Statistical Study of Sonex Accidents

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15 November 2021

Overview

- Received request to examine accidents involving the Sonex aircraft
- Items to be addressed
  - Accident causes vs. the overall homebuilt fleet
  - Engine issues
  - Effect of aircraft owned by the original builder vs. a subsequent owner

Analysis Overview

Data Sources

- Ron Wanttaja's analysis of Experimental/Amateur-Built aircraft in the NTSB accident list ("RJW Results")
- Analysis features:
  - Download of the database itself, not on the online version
  - 1998 to 2020, inclusive, updated every December
  - Includes only Experimental Amateur-Built aircraft built/operated in the US as personal aircraft
    - No SLSA/ELSA, Ultralights, Air Show/Racing aircraft, 737s, etc.
    - No foreign accidents, no foreign homebuilts in the US (were not built to US Amateur-Built aircraft requirements)
    - Above criteria eliminated ~25% of 2014 fatal accidents that were flagged as "Amateur-Built" in the online NTSB data
  - Also search overall accidents for aircraft that were E-AB but were not labeled "Homebuilt"…are added to the database
    - Usually 5-10 every year
- All Sonex designs are lumped into one
  - 56 total accidents includes
    - 7 Waiex aircraft
    - 2 Onex
    - 1 Subsonex
    - One Xenos motorglider

Analysis Process

- Convert NTSB reports to personal database
- Read full narrative of each accident
  - Probable Cause often leaves out significant clues
- Enter my own estimation of the cause into database
- Repeat ~4500 times
- Lump all Sonex models into a single category
- Other factors:
  - This report examines only reported accidents
    - Problems that don't rise to the reporting standards of NTSB 830 won't be included
  - The author's analysis process does not specify pilot error after a loss of engine power
    - The accident in question will be attributed to the engine failure, not for the pilot's inability to pull off the emergency landing

Comparison to Overall Fleet

Accident Summary 1998-2020

- Total homebuilt accidents: 4,560
- Total Sonex accidents: 56
- Will compute Yearly Fleet Accident Rates for both
  - Number of aircraft licensed as Experimental Amateur-Built as of the end of the particular year, divided by the number of accidents within that year
- Homebuilt fleet sizes are based on the number of aircraft that are listed as having an Experimental Amateur-Built certificate
- This can generate some controversy when counting the numbers of given homebuilt accidents
  - Search for Sonex aircraft in December 2020 generated 641 “hits”
  - But only 527 of them are listed as having Experimental Amateur-Built (EAB) Certificates
    - The rest have a blank in the certification entry
    - I refer to these as “Phantom Homebuilts”
- Phantom homebuilts <u>are not</u> included when computing the fleet accident rate
  - If we’re counting the total number of homebuilts based on the EAB parameter, must insist on same requirement for individual aircraft types
  - All homebuilt types are affected the same, so this has no major impact
    - There are over 5,000 aircraft in the US registry that have homebuilt names but have blank listings for certification
- The certification status is not used when tallying the number of accidents
  - All homebuilts are affected equally

Example of “Non Phantom” Sonex

Sonex N188DM

N-NUMBER ENTERED: 188DM			
Serial Number	0739	Status	Valid
Manufacturer Name	DAVID P MCGLOON	Certificate Issue Date	09/02/2015
Model	SONEX	Expiration Date	09/30/2024
Type Aircraft	Fixed Wing Single-Engine	Type Engine	Reciprocating
Pending Number Change	None	Dealer	No
Date Change Authorized	None	Mode S Code (base 8 / Oct)	50257273
MFR Year	2017	Mode S Code (Base 16 / Hex)	A15EBB
Type Registration	Individual	Fractional Owner	NO
Kit Manufacturer	SONEX LTD	Kit Model	SONEX

Experimental Amateur-Built!

REGISTERED OWNER			
Name	MCGLOON DAVID P		
Street	778 SCOTT DR		
City	GRANTS PASS	State	OREGON
County	JOSEPHINE	Zip Code	97527-9413
Country	UNITED STATES		

AIRWORTHINESS			
Type Certificate Data Sheet	None	Type Certificate Holder	None
Engine Manufacturer	JABIRU	Classification	Experimental
Engine Model	3300	Category	Amateur Built
A/W Date	03/16/2017	Exception Code	No

