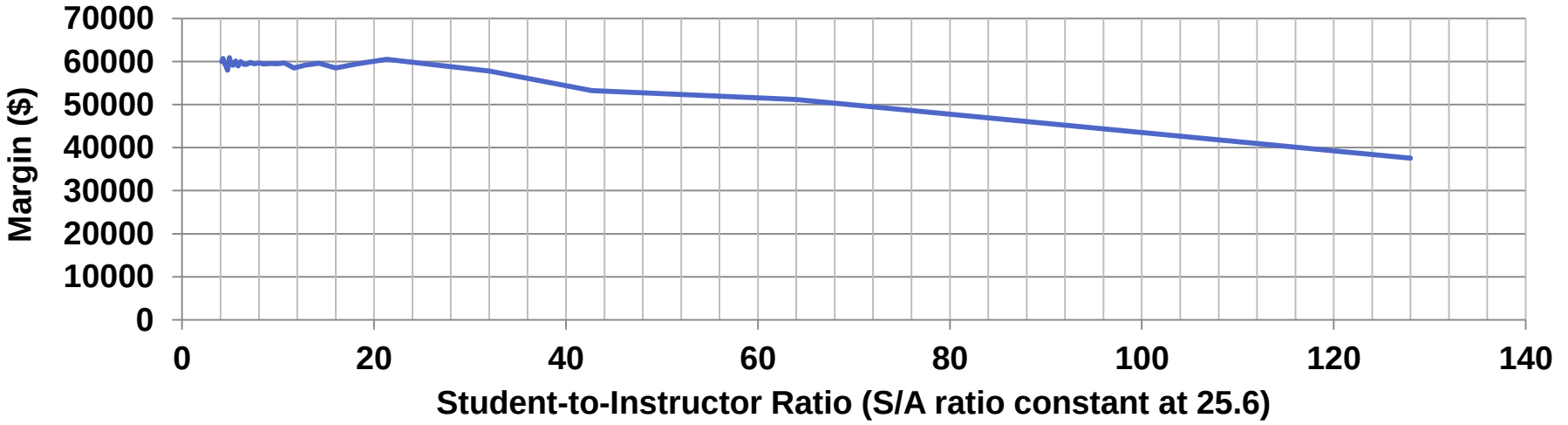
Design of Experiment

Case	# A/C	# CFI
1	1-30	1
2	1-30	2
3	1-30	3
4	1-30	4
•	•	•
•	•	•
•	•	•
30	1-30	30

Variable	Value
Demand (flights/day)	6
No. Students	128
Maintenance Rate ($/hr)	90
Student Rate ($/hr)	150
CFI Rate ($/hr)	70
Storage Rate ($/hr)	0.13
Simulation Duration (yrs)	10
Repetitions	100

Yearly Profit Margin per Aircraft





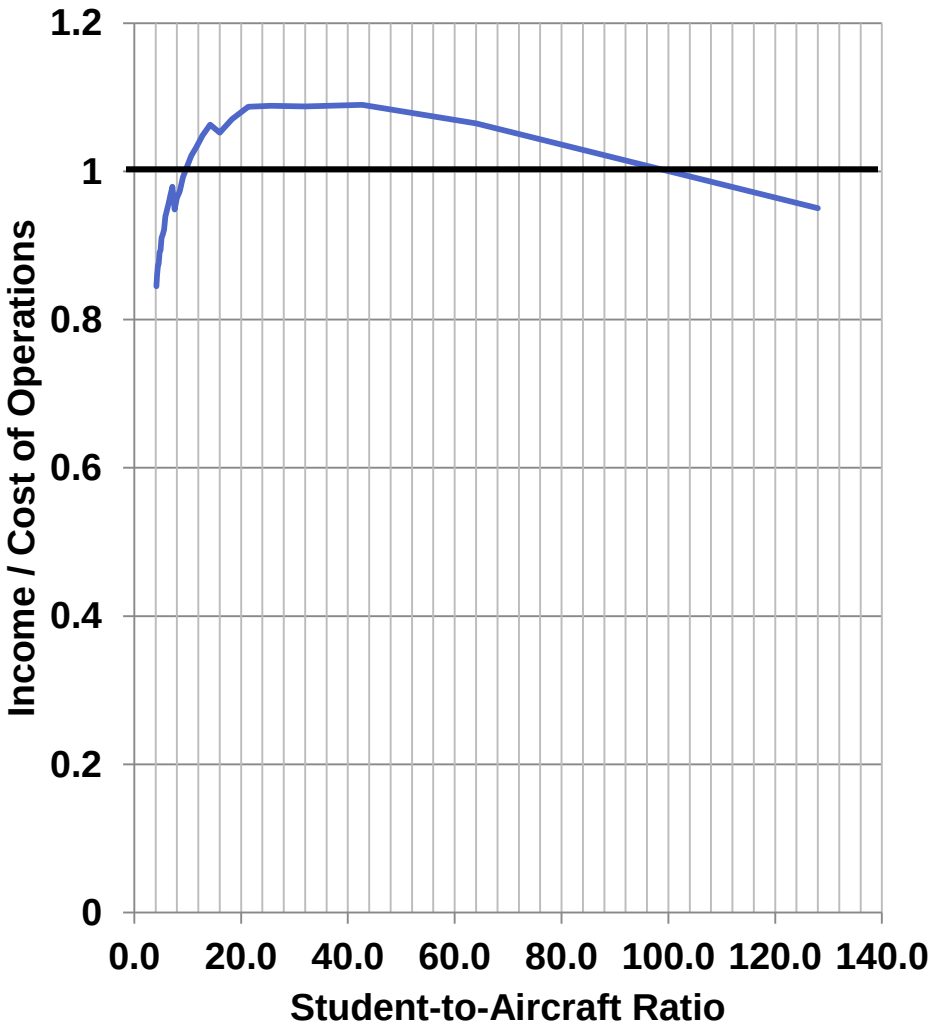
Q_I = quantity of instructors
Q_A = quantity of aircraft
Q_S = quantity of students

$$S/A = \textit{Student-Aircraft Ratio} = \frac{Q_S}{Q_A}$$

$$S/I = \textit{Student-Instructor Ratio} = \frac{Q_S}{Q_I}$$

Results are for a Cessna 172 M

Income and Costs



Q_{insp} = *total number of inspections*
Q_{ovr} = *total number of engine overhauls*

