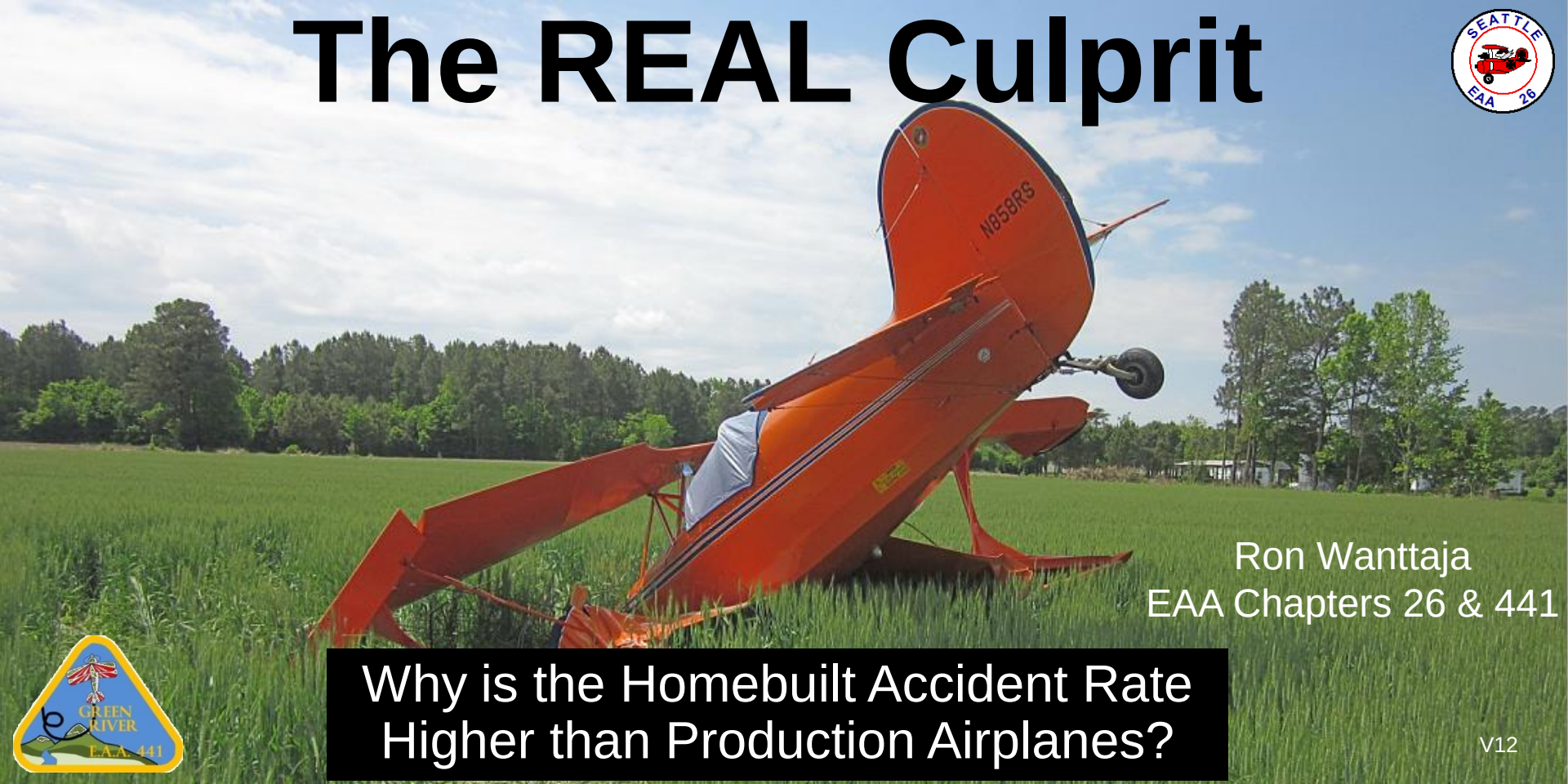
The REAL Culprit



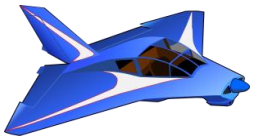
Ron Wanttaja
EAA Chapters 26 & 441

Why is the Homebuilt Accident Rate Higher than Production Airplanes?