Example of “Phantom” Sonex

Sonex N334SX

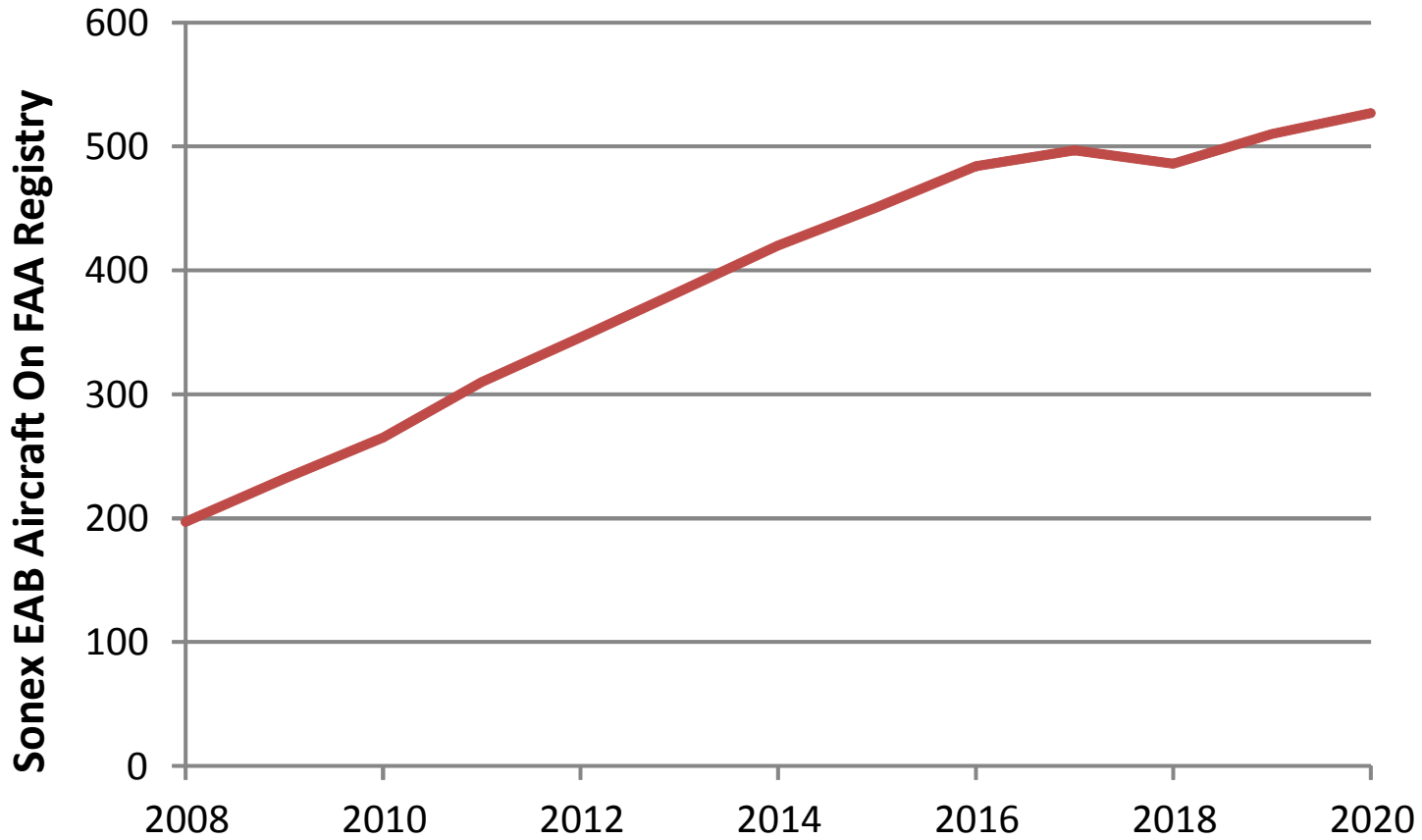
N-NUMBER ENTERED: 334SX			
Serial Number	**334**	**Status**	**Valid**
Manufacturer Name	CHRISTIE DUSTIN L	Certificate Issue Date	01/06/2016
Model	SONEX	Expiration Date	01/31/2022
Type Aircraft	Fixed Wing Single-Engine	Type Engine	Reciprocating
Pending Number Change	None	Dealer	No
Date Change Authorized	None	Mode S Code (base 8 / Oct)	50723121
MFR Year	None	Mode S Code (Base 16 / Hex)	A3A651
Type Registration	Individual	Fractional Owner	NO

Unknown Airworthiness!

REGISTERED OWNER			
Name	CHRISTIE DUSTIN L		
Street	1321 E 500 S		
City	WASHINGTON	State	INDIANA
County	DAVIESS	Zip Code	47501-7847
Country	UNITED STATES		

AIRWORTHINESS			
Type Certificate Data Sheet	None	Type Certificate Holder	None
Engine Manufacturer	Unknown	Classification	Unknown
Engine Model	Unknown	Category	None
A/W Date	None	Exception Code	No

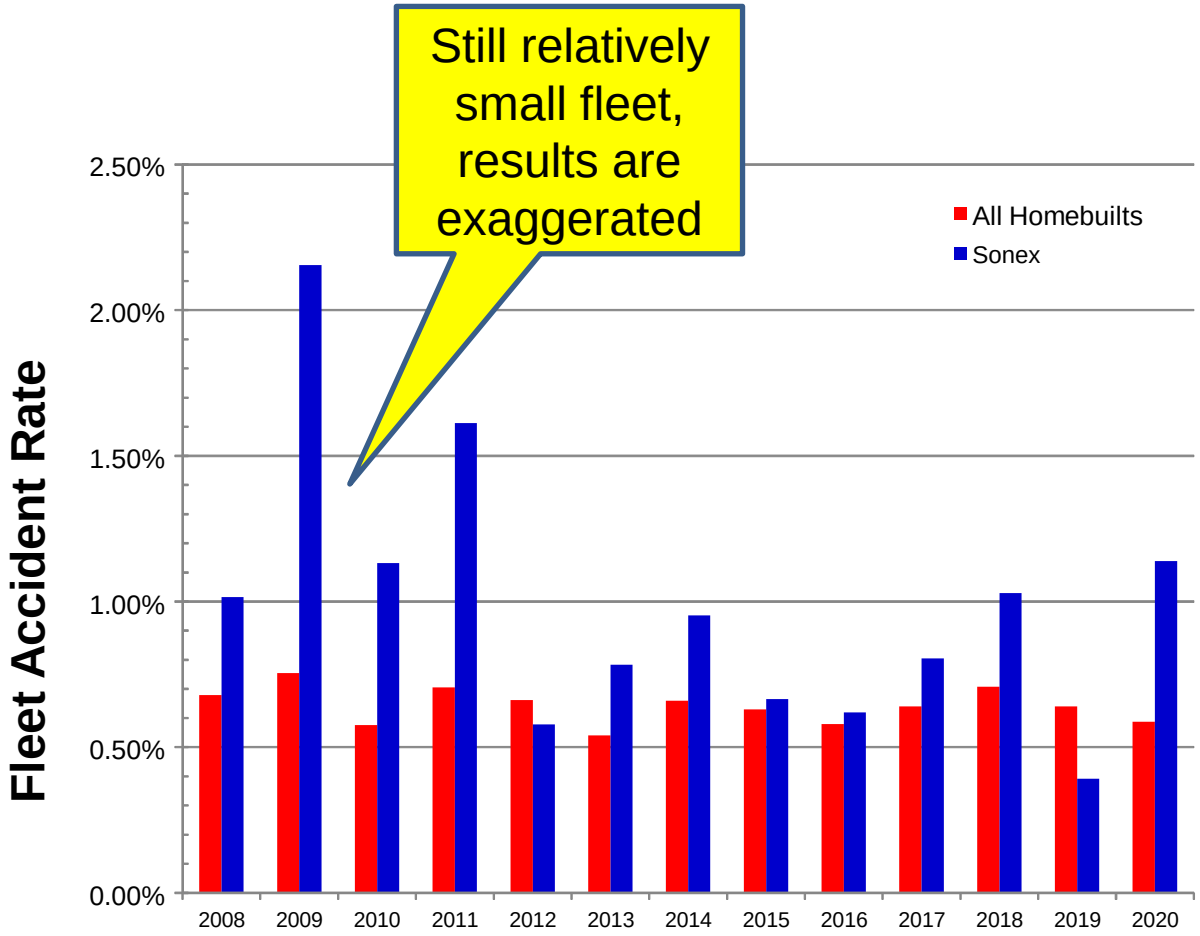
Sonex Fleet Size – 2008 through 2020



Does not include "Phantom" airplanes or non-US-registered airplanes

Annual Fleet Accident Rates

- Based on number of accidents during a given year, vs. the number of registered EAB aircraft in that year

