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The Typical General Aviation Aircraft

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Table Of Contents

Executive Summary

This report defines the typical General Aviation aircraft, as the market exists today. This definition lays the groundwork for a follow-on reliability study designed to "assist the development of future GA reliability and safety requirements."[i] The majority of the data utilized in this report came from the 1996 General Aviation and Air Taxi Activity (GAATA) survey.[4] This report has two parts; the first is to define the typical general aviation aircraft and the second is to separate the aircraft into several different categories.

The first step in defining the typical General Aviation aircraft is to pin down which aircraft types are included in the term General Aviation. General Aviation is defined for this report as any fixed-wing aircraft operating under FAR Part 91, 125, 135 (non-scheduled), or 137, excluding experimental aircraft, gliders, or any aircraft that is a known commuter or commercial air carrier aircraft. Included in this definition are a wide variety of aircraft, ranging from a single engine, single pilot piston aircraft to a twin-engine corporate business jet. But is it necessary to analyze each class of aircraft? According to the GAATA survey, almost 85% of GA aircraft are single engine piston aircraft. Among those single engine aircraft, there are a few overall characteristics that describe the typical GA aircraft. The table below shows the initial characteristics of the typical GA airplane defined in this report.

Table A – Initial Characteristics of the Typical General Aviation Aircraft

Defining Characteristics	Typical GA Aircraft
Number of seats	4
Number of engines	1
Type of engine	Horizontally opposed, 4 or 6 cylinder piston
Landing Gear Type and Configuration	Fixed Tricycle
Airframe Construction	Aluminum frame with aluminum skin, steel engine mount
Flight Control Type and Configuration	Mainly cable operated utilizing bellcranks and push-pull rods

The second goal is to separate the aircraft into independent systems that make it possible to determine the individual reliabilities. This breakdown was performed along the lines of a

[i] *Roadmap for the Reliability Study of a Typical General Aviation Aircraft*, Carl Ford, FDC/NYMA, Inc., March 1999

failure of the system. Any component that caused a system to fail was considered a part of that system. The table below shows the results of the system breakdown performed for this study. An explanation of Table B will be covered in Section V.

Table B – Typical GA Aircraft System Breakdown

Powerplant	**CIS**	**Aircraft Control**	**Airframe**	**Electrical System**
Engine System	Cockpit Instruments	***Flight Control***	Empennage	Lighting System
Fuel System	Vacuum System	Rudder System	Fuselage	Source & Dist.
Propeller System	Pitot Static System	Aileron System	Tail	
Heating/Ventilation	Alternator	Elevator System	Wings	
	Antennas	Trim System		
		Flap System		
	Added:			
	Stall warning horn	***Ground Control***		
	Circuit Breakers	Landing Gear		
	Headset/Intercom			
	ELT			

I. Introduction

This report is the first part of an overall reliability study of a typical General Aviation (GA) aircraft, as the market presently exists. It would be prohibitively costly to determine the reliability of each aircraft make and model in the GA industry, therefore it is necessary to define a single aircraft that can represent the entire GA market. This report defines such a typical aircraft. The overall reliability study "will support the development of future FAA reliability requirements through a better understanding of system, subsystem, and component level reliability of a typical GA aircraft."[i] The intended outcome of this study is to support the general aviation industry's effort to produce safer and more reliable aircraft technologies. "The baseline reliability of typical GA aircraft, as they presently exist, is unknown. This proposed study would fill that void and assist the development of future GA reliability and safety requirements."[i]

This report will define a typical GA aircraft, initially, by six broad characteristics: the number of seats, the number of engines, the type of engine, the landing gear type and configuration, airframe construction and material, and the flight control system type and configuration. The secondary goal of this report is to divide the aircraft along system boundaries. In 1997, the Office of Safety, Environment, and Mission Assurance (OSEMA) at NASA Langley Research Center published a report on the reliability of a typical general aviation aircraft's cockpit instruments. The *General Aviation Aircraft Cockpit Instrument Reliability Analysis* report utilized a fault tree analysis to assess reliability. The subsequent reliability study to this report is an expansion of the OSEMA report to consider the entire aircraft and will perform the same type of analysis for each aircraft system. Therefore, the system breakdown will fit with the requirements for a fault tree analysis. There are five aircraft system categories under which aircraft systems can be placed, or "sifted". Those categories are the Cockpit Instrumentation System, Powerplant, Airframe, Aircraft Control System, and the Electrical System.

There are several ways to "pick" a typical GA aircraft. One can simply determine the most popular GA aircraft and use that as a model to define a typical GA aircraft, or one can pick characteristics that are representative of all GA designs and create an "amalgam" aircraft. Another technique is to define classes within GA and pick a representative aircraft from each class. In order to make a decision about which technique to use, more information about the current General Aviation market is needed. The first task is to determine what aircraft are included in the term "General Aviation".

II. What is General Aviation?

The first step in defining a typical General Aviation aircraft is to define what General Aviation includes. This definition is not meant to "redefine" General Aviation but simply to place bounds upon this analysis.

General Aviation is sometimes a nebulous concept. It seems to include aircraft and exclude others dependent on whom defines the term. The definition often varies based upon the goals of the person or organization that wishes to define GA. For instance, the FAA defines General Aviation as "That portion of civil aviation which encompasses all facets of aviation except air carriers."[1] Air carriers are defined as any aircraft with a seating capacity of more than 30 seats or a maximum payload capacity of more than 7,500 pounds carrying passengers or cargo for hire or compensation. This definition is extremely broad and includes aircraft that do not meet the goals of this study. The General Aviation Manufacturer's Association (GAMA) has a similar definition: "[A]ll aviation other than commercial and military aviation."[2] Although similar to the FAA's definition, GAMA does not define commercial aviation. The Aircraft Owners and Pilots Association (AOPA) uses a much more specific definition in their annual accident analysis. GA is any aircraft except "aircraft used in Part 121 or Part 135 operations, aircraft weighing more than 12,500 pounds, [or] helicopters, gliders, and balloons."[3] While this definition limits the number of general aviation aircraft to a much smaller subset of civil aircraft and therefore more manageable, it is probably too restrictive.