T_U = *total time spent in unexpected maintenance*

C_F = *total cost of flying*
C_M = *total cost of maintenance*

P_F = *price of fuel per gallon*
P_I = *hourly price of CFI*
P_M = *hourly price of maintenance*
P_H = *hourly price of tie-downs per aircraft*

E_F = *fuel consumption rate of aircraft*

$$Cost = C_F + C_M$$

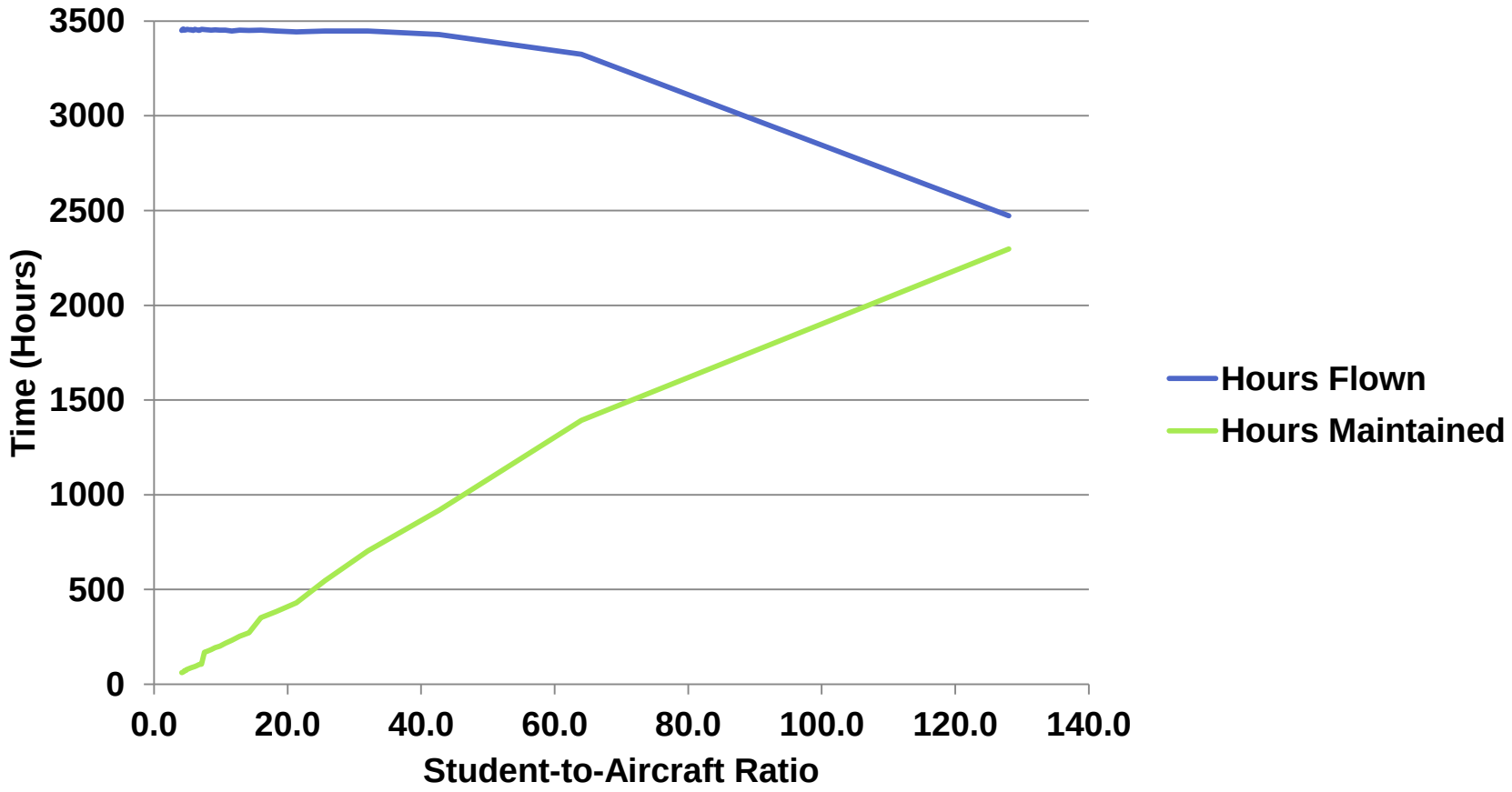
$$C_F = T_F(P_F E_F + P_I)$$
$$C_M = T_S(P_H Q_A) + 4000Q_{insp} + 18000Q_{ovr} + P_M T_U$$