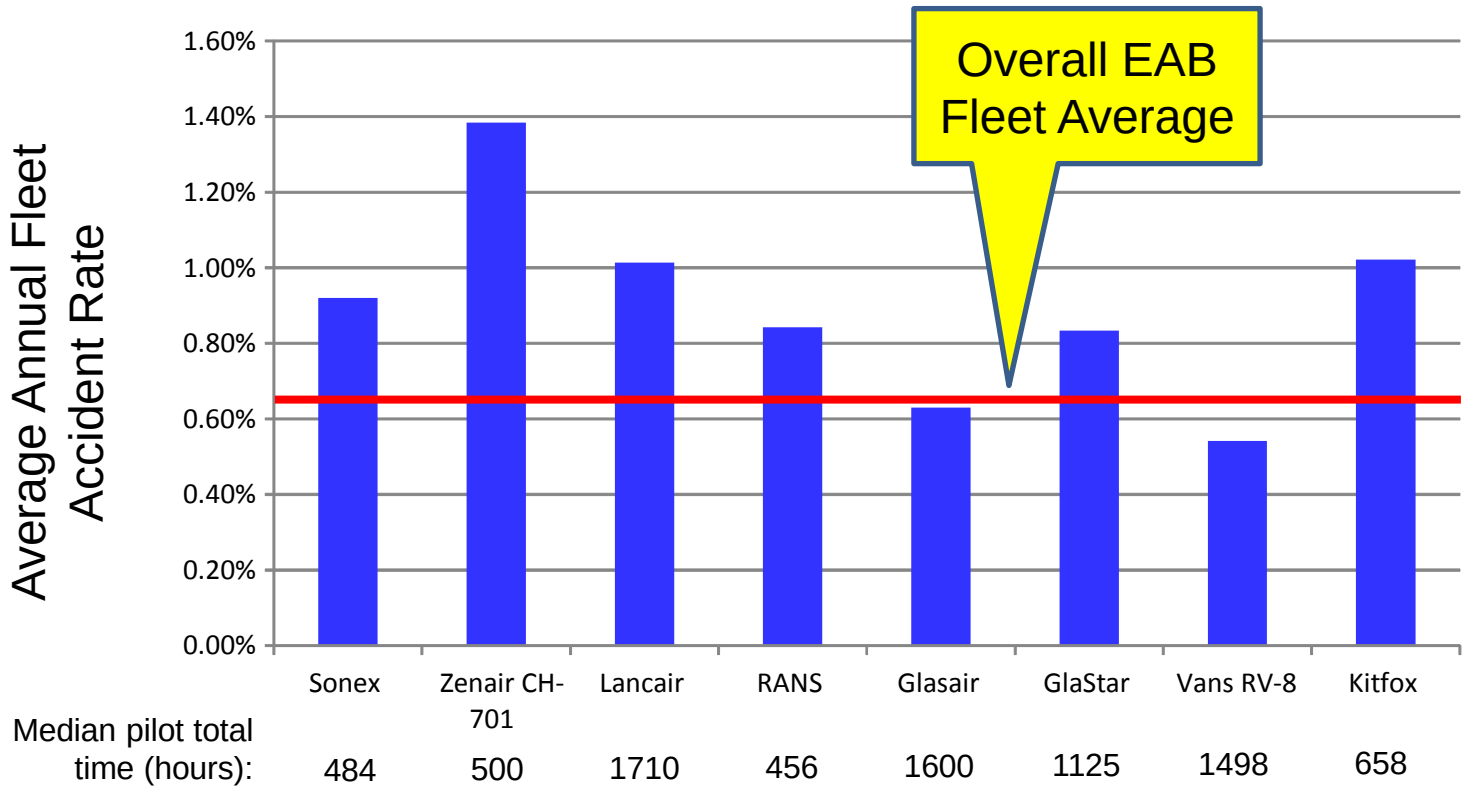


The Effect of Pilot Experience

- Obviously, more-experienced pilots are less likely to be in an accident
- While the Sonex fleet accident rate is higher than the overall homebuilt fleet, the pilots are less experienced
- Median flight hours:
  - Overall homebuilt fleet: 1,000 hours
  - Sonex: 494 hours (half as much!)

Overall Average Fleet Accident Rates 2008-2020

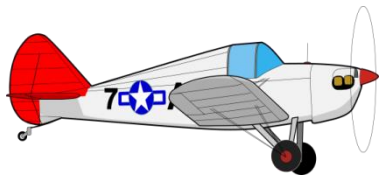
- Average Number of accidents 2008 to 2020 divided by the average number of EAB aircraft registered in same time period
- Sonex is “in family” with similar aircraft