The exclusion of commercial air carrier aircraft (737, DC-10, etc.) is universally agreed upon. While the FAA includes commuter air carrier aircraft (BAe Jetstream, Beech 1900D, etc.) in their definition of General Aviation, these aircraft operate in a similar manner to air carriers because they employ professional crews and ferry passengers and cargo not unlike large air carriers. For this reason, they will be excluded from this study. The AOPA definition excludes all aircraft under Part 135 operations, which includes commuter aircraft. However, this exclusion is too restrictive because it rules out the Air Taxi aircraft category. While this is a commercial category where the crew is hired to transport passengers or cargo, the aircraft utilized in this operational category are usually the same types of aircraft used for personal transportation. An example of an air taxi operation would be a Beech Bonanza hired out to transport an executive from his home office to a client's location. Air Taxi operations are operated under what is called Part 135 non-scheduled. Aside from the addition of the air taxi category, this report's definition of General Aviation is fairly close to the AOPA's definition.

Not-for-hire rotorcraft are also technically part of the General Aviation market; however, this category unnecessarily complicates this analysis and would receive better treatment as a separate report. Aircraft that have an experimental certification are not held to the same standards that a certified aircraft design would be; therefore, they would have a different reliability than the rest of the GA market. As a result, experimental aircraft are also excluded from this report. Thus, General Aviation is defined for this study as any fixed-wing aircraft operating under Part 91, 125, 135 (non-scheduled), or 137, excluding experimental aircraft, gliders, or any aircraft that is a known commuter or commercial air carrier aircraft.

III. General Aviation Current Market

The current GA market composition was determined by the FAA's General Aviation and Air Taxi Activity (GAATA) Survey, which is essentially the only source for the relative numbers of aircraft in use today.[4] Using the aircraft types defined as General Aviation in the previous section, it is now essential to determine their relative numbers in the current GA market. A large set of typical characteristics can be outlined by also utilizing this survey.

The GAATA survey is sent annually to a sample of any aircraft type that is not principally operated under FAR Part 121. Aircraft excluded from the survey are those aircraft registered to dealers, in the process of being sold, with known invalid addresses, and those without enough information to categorize them accurately. For more information on this survey and how it is conducted, please refer to Appendix A in the 1996 General Aviation and Air Taxi Activity Survey. Table C shows the total makeup of the active market in 1996. Active aircraft are those which have been flown for at least one flight hour in the past calendar year. The total number of fixed wing GA aircraft is 160,577. Fixed wing piston powered aircraft total 150,980 aircraft or approximately 94% of the total market. Turboprop and turbojet share the remaining

6% approximately equally. The majority (~60%) of GA piston aircraft are flown for personal use, while turboprops' largest use is corporate (~40%). Turbojets are overwhelmingly also used as corporate aircraft (78%). Those aircraft types shaded in gray in Table C are not included in General Aviation but are shown to give the reader a feel for the relative sizes of the excluded types.

Table C – Composition of GA Market by Aircraft Type [5]

Aircraft Type	Total	Corporate	Business	Personal	Instruc-tional	Air Taxi	Other
FIXED-WING	**160,577**	**8,227**	**26,963**	**93,174**	**13,248**	**3,194**	**15,699**
Piston	150,980	2,549	26,043	92,715	13,149	2,057	14,394
Turboprop	5,309	2,327	708	364	73	743	1090
Turbojet	4,287	3,350	211	94	25	393	211
ROTORCRAFT	**6,391**	**868**	**463**	**482**	**487**	**500**	**3,175**
OTHER AIRCRAFT	**4,144**	**13**	**21**	**3,247**	**255**	**0**	**601**
Gliders	1,882	0	8	1,469	176	0	226
Lighter-than-Air	2,261	13	13	1,777	79	0	373
EXPERIMENTAL	**16,198**	**176**	**788**	**12,715**	**270**	**143**	**2,036**
ALL AIRCRAFT	**187,312**	**9,286**	**28,236**	**109,619**	**14,261**	**3,838**	**37,805**

The next step is to find the aircraft makes and models that are the most popular and hopefully draw some conclusions by looking at the top sellers. Figure III-1 shows the fourteen most popular aircraft. This data was also taken from the GAATA survey. As the figure shows, the Cessna 170/172 aircraft family and the Piper Cherokee (PA28 & PA32) aircraft family constitute over one quarter of all GA fixed wing aircraft. One out of four aircraft on any GA ramp in the U.S. is one of these two types of aircraft. All fourteen aircraft included in this figure are piston-powered and, in fact, all but two (the Beech 55/58 and the Cessna 310) are single engine pistons.

Based on the data presented, the best method to represent the GA market is to construct an "amalgam" or composite aircraft based on the majority of the GA market. The small relative numbers of the turboprop and turbojet markets make the development of a representative aircraft from each class of GA unnecessarily time-consuming. While it is possible to simply pick one aircraft that is typical, it doesn't require too much extra effort and much improved applicability to take the common characteristics from several aircraft that represent the majority of general aviation aircraft.