P_S = *hourly price of flight session to students*

$$Revenue = 1.3T_F(0.3P_I + P_S) + 195Q_S$$

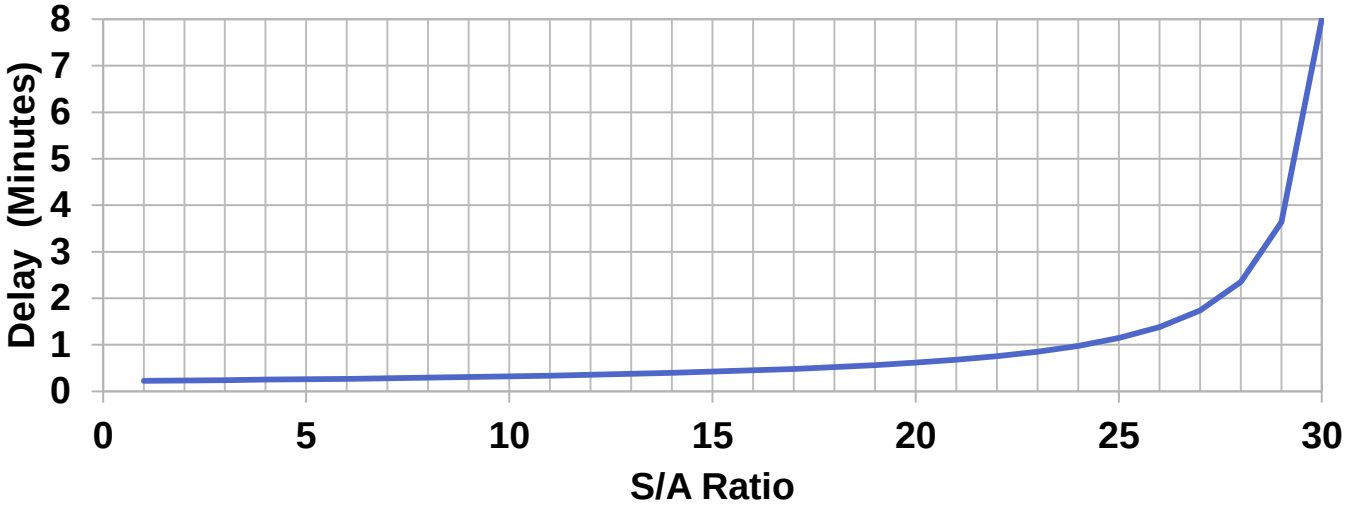
Results are for a Cessna 172 M

Maintenance Increases as S/A Increases



Results are for a Cessna 172 M

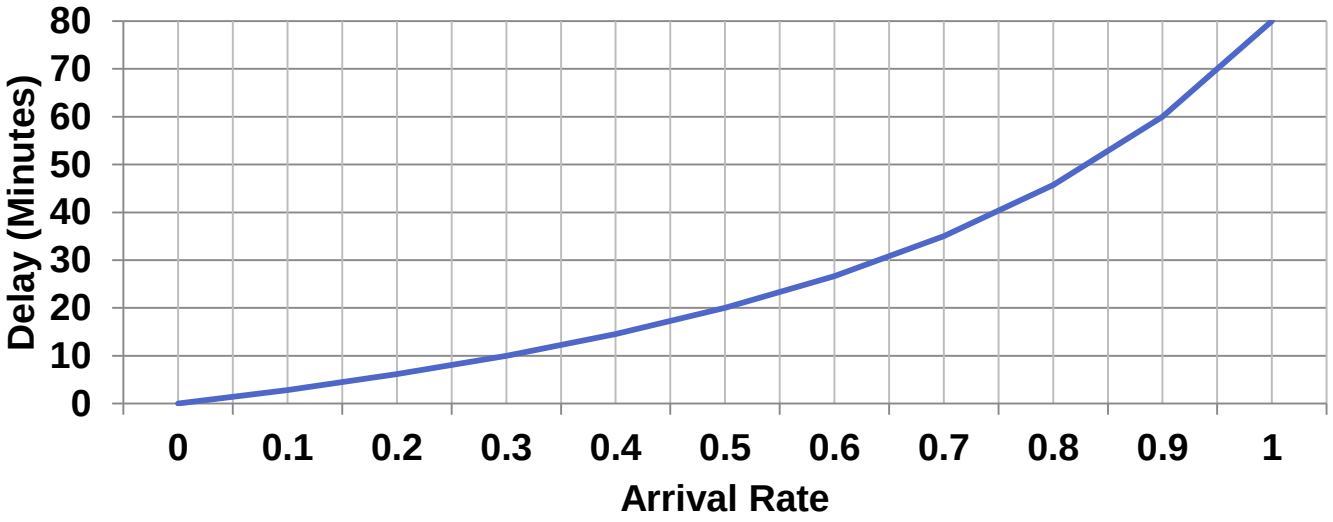
Quality of Service – M/M/1 Queuing Delay



$$\text{Expected Wait Time} = \frac{\lambda}{\mu(\mu-\lambda)}$$

λ = No. Flight Sessions (per hour)

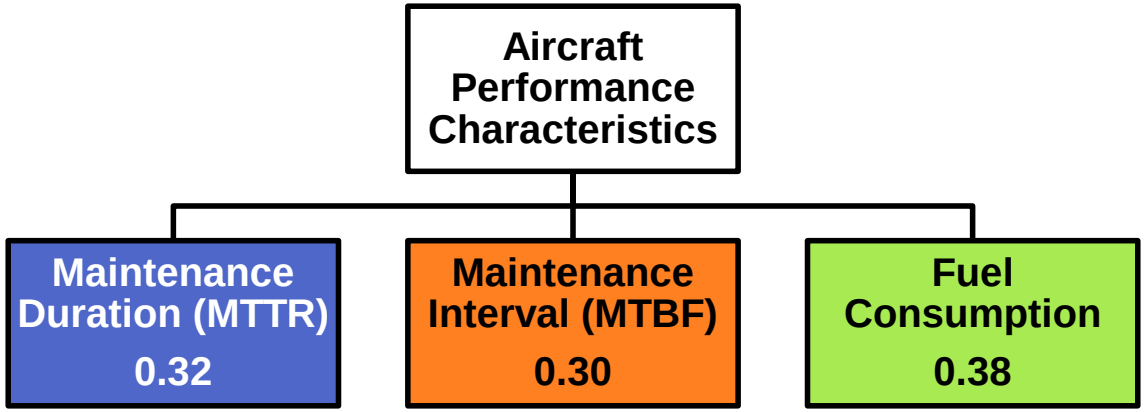
μ = Session Duration (hours)