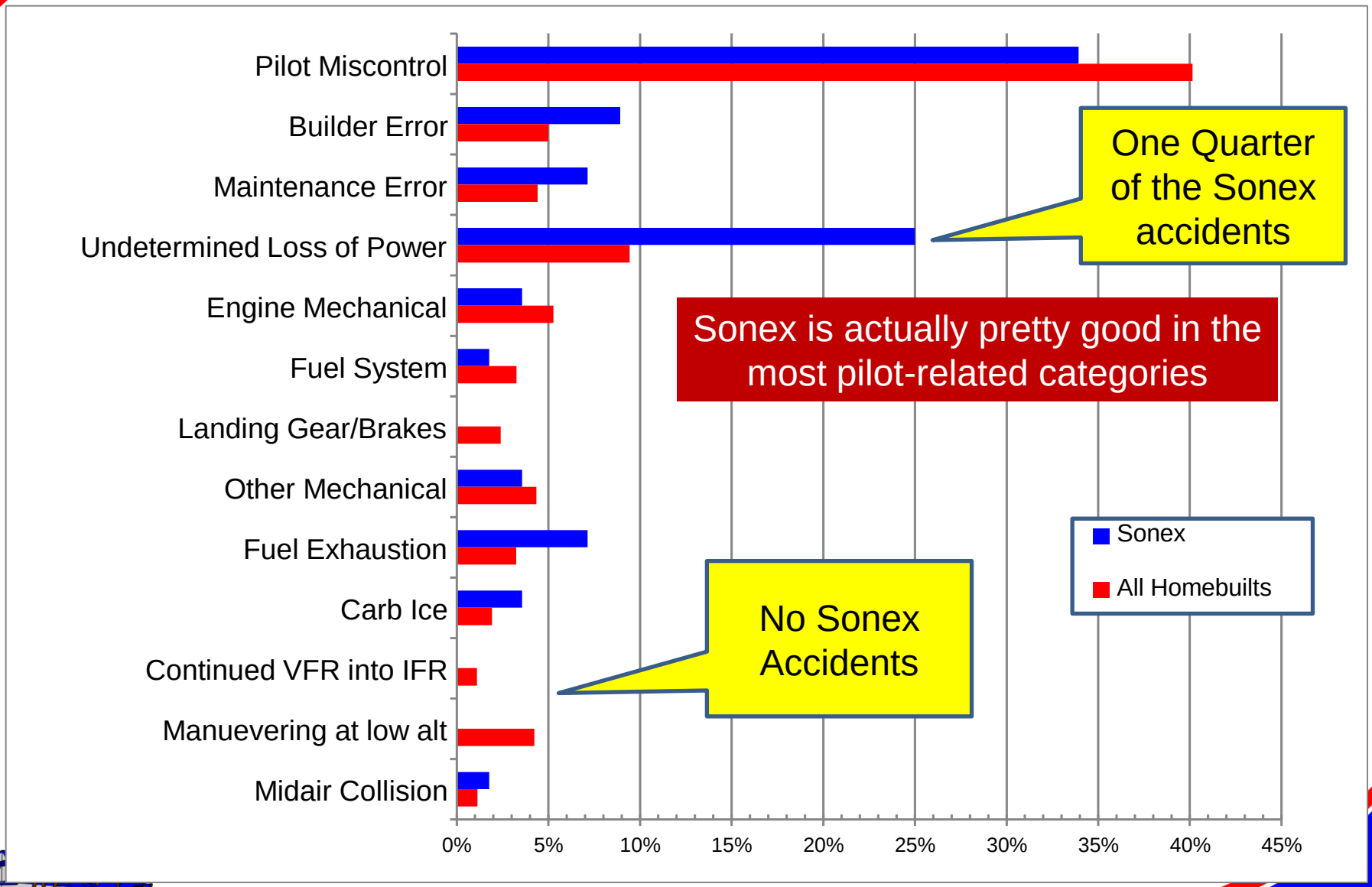
Accident Causes

A Note on the Percentages

- Remember there are only 56 Sonex accidents in the analysis period
- Each accident is basically 1.8% of the total!
  - One or two accidents, more or less, can significantly change the results
  - So don't worry about minor differences
- Pilot experience difference
  - All homebuilts: median 1000 hours
  - Sonex: 484 hours
  - Would expect Sonex has more accidents related to pilot skills or judgement



All Homebuilts vs. Sonex



The Bad News

- About 31% of all homebuilt accidents involve loss of engine power
  - Includes mechanical issues
  - Includes pilot issues (running out of fuel, etc.)
  - Includes cases where the NTSB was unable to determine why
    - Aircraft destroyed, or
    - Temporary condition
      - In many cases, the NTSB is able to re-start the engine afterwards
- **50% of all Sonex accidents begin with a loss of engine power**

The Details

- 28 out of 56 Sonex accidents involved a loss of engine power
  - On 14 (25% of total accidents, 50% of the loss of power cases) the NTSB was unable to determine the reason:
  - Six (almost half) of the undetermined engine failure cases were fatal accidents

Pilot Miscontrol

- The rate of Pilot Miscontrol (e.g., stick and rudder errors) is a bit lower than the overall homebuilt fleet
- Sonex aircraft seem less prone to accidents related to stalling or winds on takeoff or landing
  - 22% of miscontrol accidents on all homebuilts are due to stalls, 23% are due to winds
  - 16% for both on the Sonex
    - Again, though, small sample size…only 19 miscontrol cases, only three cases of accidental stalls with fully-functional aircraft
- Pilot Miscontrol is only assigned if the airplane is operational
  - Doesn't address post-engine-failure operations
- After an engine failure*:
  - 15.5% of all homebuilt pilots stalled during the emergency landing
  - Vs. 36.8% of Sonex pilots
    - Who, remember, have half the experience level vs. the homebuilt fleet
    - But… percentage for Kitfox is 21%, and not showing any post-engine-failure stalls for Zenith CH-701, and they have about the same level of experience

* Data from 2011-2020

Undermined Loss of Power

- NTSB does not investigate homebuilt accidents in the same depth as certified aircraft
  - Main goal of NTSB is to find recurring issues where a change may reduce the number of accidents
    - Finding why one Cessna 172 crashed may result in changes (e.g. AD notices) that may prevent other Cessna 172s from suffering same type of accident
    - All homebuilt aircraft, by definition, are unique
      - Almost half of homebuilts involved in accidents have non-traditional engines
  - NTSB resources are limited, hence they don't look into homebuilt aircraft as closely
  - Lycoming, Continental, etc. have large stakes in the results of accident investigations and have staff assigned
    - Analysis/forensic assistance less available for many engines used in homebuilts
- Just ~4% of Cessna 172 accidents are attributed to undermined loss of power, vs. 9.5% of all homebuilt accidents
  - 25% of Sonex accidents were attributed to undetermined engine failures. This is half of the cases where the engine failed….
- An accident may be deemed as undetermined engine failure in cases where the engine is not at fault!
  - Temporary conditions such as carburetor icing or vapor lock
  - Pilot issues, such as unadmitted fuel mismanagement
    - E.g, "I had the fuel valve on the right tank" when the left tank was actually selected

Summary of Undetermined Loss of Power

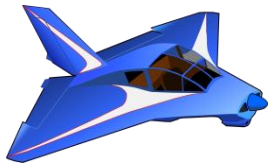
- ANC11LA060
  - …Both inspectors reported that their examination revealed no preaccident mechanical anomalies with the engine or airframe.
- CEN09CA391
  - According to a Federal Aviation Administration inspector on scene, the engine had compression, turned over by hand, and showed no outward signs of failure. No reason could be determined for the engine failure.
- CEN15FA249
  - The AeroInjector carburetor was impact separated from the engine, but remained connected to the airframe via the throttle and mixture cables. The intake housing to the turbocharger was impact separated. The cylinder rocker box over the No. 3 and 4 cylinders was also impact separated. There was some rearward distortion to the No. 3 and 4 valve rocker arms and rod housings. Engine continuity was confirmed through the engine to the flywheel. In addition, valve train continuity was established. … All four cylinders were borescoped and found to have normal wear and deposits on the cylinder bores, pistons, and valves. The AeroInjector's throttle slide operated smoothly and normally, and its needle valve was installed in the proper orientation. The needle valve was unobstructed and channeled fuel when fuel was added to the AeroInjector's fuel inlet.
- CEN21LA092
  - Report not completed. The pilot reported that he had a “sick engine” and he was “just trying to make the field.”
- CEN21LA100
  - Report not completed
- CHI08CA170
  - No mention of engine inspection, just that it quit for unknown reasons
- ERA11FA374
  - A thorough examination of the engine could not be accomplished due to the thermal damage. However, the engine case assembly and exhaust system appeared to be intact. Inspection of the spark plugs and carburetor did not reveal any anomalies other than post impact thermal damage.