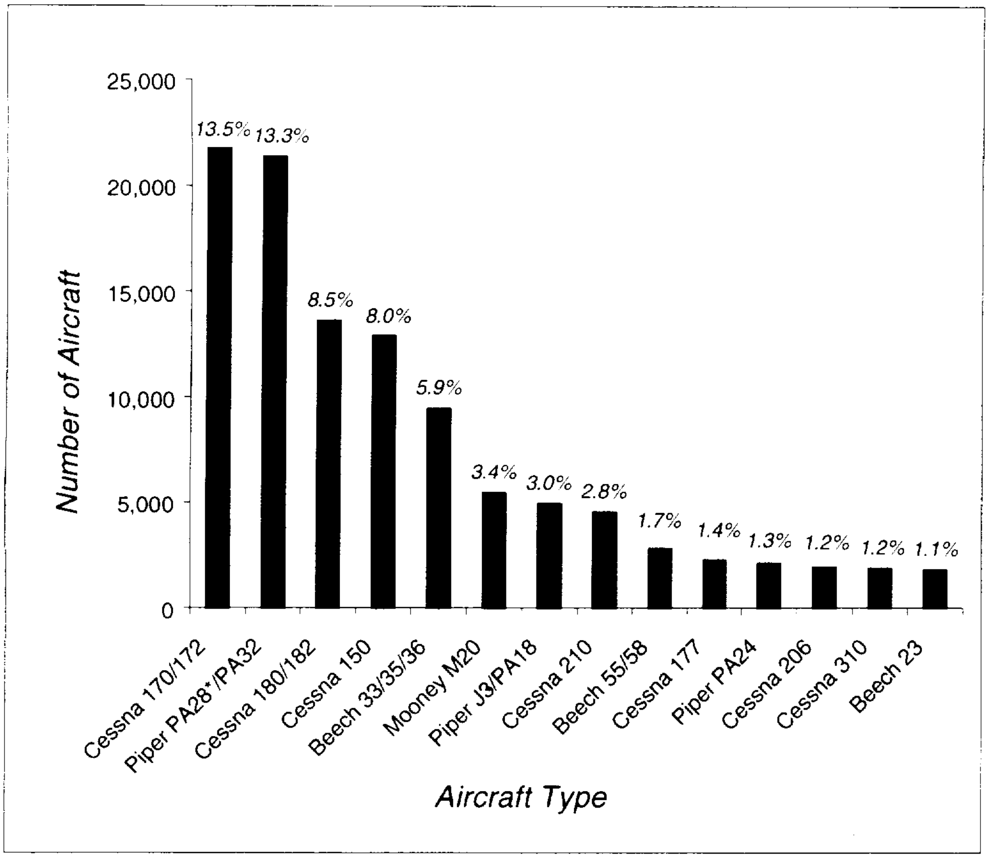

Figure III-1 – Breakdown of Current GA Market by Aircraft Make/Model

IV. The Typical General Aviation Aircraft

Instead of gathering data on *every* individual aircraft system of *each* type of GA aircraft, the field was narrowed by looking at some overall characteristics first. Therefore, the typical GA aircraft will be initially defined by six broad characteristics; number of seats, number of engines, type of engine(s), landing gear type and configuration, airframe construction and material, and the flight control system type and configuration. The data for the number of seats, number of engines, and the landing gear is taken from the 1996 GAATA survey and only includes active aircraft. The engine type data was taken from the 1994 U.S. Aircraft Census and includes all registered aircraft and their engine classification. The airframe and flight control system information was determined using a subset of the current GA market. This subset will be discussed in more detail in Section E.

A. *Number of Seats*

In order to define with complete confidence the average number of seats, each aircraft model's seat capacity must be identified and included in a weighted average. Unfortunately, there are over 200 different aircraft models, each with their own NTSB identifier code. The amount of work to determine the type of aircraft and perform research on each aircraft is expansive and inefficient. However, the top 25 most popular GA aircraft models comprise almost 70% of the total GA market and can serve as an effective indicator of the entire market. The numbers and names of the top 25 aircraft are included in Appendix A. A simple weighted average of the model seat capacity and the number active yields an average of 4.02 based upon 70% of the total market. A percent breakdown of the number of seats is also shown in Figure IV-1.

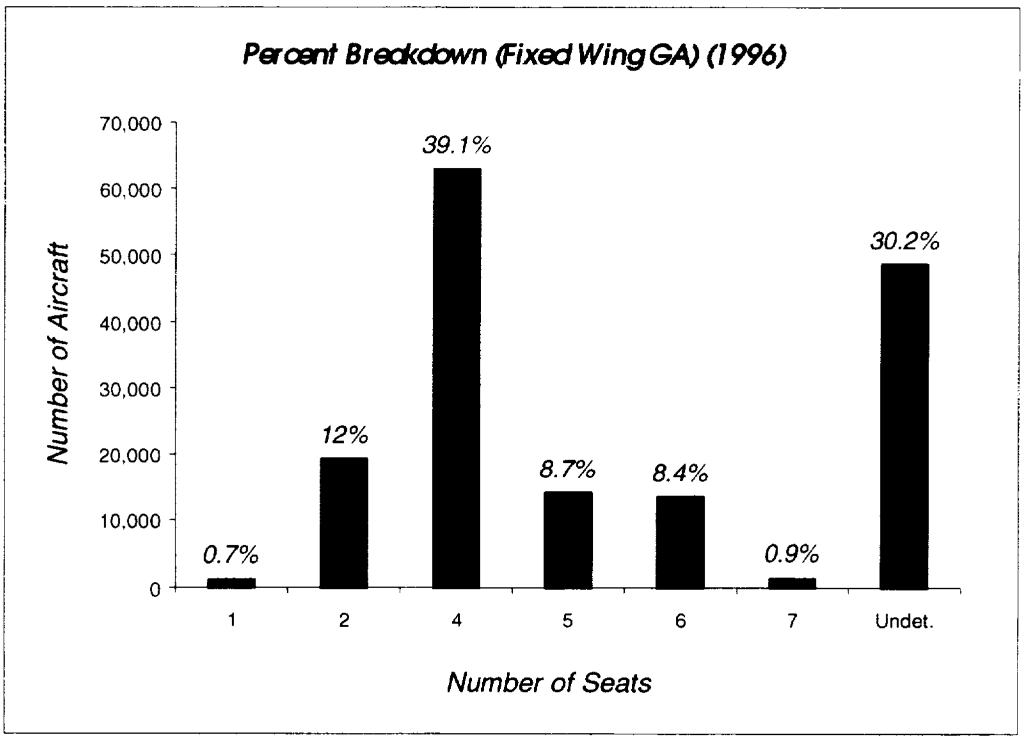

Figure IV-1 – Percent Breakdown of GA Model Seat Capacity

B. Number of Engines

The number of engines on a typical GA aircraft is easily determined from Table 8.2 of the 1996 GAATA survey. This data is summarized in Figure IV-2 below. The typical GA aircraft will be single engine because 85% of all GA are single engine.