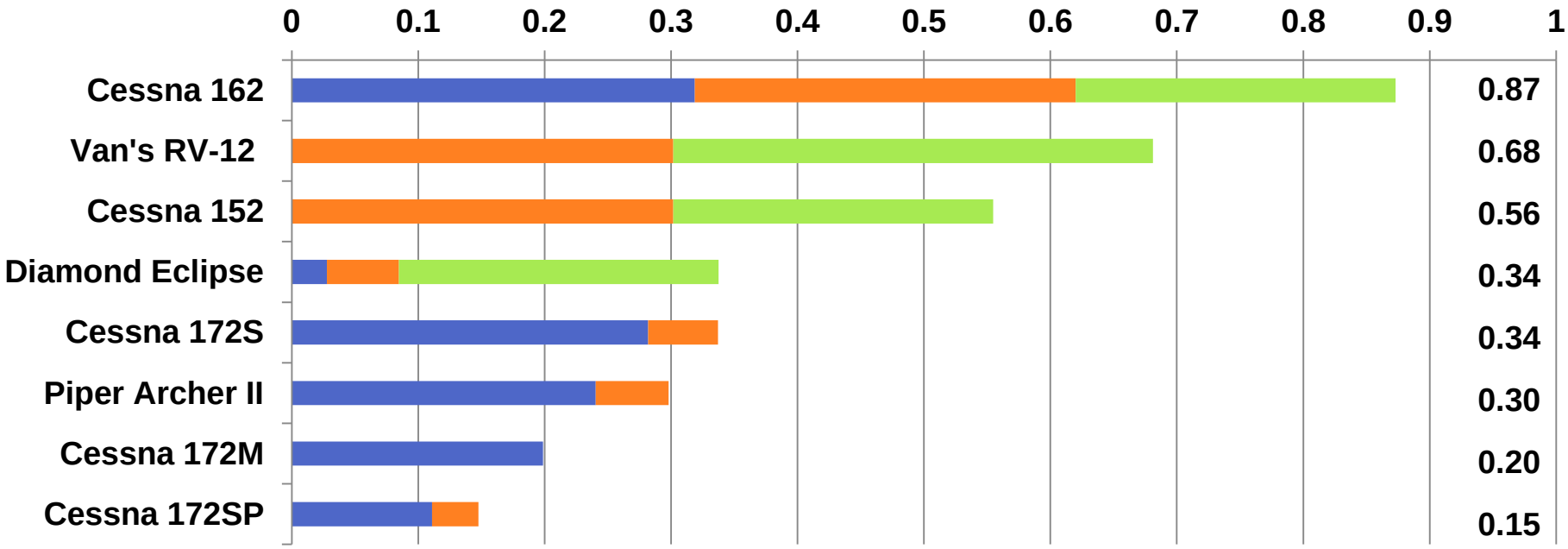


Utility Scores

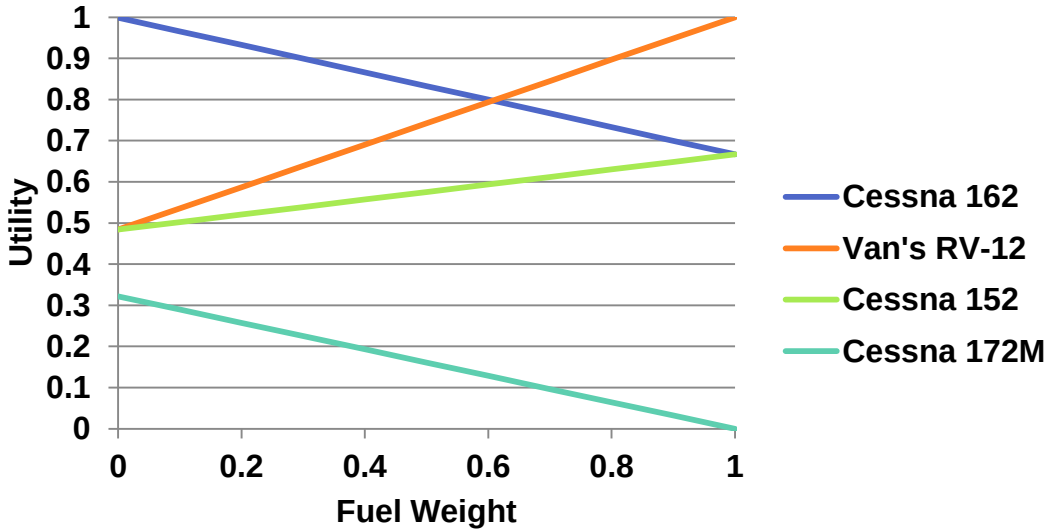
$$W_a = \frac{\frac{M_a}{M_0}}{\sum_{n=1}^{3} \frac{M_a}{M_0}}$$