Summary of Undetermined Loss of Power - 2

- ERA13LA024
  - Continuity of the engine valvetrain and powertrain were confirmed, and rotation of the engine utilizing the starter showed no binding or other faults. Operation of the ignition system to the bottom spark plugs was confirmed, though operation of the top spark plugs could not be confirmed as the required engine speed could not be attained. The spark plugs appeared to be in new condition. Examination of the fuel system showed that fuel was available to the engine, with no anomalies noted.
- ERA13LA254
  - Examination of the wreckage did not reveal any cracks in the engine case or oil residue in the engine compartment. With the exception of a disconnected oil breather tube, the FAA inspector did not observe any preimpact anomalies. The pilot added that the oil breather tube was "flimsy" and most likely separated during impact. He further stated that there was no evidence of an oil leak in the air or on the ground.
- ERA14LA018
  - After the accident, under the direction of the FAA inspector, the pilot was able to rotate the propeller through and get compression on three cylinders, but then it locked on the fourth cylinder. The pilot moved the propeller backwards slightly and was then able to continue rotation. He subsequently started the engine and it ran without hesitation. The pilot then removed all of the cylinders and did not observe any preimpact mechanical malfunctions.
- ERA15FA003
  - The engine sustained significant impact damage. The front of both valve covers were impact damaged and the exhaust tubes were crushed and bent back. The engine's crankshaft could not be rotated due impact damage and contamination from mud; however, all cylinder valves were intact and could be manually actuated by depressing their respective springs. In addition, the valve assemblies and cylinders were disassembled for inspection, which revealed no anomalies. The crankshaft was intact. All connecting rods were intact and remained connected with no evidence of abnormal distress. The engine's AeroInjector fuel metering unit was impact damaged. Its fuel line assembly remained intact and the inline throttle valve was in the open position. The fuel mixture position could not be determined. The ignition system data plate was recovered; however, no other components from the ignition system except the spark plugs and portions of the spark plugs ignition leads were recovered. All spark plugs were removed. Their electrodes were undamaged and free of contamination.

Summary of Undetermined Loss of Power- 3

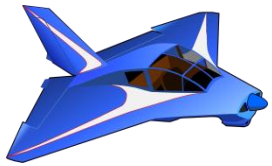
- ERA18LA083
  - The airplane was not recovered.
- WPR09CA152
  - Post examination of the airplane and engine by an FAA inspector did not reveal any pre-impact malfunctions that would explain the loss of power.
- WPR20LA196
  - Report not yet completed



Engines Listed in Undetermined Power Failure Cases

- Table contains entries from NTSB accident database
  - Eight out of fourteen cases are identified as Aerovee engines
- Two cases with no entry:
  - FAA registry says aircraft in CEN21LA092 has an “AMAT/EXPR” engine
  - No entry at all for aircraft listed in CEN21LA100

NTSB	Engine Mfg	Eng Model
CHI08CA170	Kindig	AeroVee 2180
WPR09CA152	Aeroconversions	Aerovee
CEN09CA391	AMA/EXPR	UNKNOWN ENG
ERA11FA374	Jabiru	120
ANC11LA060	Volkswagen	AeroVee 2.1
ERA13LA024	AeroVee	2.0
ERA13LA254	AeroVee	2180
ERA14LA018	Great Plains	2180 VW
ERA15FA003	AeroVee	2180
CEN15FA249	Experimental	AeroVee Turbo
ERA18LA083	Volkswagen	
WPR20LA196	AEROVEE	2.1
CEN21LA092	*(no entry)*	
CEN21LA100	*(no entry)*	



Loss of Power with Known Engine-Related Causes

- Specific mechanical problems were noted on ten of the 56 Sonex accidents, of which eight are engine-related
- Of the eight, there are only two cases with the same root cause
  - Two instances are not enough to establish a trend!
  - CHI05CA032 and CEN15LA028, both attributed to fatigue failure of the crankshaft
    - In CHI05CA032, the NTSB noted "… the builder's failure to verify the dimensions of the shrink-fit crankshaft components prior reassembling the engine"
  - Neither is identified by the NTSB as an Aerovee engine
    - CHI05CA032: "Volkswagen 2180"
    - CEN15LA028 does not have an engine make/model entry.
    - The FAA registry lists both aircraft as "AMAT/EXPR Unknown Engine"