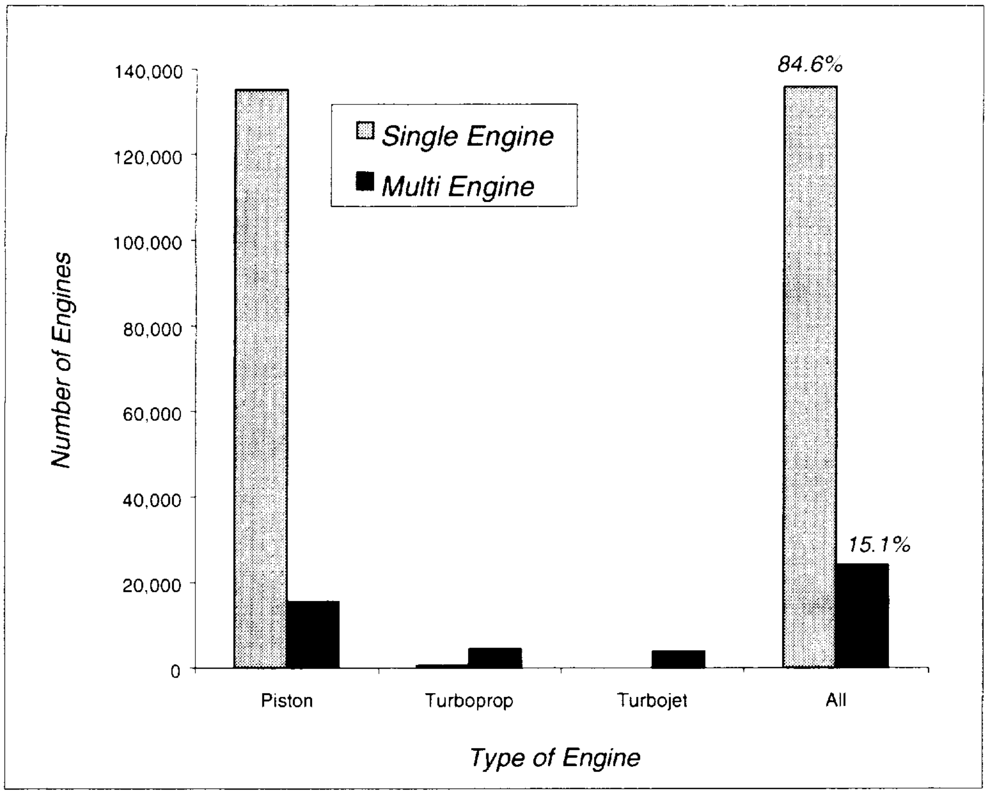

Figure IV-2 - Typical Number of Engines

C. Type of Engine

The typical engine type can be obtained from the 1994 Census of U.S. Aircraft and the 1996 GAATA survey. Figure IV-3 shows the relative proportions of piston vs. turboprop or turbojet engines. As was implied earlier, the overwhelming majority of engines are piston. Figure IV-4 shows the different major manufacturers of aircraft piston engines. Lycoming and Continental together comprise almost 83% of the total aircraft piston engine market. These engines are typically horizontally opposed, 4 or 6 cylinder carbureted piston engines.