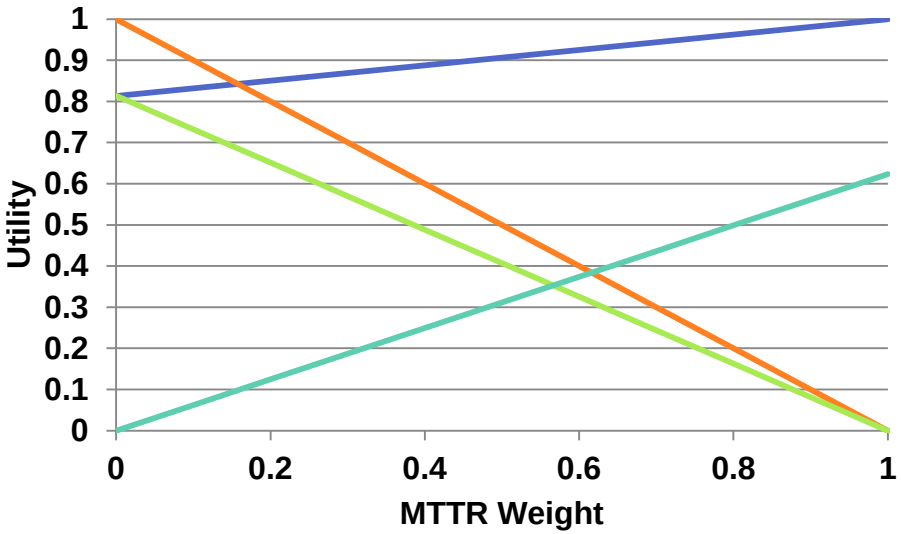
W = Weight
M = Margin
a = Attribute

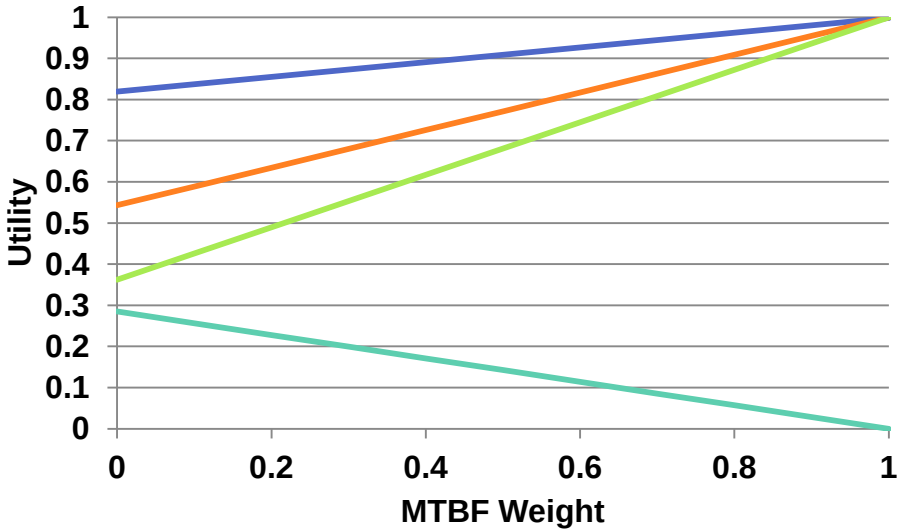




Sensitivity Analysis







Yearly Results Across Aircraft

Aircraft	Maximum Profit ($)	F/M Ratio at Max Profit	S/A Ratio at Max Profit	S/A Ratio to Break Even	Student Wait Time at Max Profit (min)
Cessna 162	96336	3.9	43	6	2.4
Van's RV-12	81146	4.5	21	6	1.1
Cessna 152	69646	4.5	23	8	1.2
Diamond Eclipse	61459	4.5	21	7	1.1
Cessna 172S	75174	4.8	43	10	2.4
Piper Archer II	48977	7.0	21	10	1.1
Cessna 172M	55345	3.7	43	10	2.4
Cessna 172SP	19343	4.2	21	12	1.1

Student-to-Instructor Ratio constant at 4.3

Return on Investment

Aircraft	High unit price ($)	ROI (pessimistic)	Low unit price ($)	ROI (optimistic)
Cessna 162	90,000	**11 months**	70,000	**9 months**
Van's RV-12	123,000	**17 months**	60,000	**6 months**
Cessna 152	40,000	**6 months**	20,000	**3 months**
Diamond Eclipse	100,000	**5 years 1 month**	85,000	**13 months**
Cessna 172S	368,000	**19 months**	80,000	**15 months**
Piper Archer II	112,000	**2 years**	47,000	**10 months**
Cessna 172M	219,000	**4 years**	18,000	**3 months**
Cessna 172SP	390,000	**22 years 1 month**	100,000	**6 years**

Yearly inflation: 3%

Conclusion and Recommendations

- Large quantities of time in maintenance results in lower profits
- Recommend flight schools place a higher value on tailoring fleet size to fit their demand
- Recommend a homogeneous fleet of Van's RV-12 or Cessna 152
- Recommend a study focused on flight school maintenance

QUESTIONS?

References

[1]J. Higgins and K. Lovelace, "An Investigation of the United States Airline Pilot Labor Supply." 2013.

[2] "U.S. Refiner Petroleum Product Prices," *U.S. Energy Information Administration*. [Online]. Available: http://www.eia.gov/dnav/pet/pet_pri_refoth_dcu_nus_m.htm. [Accessed: 16-Oct-2014].

[3] "Let's Go Flying: Certificates Comparison," *Aircraft Owners and Pilots Association*. [Online]. Available: http://www.aopa.org/letsgoflying/cert_comparison.html?keepThis=true&TB_iframe=true&height=530&width=675. [Accessed: 08-Oct-2014].

[4] "Let's Go Flying: Pilot certificate options and timelines," *AOPA*. [Online]. Available: http://www.aopa.org/letsgoflying/ready/time/options.html. [Accessed: 20-Oct-2014].

[5] Edwards, Jeremy. "Flying Schools in the US". *IBISWorld Industry Report.* N.p., (July 2014) [Accessed: 4-Oct-2014].

[6] "U.S. Civil Airmen Statistics," *Federal Aviation Administration*. [Online]. Available: http://www.faa.gov/data_research/aviation_data_statistics/civil_airmen_statistics/. [Accessed: 08-Oct-2014].

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[8] Blair, Jason; Freye, Jonathon. "Flight Training Capacity in the Context of Recent Legislation: An Examination of the Impacts of Reduced Training Capacity, and the Declining Rates of Airmen Certification." National Association of Flight Instructors. N.p., (3/1/2012) Web. 4 Oct. 2014.

[9] *Federal Aviation Regulations Aeronautical Information Manual*, 2014 ed., Aviation Supplies & Academics, Newcastle, WA, 2014, pp. 31-131, 447-494.

[10]R. Mola, "Cessna's Golden Oldie," *Air & Space Smithsonian*. [Online]. Available: http://www.airspacemag.com/history-of-flight/cessnas-golden-oldie-10240010/?no-ist=&page=2. [Accessed: 08-Apr-2015].