Other Six Engine-Related Loss of Power Cases

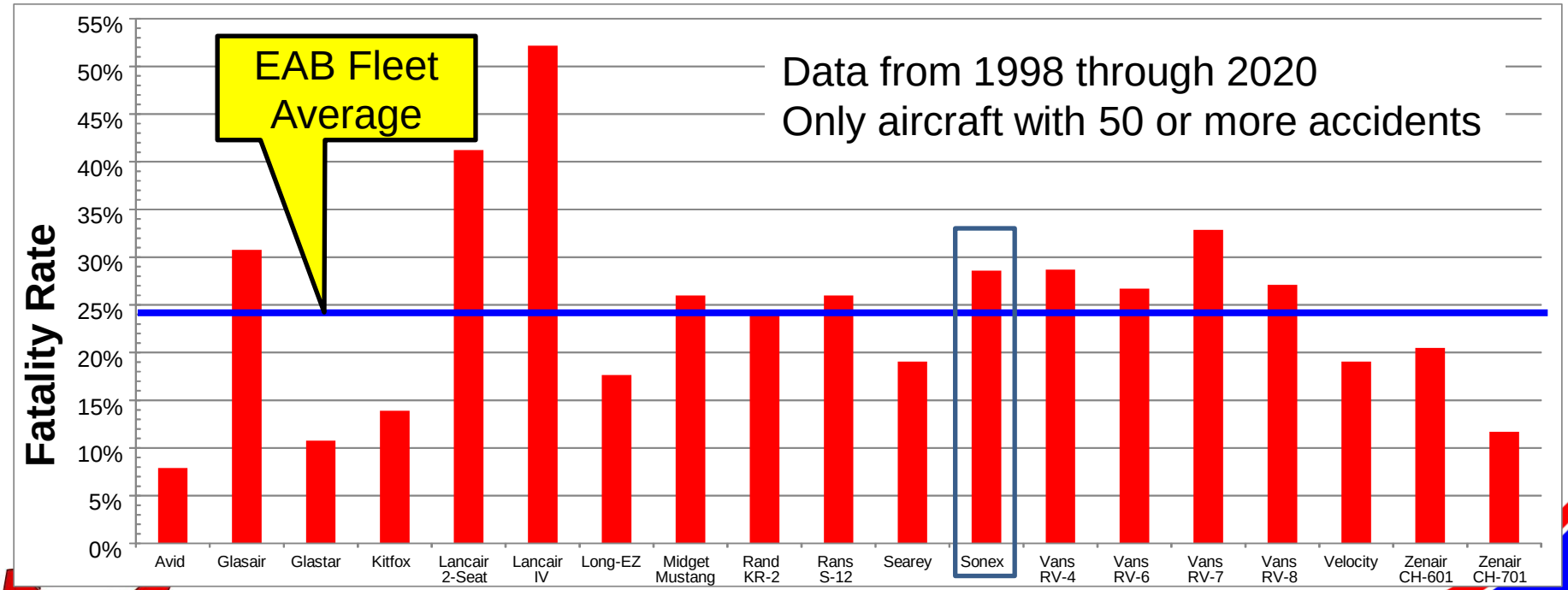
- CHI06LA088: Restricted throttle cable (Aerovee engine)
- ERA09CA162: Failure of the ignition power supply due to the improper installation of the electronic control unit (UL Power engine)
- ERA14FA123: Improper repair of stripped spark plug (Aerovee engine)
- WPR16LA050: Builder's failure to properly align the Force One Main Bearing, which resulted in a blockage of the oil transfer hole (“Type 1 VW” engine)
- CEN16LA273: Separated rocker arm (Aerovee engine)
- WPR20CA132: Pressure regulator not keeping continuous fuel pressure (Jabiru engine)

Two Other Loss-of-Power Cases

- Two remaining cases are fuel-related
  - Generally, the leading cause of loss of power in homebuilt aircraft
- CEN10LA050: Clogged fuel screen that resulted in fuel starvation caused by the builder's inappropriate use of a fuel tank sealant in a plastic tank (Jabiru engine)
- ERA17FA117: Failure to properly secure oil and fuel line fittings during maintenance, which resulted in an inflight engine fire (Jabiru engine)

Fatal Accident Rate

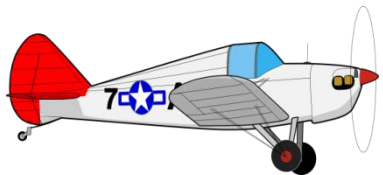
- "Fatal Accident Rate" is the percentage of accidents that result in at least one fatality
- Sonex is slightly above average



Non-Builder Owner Accidents

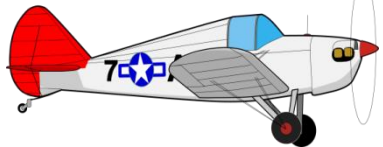
Finding the Accidents Involving Purchasers of Homebuilt Aircraft

- Question was asked about accident rate between the original builder of a homebuilt vs. subsequent purchasers
  - NBO: Non-Builder Owner
  - Past analysis shows that about half of homebuilt aircraft have new owners seven years from completion
- Data is not easily extracted from NTSB accident database
  - Sometimes mentioned in the narrative, but no definitive flags