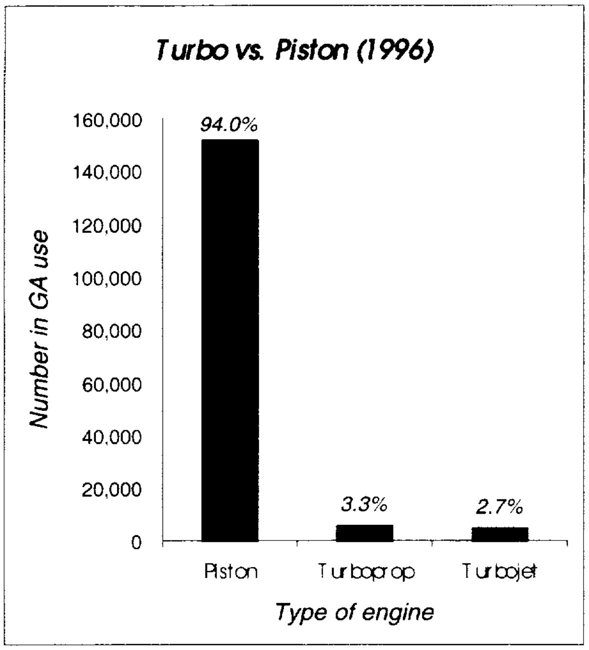

Figure IV-3 – Types of GA Engines

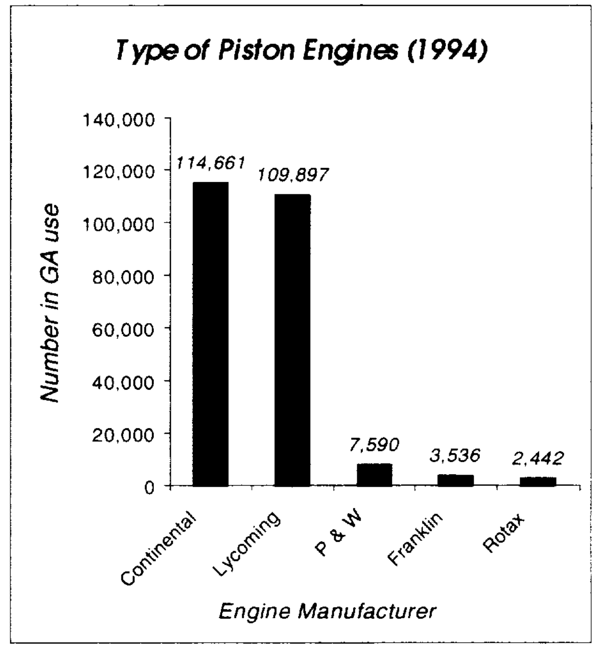

Figure IV-4 – Piston Engine Manufacturers

D. Landing Gear Type and Configuration

The information on landing gear for the active GA fleet was also obtained from the GAATA survey. Two different aspects of the landing gear were investigated to define the typical landing gear. The landing gear type is either fixed or retractable and the configuration is either conventional (two mains and a tailwheel) or of a tricycle configuration. Figure IV-5 shows the make-up of the GA landing gear type market. As the figure shows, 63% of the market have fixed landing gear. However, a large number of retractable landing gears are in the turboprop and turbojet categories. If piston aircraft are the only ones considered, there are almost three times as many fixed gear aircraft as there are retractable gear aircraft. While the typical GA aircraft will have fixed gear in this study, an reliability analysis of retractable landing gear can be included as an add-on study to the baseline typical GA aircraft.

Figure IV-6 shows the various landing gear configurations for each major aircraft manufacturer plus the overall market make-up. Tricycle gear are overwhelmingly the most popular and will be considered the typical landing gear configuration.

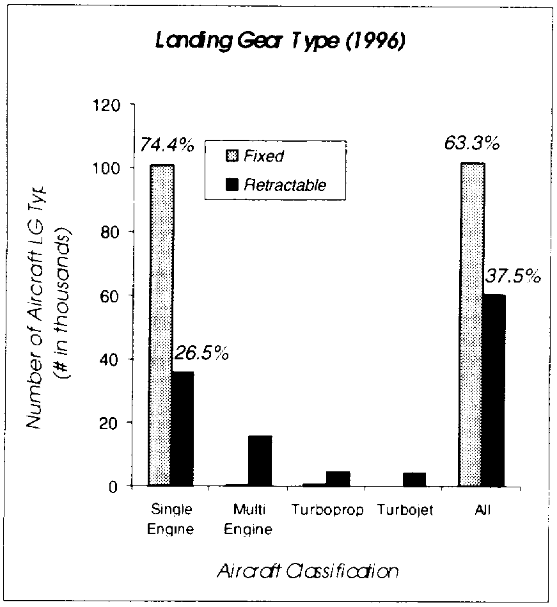

Figure IV-5 – Landing Gear Type

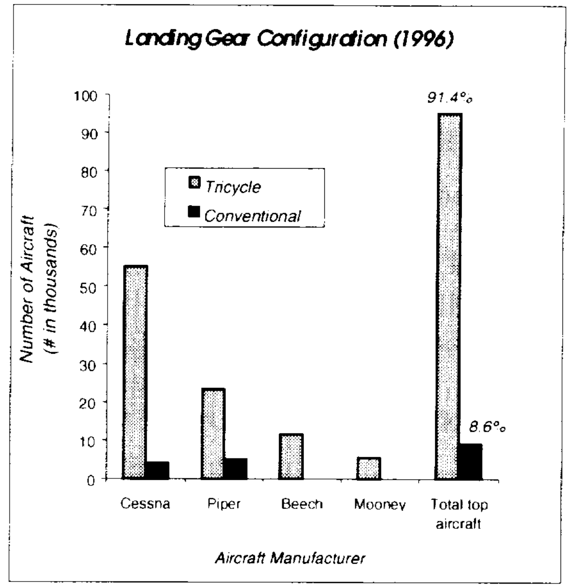

Figure IV-6 – Landing Gear Configuration

E. Some Simplifying Assumptions

Up to this point in the definition of a typical GA aircraft, it was possible to make decisions based upon the entire GA market. However, in order to define a typical airframe and flight control system, it is necessary to refine the number of aircraft examined. Unfortunately, no known agency tracks the construction and type of the airframe or flight control systems of GA aircraft. It would be extremely time consuming to investigate every GA aircraft's airframe construction and flight control systems and even more difficult to categorize the typical configurations. In order to simplify the analysis and retain accuracy, the number of aircraft used as a data set for the airframe and flight control system will be reduced to six. The top six aircraft that will be referenced from this point on in the report are presented in Table D.

There are several reasons why these aircraft are typical of the rest of the GA market. These six aircraft models comprise 45.5% of all GA aircraft and they are also the most popular. In other words, on any GA airport ramp in the U.S., almost one out of every two aircraft is one of these six. All six are single engine piston aircraft with tricycle landing gear. These aircraft are also a good spectrum of single engine aircraft ranging from the relatively economical trainer Cessna 150 to the executive, high performance Mooney M20.

Table D – Top Six General Aviation Aircraft

Rank	Type of Aircraft	Nickname	# of seats	# of Aircraft	% Total GA
1	Cessna 172	Skyhawk	4	19,754	12.30%
2	Piper PA28	Archer, Cadet, Cherokee, Arrow, Warrior, Dakota	4	17,947	11.18%
3	Cessna 150	Aerobat, Commuter	2	12,885	8.02%
4	Cessna 182	Skylane	6	11,573	7.21%
5	Beech 35	Bonanza	4-6	5,450	3.39%
6	Mooney M20	Ranger, Master, Chaparral, Executive, Statesman, Ovation, 201, Encore, Bravo, Eagle	4	5,423	3.38%

F. Airframe Construction and Material

The typical airframe is defined based upon the above six aircraft. These aircraft are of a semi-monocoque design and use aluminum spars, stringers, and frames covered by aluminum skins. The only two exceptions to this rule are the Mooney, which has a steel fuselage frame, and the Beech 35, which has a magnesium-skinned tail, but those minor exceptions will be ignored for the airframe. All six have steel engine mounts and steel landing gear struts. Five aircraft have a conventional tail and one has a V-tail.