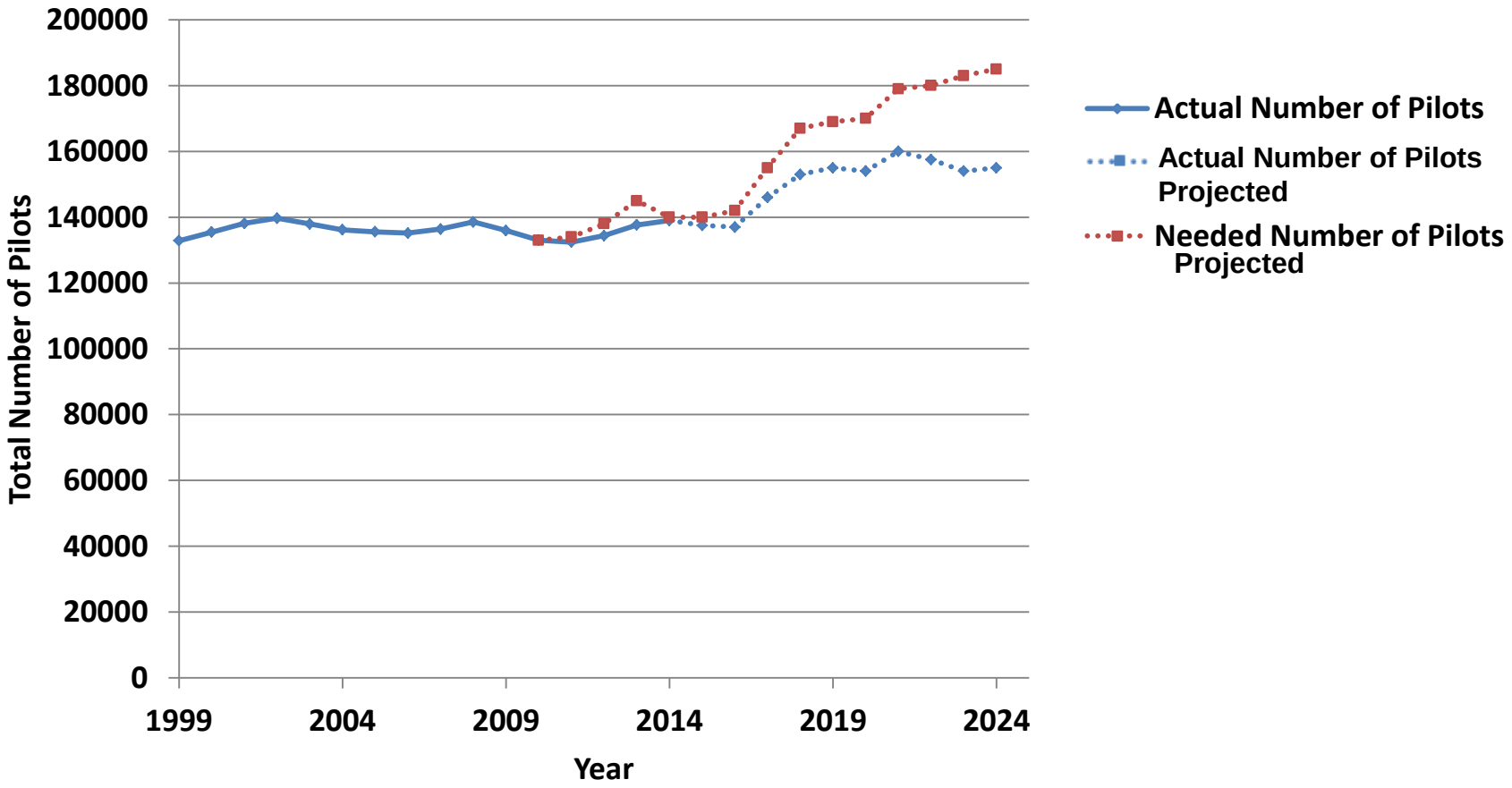
[11] "2012 172S Skyhawk Price List." Cessna Skyhawk SP, 14-Feb-2012.

BACKUPS

Definitions

- **Single Engine Aircraft:** An aircraft containing one engine to be used for propelling the aircraft
- **Primary Training Aircraft:** a class of aircraft designed specifically to facilitate flight training of pilots
- **Airline Transport Pilot (ATP):** highest level of aircraft pilot license

Will the total number of pilots be sufficient for the demand?



Source: University of North Dakota [1]

Types of Flight Schools

	Number of Schools	PROS	CONS
PRIVATE	410 (Part 141)	• Enroll any time without admission requirements • Learn at your own pace	• Cost and duration not fixed • Own a certificate rather than a degree
UNIVERSITY	113	• Earn a degree • Receive governmental assistance (scholarships, grants, loans, G.I. Bill etc.)	• Admission process • Less flexible schedule
MILITARY	11	• G.I. Bill and other military grants help with costs of school • Fly aircraft free of charge	• Rigid schedule • Duty service prior to benefits

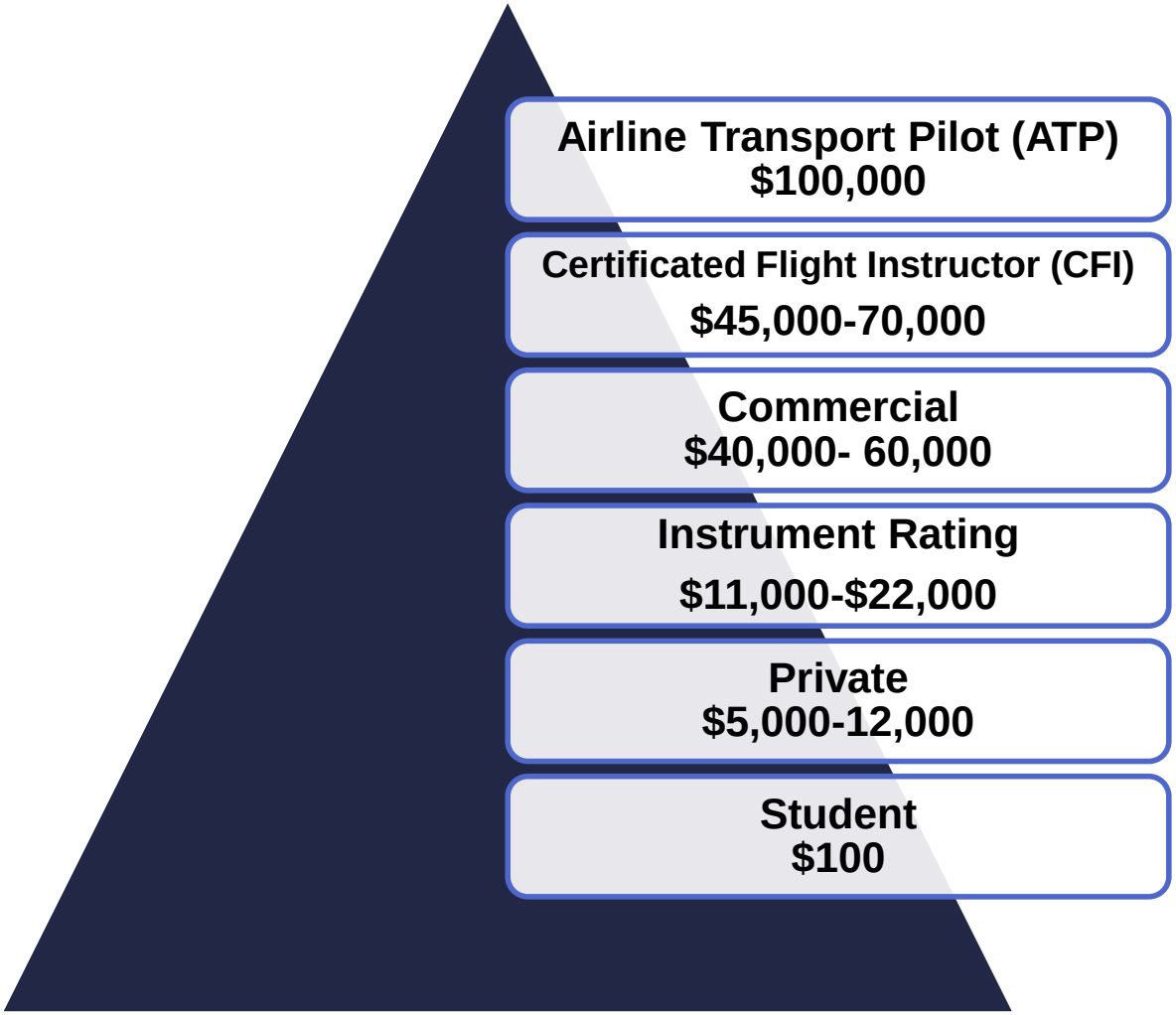
Federal Aviation Regulations for Private Flight Schools