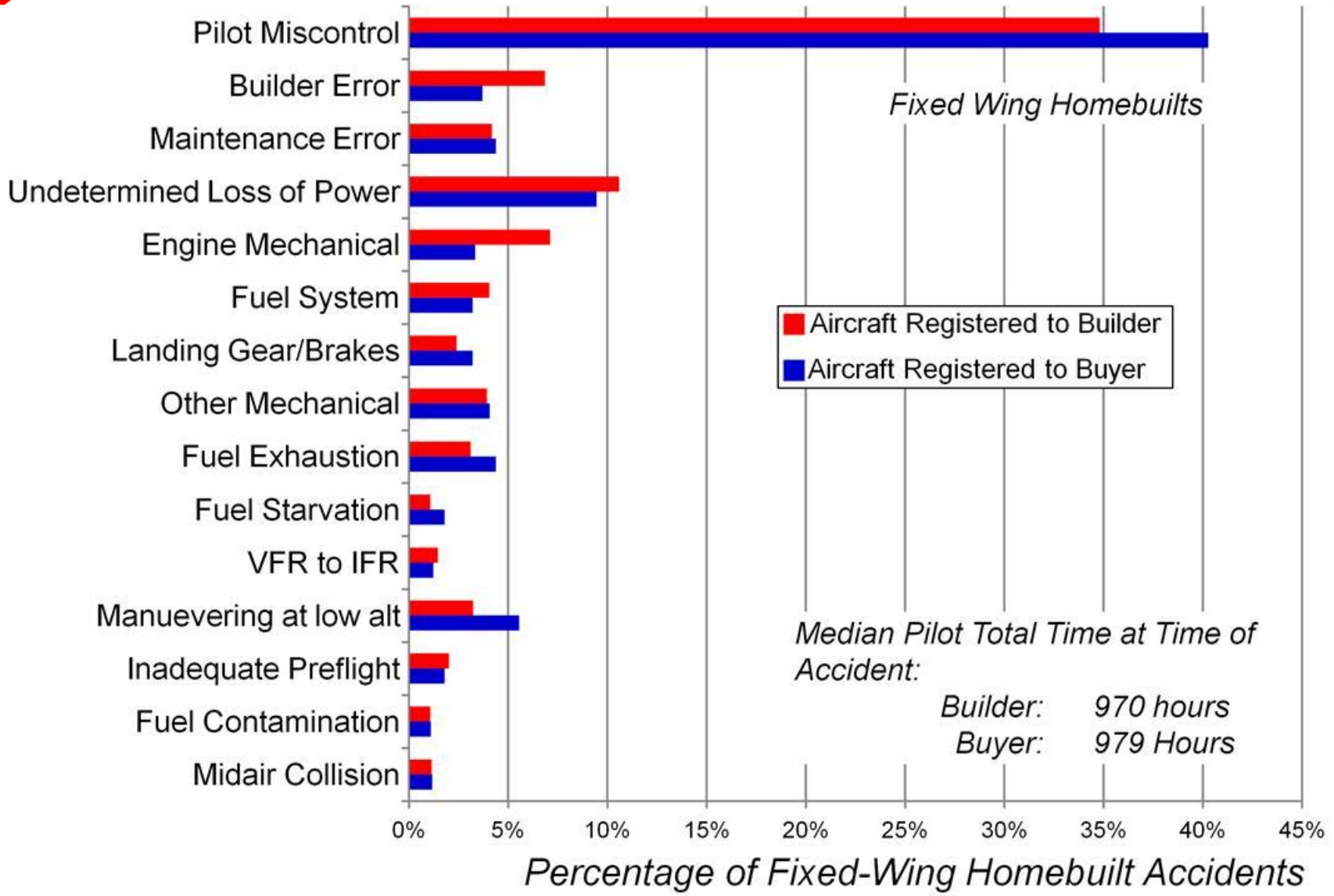


Finding the Builders vs. the NBOs

- Narrative is examined for mention of the buyer vs. builder status
  - If it was a recent purchase, the NTSB report typically mentions it
  - However, cannot make assumptions if no comment is included
- The “Manufacturer Name” of the aircraft is compared with the owner’s name
  - Both fields have traditionally been included in the NTSB report
    - However, starting in 2020, most of these entries have been removed…even from past accidents!
      - Ran a similar process on the FAA Registry, instead
  - If the “Jones RV-6” is registered to a “Jones, David,” it is assumed to be builder-owned
    - If the Jones RV-6 is registered to a “Smith, Peter,” it is assumed to be NBO
    - Business names/LLC names, no assumption is made
- If the pilot is listed as having less Time in Model than the aircraft flight hours, it is assumed to be NBO (otherwise, builder)
  - Used a threshold of two hours (e.g., if the airplane time is 100 hours, and the pilot time in type is 98 hours, still assumed to be the builder)
    - Two hours would assume one hour ground test, and that the accident may have occurred at the end of a one-hour test flight
    - In reality, have seen aircraft with ten or more hours that are listed as on their maiden flight with the builder
- For the overall aircraft accidents 1998-2020, the numbers of builders vs. NBOs is almost identical (2008 vs.2055)

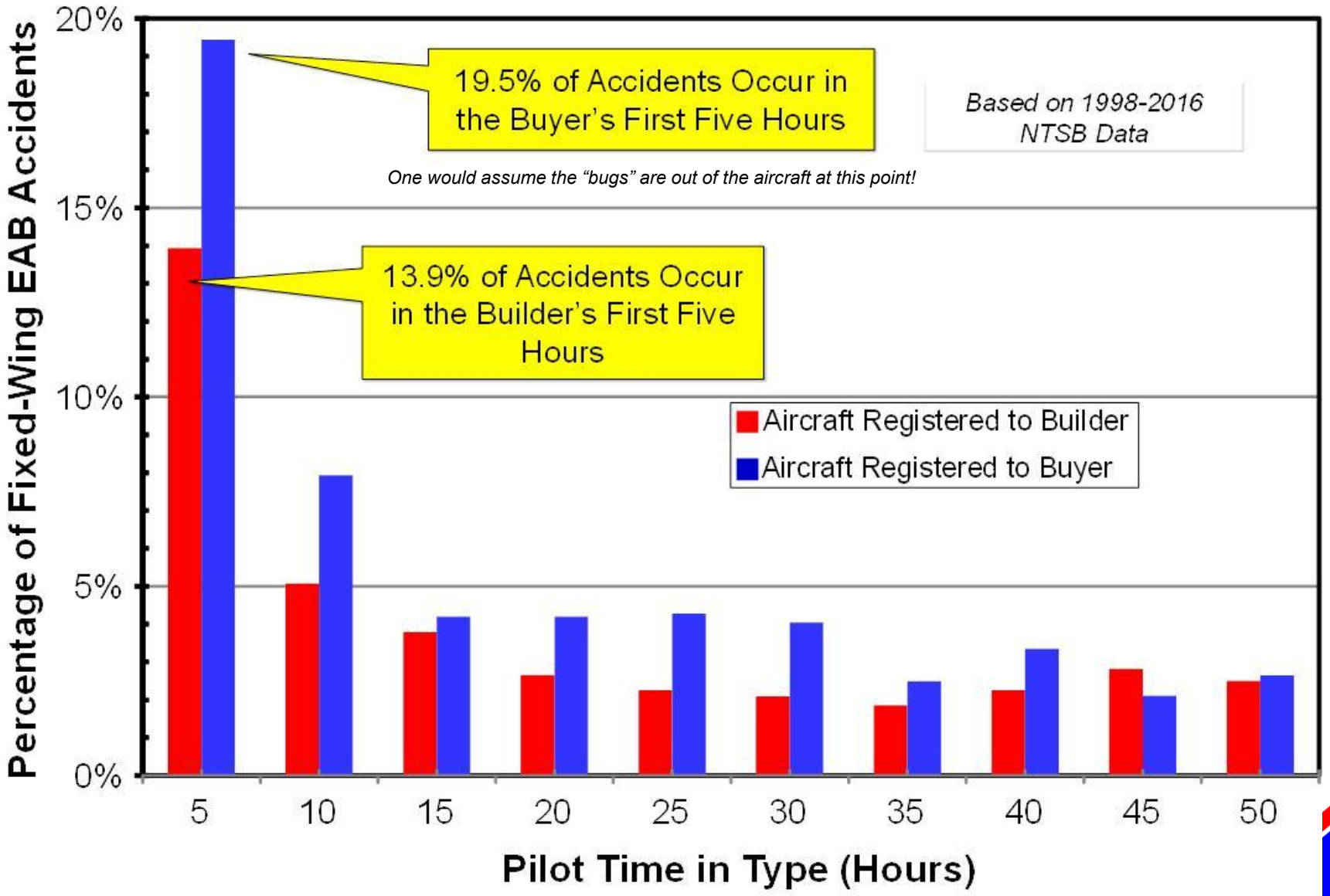


Overall Results – All Accidents



Data is from 1998-2016, hence the median hours are slightly different from that previously shown