G. Flight Control System Type and Configuration

The flight control systems of all six aircraft are fairly similar. Five out of the six aircraft have two ailerons, an elevator or stabilator, and a rudder. Five out of the six are basically cable-operated which utilize bellcranks and push-pull rods to activate the actual control surface. The yokes or control "U" in all six aircraft operate in basically the same manner as well. The Beech 35 is slightly different because of the V-tail. Like the other aircraft, the 35 still uses cables and bellcranks to operate the surfaces, but it uses a mixing unit in the empennage that mixes the elevator and rudder commands. The Mooney's flight control system utilizes a system solely comprised of push-pull rods. Four out of the six aircraft utilize a Fowler flap system and almost all of these aircraft operate the flaps by an electric motor. All six aircraft have longitudinal trim and a few have options for the other two axes. Table E shows the various characteristics of each aircraft's flight control system.

Table E - Flight Control Systems of the Top Six Aircraft

Aircraft Model	Flight Control System	Tail	Pitch controller	Flaps (type, power)	Trim (axes, power)
Cessna 172	Cable-Operated: utilizing push-pull rods, bellcranks, spockets and roller chains	Conventional	Elevator	Fowler, electric	Longitudinal, manual
Piper PA28	Cable-Operated: utilizing push-pull rods, bellcranks, sprocket and roller chains	Conventional	Stabilator	Plain, electric/manual	Longitudinal, manual (quasi-directional trim)
Cessna 150	Cable-Operated: utilizing push-pull rods, bellcranks, spockets and roller chains	Conventional	Elevator	Fowler, electric	Longitudinal, manual
Cessna 182	Cable-Operated: utilizing push-pull rods, bellcranks, spockets and roller chains	Conventional	Elevator	Fowler, electric	Longitudinal, manual
Beech 35	Cable operated: utilizing push-pull rods, bellcranks, differential mixing unit ("trapeze") for V-tail	Butterfly Tail	Butterfly Tail	Fowler, electric	Longitudinal, manual (quasi-lateral trim)
Mooney M20	Push-Pull tubes using rod-end bearings & bellcranks	Conventional	Elevator	Slotted, electric	Longitudinal, manual or electric

H. Summary

The typical general aviation aircraft is a four-place, single engine piston all-aluminum aircraft with a cable-operated flight control system as shown in Table F.

Table F – Initial Characteristics of the Typical General Aviation Aircraft

Defining Characteristics	Typical GA Aircraft
Number of seats	4
Number of engines	1
Type of engine	Horizontally opposed, 4 or 6 cylinder piston
Landing Type and Configuration	Fixed Tricycle
Airframe Construction	Aluminum frame with aluminum skin, steel engine mount
Flight Control Type and Configuration	Mainly cable operated utilizing bellcranks and push-pull rods

V. System Level Definitions of the Typical Aircraft

Once the typical GA aircraft is defined, the aircraft can be broken down into different systems, and more refined definitions of the typical GA aircraft can be made. The first part of this section will cover the definition of a system and investigate which systems are typical among the six aircraft defined previously. The second part will actually place or "sift" those systems into five top-level categories in preparation for the reliability analysis.

A. Typical System Definition

Prior to splitting the aircraft into parts, the first step is to define which systems are typical and should be included in the aircraft. This was mainly accomplished by taking an in-depth look at the six aircraft and including whatever is common or typical among them.

1. Engine

The first step in defining the aircraft systems is to look at the engines that power today's and yesterday's GA aircraft. There are a set of eight aircraft engine models that principally power all six typical aircraft and are also among the most popular of all engines. Those eight aircraft engines are shown in Table G below. They are all horizontally opposed 4 or 6 cylinder piston engines with a horsepower range of 100-285. Two of these engines are fuel-injected but the rest have carburetors. It will be left to the subsequent analysis to decide whether fuel injection will be considered for the engine's reliability.

Table G – Engines used on Top Six Aircraft

Make of Engine	Engine Model Number	Number of Cylinders	Horsepower	Number of Engines Produced	Name of Example Aircraft
Lycoming	O-320	4	150-160	36,503	Piper PA28, Cessna 172
Continental	O-470-R	6	230	16,045	Cessna 182
Lycoming	O-360	4	160-180	15,858	Piper PA28
Continental	O-200	4	100	14,001	Cessna 150
Continental	IO-520	6	285	16,321	Beech V35
Lycoming	O-235	4	108	11,030	Cessna 152
Lycoming	IO-360	4	180-200	10,435	Piper PA28, Mooney M20
Lycoming	O-540	6	235-260	7,682	Piper PA28

One problem with defining a typical GA aircraft is the availability of data for aircraft parameters that the FAA does not track. One of those parameters is whether an aircraft has a constant-speed propeller or a fixed-pitch propeller. To further complicate the decision, one aircraft of a certain model would be equipped with a constant-speed propeller while another aircraft of the same model would not. However, the addition of a constant-speed propeller would only make the reliability of a typical GA aircraft more conservative. As a result, the constant-speed propeller will be included.

2. Fuselage

Defining the typical fuselage configuration involves making several choices that are not supported by trends. As explained in previous sections, the fuselage and wings are of semi-monocoque construction with aluminum spars and aluminum frames covered by aluminum skin. There are other parameters that need to be determined before any further analysis can be done. The first parameter is the choice of a high wing or a low wing configuration. Based on the top 25 aircraft, which represent 70% of the total GA market, there is a slight preference for a high wing configuration (57% vs. 43% of the top 25 aircraft). However, since Cessna makes a majority of their aircraft high wing and Cessna is such a dominant force in the GA sector, it possibly skews the data towards the high wing configuration. Before any further steps were taken to determine if this was a true trend, the eventual purpose of this choice must be addressed. It was initially decided that this choice doesn't affect the reliability analysis; therefore, due to the lack of a reliable indicator one way or another, this issue was deferred until it needs to be addressed in the airframe reliability section.

The choice between one or two doors was also deferred. Normally, the number of doors is directly related to the wing configuration. High wings have two doors while low wings have one door. However, if the reliability analysis necessitates a choice for this issue in the future, the typical configuration will need to be modified.