	FAA Certified School	FAA Certificated Instructors	Greater FAA Oversight	Rigid Training Schedule	Lower Hourly Requirement for Licenses
Part 61		×			
Part 141	×	×	×	×	×

- **Part 61** schools are more flexible and better for students pursuing their license on a less regular schedule. The minimum hours to earn a license are greater.
- **Part 141** schools have their curriculum approved by the FAA and are more rigid. They are better for full-time students pursuing a career in aviation.
- **Both** require students to meet the same standard of performance in order to obtain a pilot certificate.

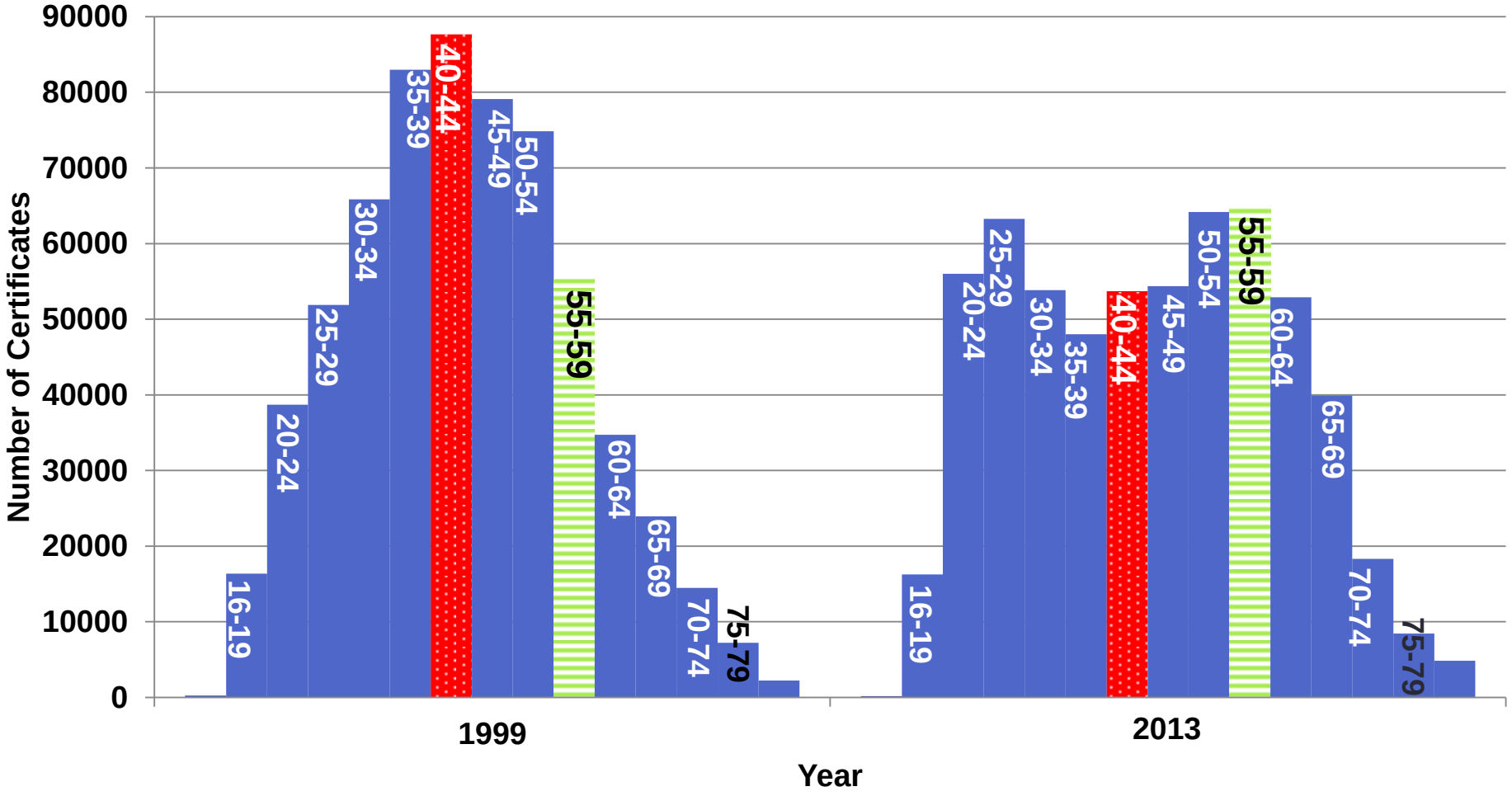
Source: AOPA [3], FAR AIM [9]

Typical Costs to Acquire Licenses



Source: AOPA [4], Dulles Aviation

License Holders are Aging



Source: Federal Aviation Administration [6]

Limitation

Flight inspections and engine overhauls are scheduled after the simulation has run through the duration of the scheduler meaning that there is potential for the maintenance time and flight time for a single aircraft to exceed the number of hours simulated for under certain conditions.