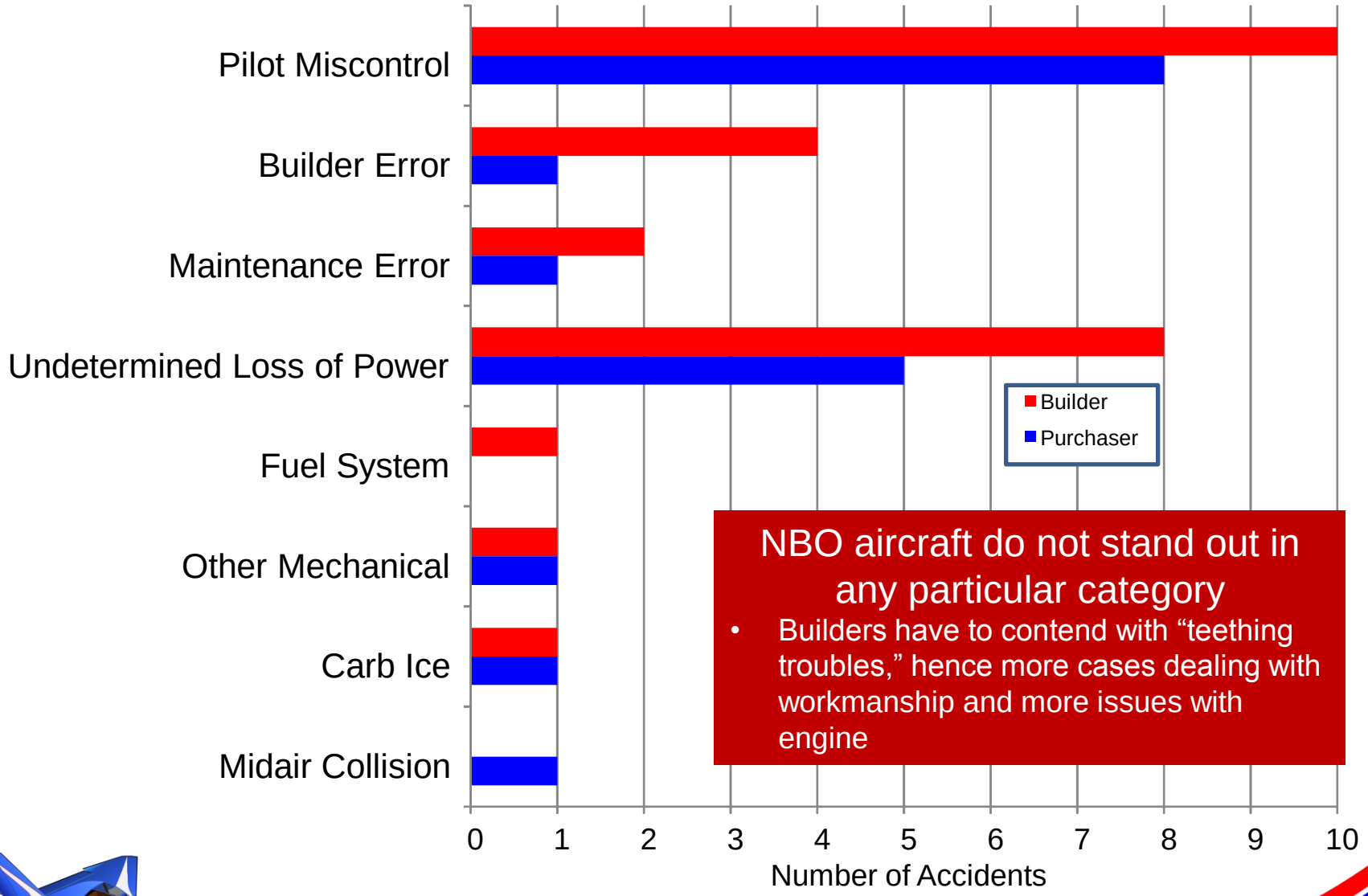
Surprisingly, NBOs are More Likely to have an Accident in their first ten hours than Builders!



NBOs and the Sonex

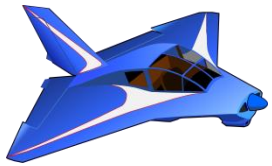
- The ratio for builders vs. NBOs for the Sonex is slightly biased towards builders
  - 29 builder-owned accidents vs. 22 NBO accidents
    - Four accidents where the owner status was not able to be determined
- With just 22 NBO accidents, comparison by percentage isn't useful
  - Each accident is nearly 4% of the total, and one or two accidents either way can skew the results
- Compare them by number of accidents only
  - Remember that the NBO set is seven fewer than the builder-owned set

Sonex Builder vs. NBO



NBO aircraft do not stand out in any particular category

- Builders have to contend with "teething troubles," hence more cases dealing with workmanship and more issues with engine



Accidents involving builder-owned Sonex Aircraft involve power failure in 52% of cases, vs. 41% of NBO

Looking at Mechanical Issues

- Sonex has 14 undetermined loss of power cases
  - Eight builder-owned
  - Five NBO
  - One where ownership status was unclear
- Of the ten known mechanical issues
  - Five builder-related
  - Two NBO
  - Three unknown

Summary

Summary

- Sonex aircraft seem to be “in family” with other low-powered homebuilt sport aircraft
  - Fleet accident rate is higher than average, but similar to aircraft such as the Zenith CH-701 and the Kitfox
  - The pilots involved in accidents with these aircraft typically have half the experience of those in the overall homebuilt fleet, which helps explain the higher accident rate
- The fatal accident rate for the Sonex design is slightly above average, but this should not be considered an issue
  - The low-wing configuration makes it more difficult to protect occupants in a severe crash
  - The Sonex is also of higher performance than most of its competitors, which would also make the fatal rate higher
- The relatively low number of accidents make it difficult to find any given problem areas
  - However, half the accidents were due to problems with maintaining engine power, and the NTSB was unable to determine the reason in half of *those*
    - This is not due to any actions or policies of Sonex, but it is obviously in the company’s benefit to gain more information
  - In addition, Sonex pilots seem to have a higher rate of stalling after an engine failure
- While the sample size is very low, it does not appear that Non-Building Owners (NBOs) of Sonex aircraft suffer a significantly different accident rate