3. Fuel System

The selection of a typical fuel system depends on the configuration and make of the aircraft involved. If the aircraft has a high wing configuration, the majority of fuel feed systems is gravity-fed; however, if the aircraft is low wing, it most likely requires a fuel boost pump to deliver fuel to the engine driven fuel pump. The choice of a typical fuel system is dependent on the wing configuration. However, the only significant difference between the two types of fuel systems is the inclusion of a fuel boost pump. Therefore, since the choice between a low or high wing fuselage is not needed for this analysis, the fuel system will include a fuel boost pump. Otherwise, the fuel system will not be dependent on the wing configuration. Also, the inclusion of an extra fuel pump makes the eventual reliability analysis only more conservative.

The typical fuel system will consist of a tank in each wing (bladders or aluminum tanks) that are gravity fed to a tank selector valve, which also may contain a fuel strainer, and the fuel is then fed into a fuel boost pump. From the boost pump, the fuel is fed into an engine driven fuel pump, which delivers the fuel into the injectors or carburetor.

4. Other Systems

As defined in Section IV.D, the typical landing gear will be fixed and of a tricycle configuration. The top six aircraft also all have hydraulic brake systems. The brake system is self-contained with hydraulic brake lines running from the toe brakes in the cockpit to a master cylinder. From the master cylinder, hydraulic lines run to the disc brakes inside of each of the two main tires. The landing gear also includes a parking brake system and a ground steering system that is operated by the rudder pedals.

The typical flap system of the top six aircraft utilizes Fowler type flaps that are electrically operated. The flap system consists of the jackscrew and rails that actuate the flaps, the electric motor that powers the jackscrew, and the flap selector switch in the cockpit.

All six aircraft have longitudinal trim that is actuated manually. The trim system includes a control wheel in the cockpit and the cables and associated equipment that connect the wheel to the trim tab, including the trim tab actuator.

B. System Breakdown

In attempting to define the reliability of an entire aircraft, it is useful to break the aircraft into several different categories where the reliability of each category can be independently determined. In order to get accurate results, each system needs to be reasonably independent or a subset of another system. There are two basic ways of accomplishing this breakdown. The first is by location. For instance, any component that is located forward of the firewall would be considered part of the engine system, everything aft would be the fuselage, the wings would be a separate system, etc. However, this method doesn't sort systems by function, an essential property for a fault tree analysis. The second method is to define systems by their failure and everything that would cause a failure of the system. Any component of a system that is essential to the system's function will be included under that system. For example, the flap selector switch in the cockpit would be included in the flight control system under the flap subsystem because if the switch fails, the entire flap system is considered failed. This method breaks the aircraft apart by function allowing a cleaner reliability analysis. Each typical aircraft system can then be included under one of the following five categories: Cockpit Instrumentation System, Powerplant, Airframe, Aircraft Control System, or the Electrical System.

1. Cockpit Instrumentation System

The Cockpit Instrumentation System reliability has already been determined by the Office of Safety, Environmental, and Mission Assurance's CIS report. It has been published previously and will not be modified in this analysis. The typical cockpit instrumentation system defined by this report is what is considered minimum by the FAA. This includes all the cockpit instruments that provide information to the pilot needed to fly the airplane. This approach also includes several systems that provide function to the cockpit instruments. The CIS report models all the FAA-required cockpit instruments, plus the vacuum system, the pitot-static system, the antennas, and the alternator. Unfortunately, because the report only modeled the minimum instruments required by the FAA, it left out a few system components that belong under this category when expanding this analysis to model the entire aircraft. These components will be mentioned here but are not modeled in the reliability analysis.

The first system that is not originally included in the Cockpit Instrumentation System is actually not located in the cockpit. A stall warning horn, usually located on the leading edge of either wing, is a simple, usually mechanical device that emits a buzz when the aircraft is on the edge of controllable flight. This device provides an essential function of providing the pilot with warning of an impending stall.

The second system component not included is the Headset/Intercom system. The wiring and switches associated with providing audio signals from and to the radio and the navigation instruments have a certain reliability and their failure may cause loss of information. This system component would also include the Push-to-Talk (PTT) switch and the associated back up interior speaker.

The third component not included in the CIS report is the presence of circuit breakers in the majority of cockpit controls. Other circuit breakers, such as those for the aircraft lights, will be modeled in the other sections as they apply.

The final component that would be included in the CIS section (simply because there is no other category that it fits under) is the Emergency Location Transmitter or ELT. This is a small self contained box and antenna usually mounted in the empennage that transmits a radio signal in the event of a crash.

2. Powerplant

This category includes anything that is involved in providing thrust for the aircraft. It includes the engine and all of its associated components, the propeller system, and the fuel system. The fuel system is included because it is functionally linked to the engine. If the fuel system fails, then the engine system fails, and the entire powerplant fails. The one exception to this system definition is the Heating and Ventilation System. This system is included here because of the danger of leaking engine gases into the cabin. While it technically doesn't contribute to the thrust of the aircraft, it is included here because its failure is related to the engine's function.

3. Airframe

Airframe includes anything that is required to maintain the structural integrity of the aircraft. This includes the wings, empennage, tail, and the fuselage. The fuselage includes all the fuselage frames, the engine mount, firewall, windshield and windows, the engine cowling, and the seats and seat belts.

4. Aircraft Control

The Aircraft Control category includes anything that controls the aircraft's attitude, heading, altitude or changes the aerodynamic characteristics of the aircraft in the air or on the ground except what is included in the Powerplant system. This includes the elevator, aileron, rudder, and flap systems. The typical GA aircraft has a longitudinal trim control, therefore, that is included here as well. The landing gear system is also included under this category, which may seem counterintuitive; however, if the landing gear fails, the loss of function is a loss of control of the aircraft. The landing gear system includes the actual landing gear, tires, brakes, hydraulic system, the parking brake, and the ground steering system.

5. Electrical System

The electrical system has two subsystems. The first is the Source & Distribution subsystem, defined as any component that is essential in providing electrical power to the various parts of the aircraft. This includes the alternator, the battery, the circuit breakers, and any wiring not included in any other system. The second part of the Electrical System is the Lighting System. This includes all the lights, exterior and interior, on the aircraft and the components that are essential to their operations (including the cockpit switches).