Equations

Q_S = quantity of students
Q_I = quantity of CFI
Q_A = quantity of aircraft

T_F = total time spent flying
T_M = total time spent in maintenance

C_O = total cost of operations
C_M = total cost of maintenance
R = revenues
P_O = total profit margin = $R+(C_O+C_M)$

$$S/A = \text{Student-Aircraft Ratio} = \frac{Q_S}{Q_A}$$

$$S/I = \text{Student-Instructor Ratio} = \frac{Q_S}{Q_I}$$

$$F/M = \text{Flight-to-Maintenance Ratio} = \frac{T_F}{T_M}$$

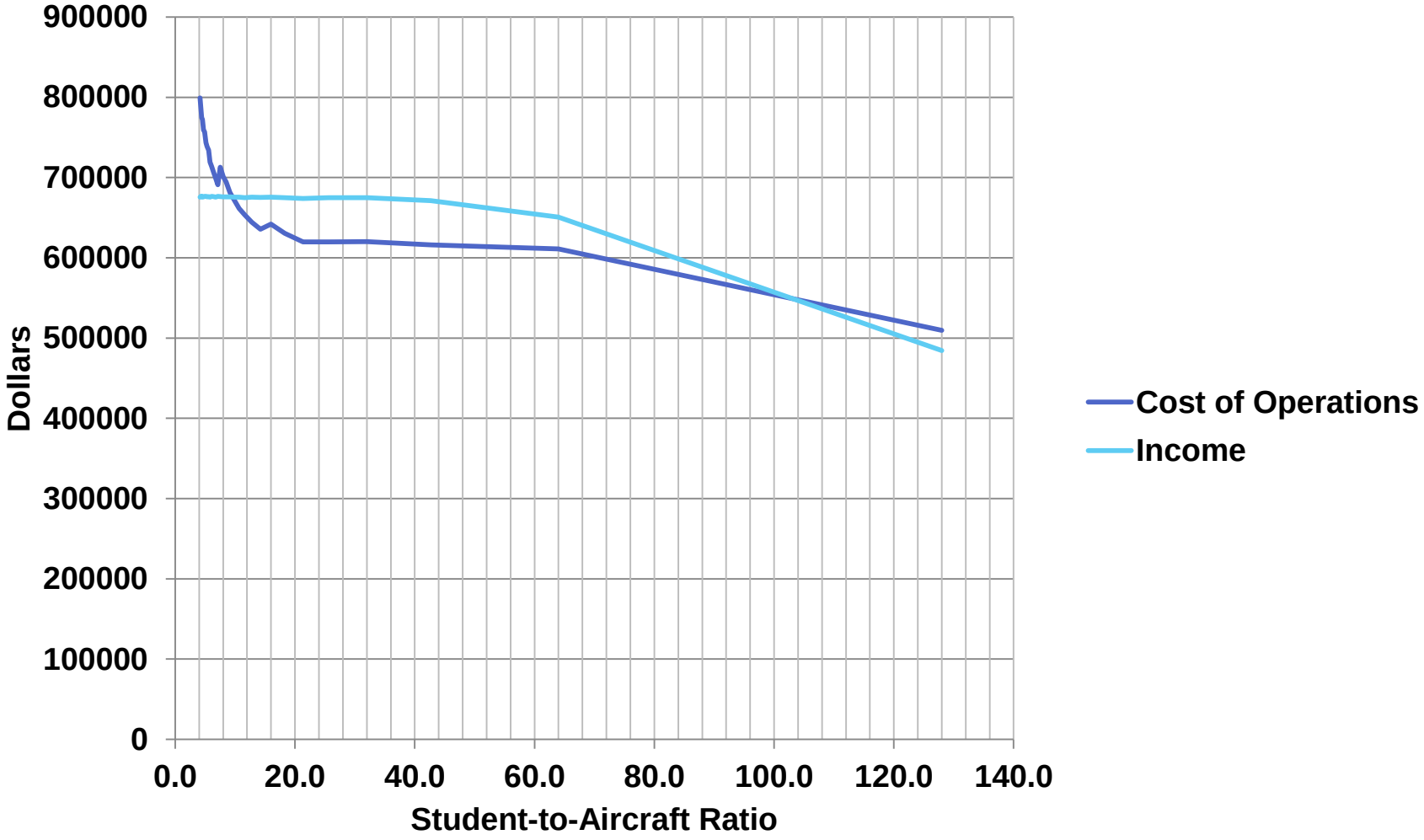
$$T_O = \text{Total Occupational Time per Aircraft} = \frac{(T_F+T_M)}{Q_A}$$

$$\text{Total Occupational Time} = \frac{(T_F+T_M)}{Q_A}$$

P_F = price of fuel per gallon
P_I = hourly price of CFI
P_M = hourly price of maintenance

$$R = 1.3\,T_F(0.3\,P_I+P_F)+195\,Q_S$$

Cost of Operations vs. Income



Results are for a Cessna 172 M

Aircraft Data

Aircraft	New Unit Price (2015)	Used Unit Price (Range)	Used years considered (range)	New Engine price ($)	Rebuilt Engine price($)	GTOW (lbs)	Fuel Consumption rate	Number of built aircraft	Years in Production	Number of Seats
Cessna 162	-	$80K-$90K [6]	2009-2013 [6]	$27K [9]	$23K [9]	1320 [21]	6.3 [21]	272 * [11]	2009-2014 [21]	2 [21]
Van's RV12	$123K [20]	$60K-$90K [17]	2008-2014 [17]	$ 20K [20]	$16K [20]	1320 [19]	4 [19]	355 [19]	2008- [19]	2 [19]
Cessna 152	-	$24K-40K [3]	1977-1983 [3]	$30K [12]	$17K [12]	1670 [2]	6 [2]	7584 [2]	1977-1985 [2]	2 [2]
Diamond Eclipse	$100K [10]	$85K- [22]	1998-2015 [22]	$27K [9]	$23K [9]	1764 [10]	5 [10]	500 [10]	1994- [10]	2 [10]
Cessna 172S	$368K [21]	$80K- $350K [5]	1999-2015 [5]	$55K [12]	$35K [12]	2550 [21]	8 [21]	43000 [21]	1998- [21]	4 [21]
Piper Archer II	-	$40K-$90K [13]	1976-1982 [13]	$55K [12]	$35K [12]	2550 [15]	8.8 [15]	10,500 [15]	1976-1981 [15]	4 [15]
Cessna 172M	-	$42-$100 [6]	1973-1976 [6]	$55K [12]	$35K [12]	2550 [6]	8 [6]	7306 [6]	1973-1976 [6]	4 [6]
Cessna 172SP	-	$100-$390K	2001-2009	$55K [12]	$35K [12]	2550 [5]	4.9 [5]	1000** [5]	1998-2009 [5]	4 [5]

Aircraft Data References

[1] "- Diamond Eclipse Flight Training." [Online]. Available: http://flighttraining.aopa.org/learntofly/articles/diamond0308.html. [Accessed: 11-Apr-2015].

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Sensitivity Analysis