VI. Conclusions

There were two goals associated with this study. The first is to define the typical general aviation aircraft based on the current population, and the second was to "sift" the different components that make an aircraft fly into systems that are reasonably independent. Based upon the current population, the typical General Aviation aircraft is four-place, single engine piston all-aluminum aircraft with a fixed tricycle landing gear and a cable-operated flight control system. The table below gives the defining characteristics of the typical GA aircraft.

Table H – The Typical General Aviation Aircraft

Defining Characteristics	Typical GA Aircraft
Number of seats	4
Number of engines	1
Type of engine	Horizontally opposed, 4 or 6 cylinder piston
Landing Gear Type and Configuration	Fixed Tricycle
Airframe Construction	Aluminum frame with aluminum skin, steel engine mount
Flight Control Type and Configuration	Mainly cable operated utilizing bellcranks and push-pull rods
Propeller	Constant-Speed
Flap Type and Power	Electrically actuated Fowler flaps
Trim	Manually actuated longitudinal

The secondary goal of this report is to define which aircraft components belong in which system. The following table depicts the system breakdown from an overall aircraft standpoint. CIS stands for the Cockpit Instrumentation System and the added items are the components that were not included in this category as explained in Section V.B.1. The Aircraft Control system is split between the Ground Control and the Flight Control systems.

Table I – Overall System Breakdown

Powerplant	CIS	Aircraft Control	Airframe	Electrical System
Engine System	Cockpit Instruments	***Flight Control***	Empennage	Lighting System
Fuel System	Vacuum System	Rudder System	Fuselage	Source & Dist.
Propeller System	Pitot Static System	Aileron System	Tail	
Heating/Ventilation	Alternator	Elevator System	Wings	
	Antennas	Trim System		
		Flap System		
	Added:			
	Stall warning horn	***Ground Control***		
	Circuit Breakers	Landing Gear		
	Headset/Intercom			
	ELT			

Throughout this study, it was surprising how clearly defined a lot of aircraft parameters were. A large majority of GA aircraft share similar design characteristics. The data on most characteristics, such as engine type and landing gear configuration, showed a definitive trend. Although it is possible to pick a single representative aircraft, it is more valuable to create an amalgam from several different aircraft models that would better represent the market. There are three or four aircraft manufacturers, whose fairly similar designs dominate the market, making the definition of a typical aircraft possible and reasonably accurate. There were a few characteristics that were impossible to find data on. For example, the FAA doesn't track whether aircraft are equipped with a constant-speed or fixed-pitch propeller. There were also a few characteristics that showed no trend one way or another. Otherwise, the typical GA aircraft as presented in this report is well defined and representative of the entire GA market.

Appendix A

Figure A-1 shows the top 25 aircraft models, their nicknames, the number of seats, and their relative number in the GA market.

Figure A-1 – Top 25 Aircraft Make/Models

Rank	Type of Aircraft	Nickname	Num. of seats	Num. of Aircraft	% Total GA
1	Cessna 172	Skyhawk	4	19,754	12.30%
2	Piper PA28	Archer, Cadet, Cherokee, Arrow, Challenger, Charger, Chief, Cruiser, Flite Liner, Warrior, Dakota	4	17,947	11.18%
3	Cessna 150	Aerobat, Commuter	2	12,885	8.02%
4	Cessna 182	Skylane	4	11,573	7.21%
5	Beech 35	Bonanza	4-6	5,450	3.39%
6	Mooney M20	Ranger, Master, Chaparral, Executive, Statesman, Ovation, 201, 205, Encore, 231,252	4	5,423	3.38%
7	Cessna 210	Centurion	4-6	4,516	2.81%
8	Piper PA32	Lance, Saratoga, Cherokee SIX	6 (7 opt.)	3,398	2.12%
9	Piper PA18	Super Cub	2	2,616	1.63%
10	Piper J3	Cub	2	2,304	1.43%
11	Cessna 177	Cardinal	4	2,274	1.42%
12	Piper PA24	Comanche	4	2,092	1.30%
13	Beech36	Bonanza	6	2,081	1.30%
14	Beech33	Bonanza, Debonair	5	2,078	1.29%
15	Cessna 180	Skywagon	5	1,990	1.24%
16	Cessna 170		4	1,986	1.24%
17	Cessna 206	Super Skywagon, Super Skylane, Stationair, Stationair 6	6	1,921	1.20%
18	Cessna 310	-	6	1,872	1.17%
19	Beech 23	Sierra, Sport, Sundowner, Musketeer	4	1,812	1.13%
20	Beech 55	Baron	6	1,570	0.98%
21	Piper PA34	Seneca	7	1,397	0.87%
22	Cessna 140		2	1,393	0.87%
23	Cessna 185		6	1,372	0.85%
24	Beech 58	Baron	6	1,231	0.77%
25	Cessna 188		1	1,108	0.69%
	Totals			**112,043**	**69.78%**

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13. ABSTRACT (*Maximum 200 words*)

The reliability of General Aviation aircraft is unknown. In order to "assist the development of future GA reliability and safety requirements", a reliability study needs to be performed. Before any studies on General Aviation aircraft reliability begin, a definition of a typical aircraft that encompasses most of general aviation's characteristics needs to be defined. In this report, not only is the typical general aviation aircraft defined for the purpose of the follow-on reliability study, but it is also separated, or "sifted" into several different categories where individual analysis can be performed on the reasonably independent systems. In this study, the typical General Aviation aircraft is a four-place, single engine piston, all aluminum fixed-wing certified aircraft with a fixed tricycle landing gear and a cable operated flight control system. The system breakdown of a GA aircraft "sifts" the aircraft systems and components into five categories: Powerplant, Airframe, Aircraft Control Systems, Cockpit Instrumentation Systems, and the Electrical Systems. This breakdown was performed along the lines of a failure of the system. Any component that caused a system to fail was considered a part of that system.

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