V12

Introduction

- Just about every source shows the accident rate for Experimental Amateur-Built (EAB) aircraft is higher than that of production-type aircraft
  - Some reports have said our rate is NINE TIMES higher!
- Certainly there's more risk due to first flight accidents
  - About 0.80% of new homebuilts suffer an accident on the first flight
- But what else is contributing?
  - By my accounting, we still have a fleet accident rate ~45% higher when first-flight accidents are included



Will include a link to these charts on the last page

How I Got in this Mess

- In October 2002, brought my Fly Baby to a “Homebuilt Weekend” at Seattle’s Museum of Flight
- Was snagged by a crew from local TV station and asked, essentially, “Do home-made airplanes crash more often?”
- All I could do it wing it with information I’d heard
  - "Once we complete our test period, our accident rate is about the same as production aircraft,“
  - "Most of our accidents during the test period relate to problems with the fuel system.”
  - “Once the test period is completed, our accident rate in weather-related accidents is lower, though we tend to have a few more crashes in other categories.“
- Afterwards, got wondering…how accurate had I been?*
- Led to my performing my own independent analysis of NTSB records

* Spoiler: Not very

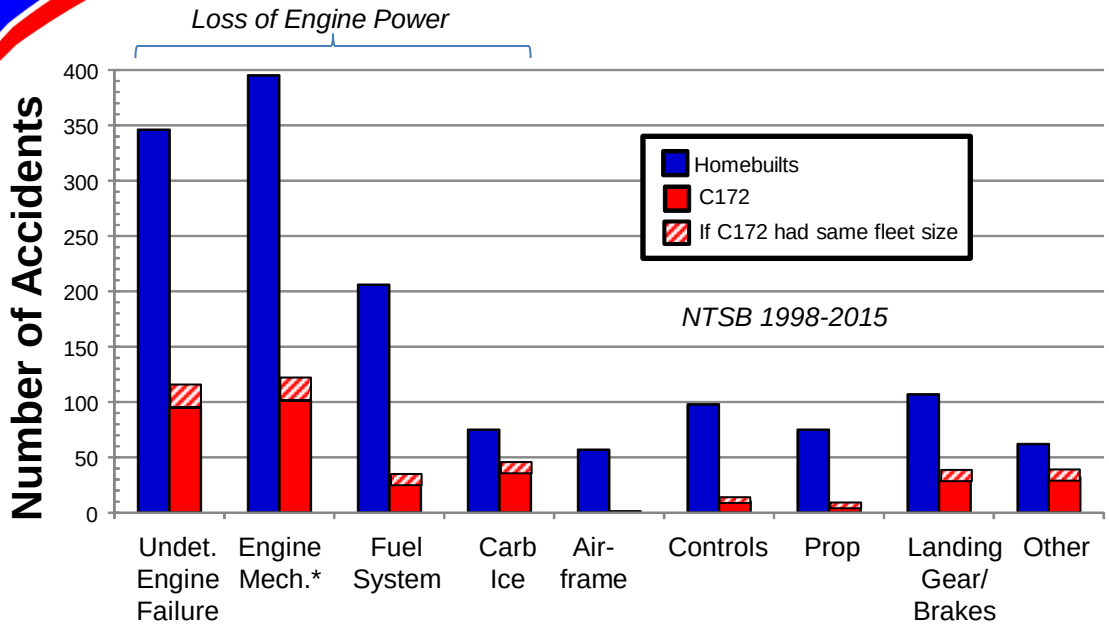
Fallout

- Decided to do my own analysis of homebuilt accidents
- Since then, have read over 4,700 NTSB reports on homebuilt accidents and assigned a cause to each (Covering 1998 through 2021)
  - Based on my own reading of the Narrative, not the NTSB Probable Cause
- Repeated on ~4,000 additional production-type airplanes
  - Cessna 172s and 210s, Piper PA-28s, Bonanzas, Cirrus, etc.
    - Analysis period generally shorter (5-15 years)
- Only consider REPORTED accidents
- Database doesn't include aircraft registered as Special Light Sport or Experimental Light Sport, or non-registered ultralights

Comparing Homebuilts to Cessna 172s

- We need a common GA aircraft to compare to homebuilts
  - Cessna 172 is probably the single best example
- EABs have fewer accidents due to Pilot Miscontrol (stick and rudder mistakes): 40% vs. 60% of all accidents
  - Comparing ALL pilot-error categories: 57% vs 80%
  - BUT: Pilots of the homebuilts involved in accidents have four times the experience level of the Cessna 172 set
    - 1000 hours median, vs. 240 hours for the 172s
- Fleet sizes are almost the same
  - About 22% more homebuilts than Cessna 172s
  - Gives us a chance for comparison by numbers instead of percentages

Comparing NUMBERS (not percentages) of Mechanical Failures



- Builder/Maintainer Error
  - –11.8% of EAB accidents
  - –2.5% of Cessna 172 accidents
- Loss of engine power
  - –32.8% of EAB cases
  - –15% of Cessna 172 accidents

** Includes engine internal issues, ignition issues, cooling issues, carburetor issues, etc.*

The Culprit is Loss of Engine Power

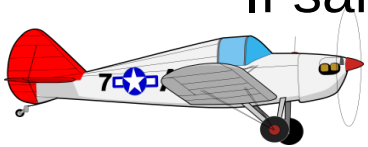
- Percentage-wise, the homebuilt fleet suffers twice as many accidents due to loss of engine power as Cessna 172s
  - Includes mechanical issues, undetermined cases, and pilot-induced engine failures
- Coincidentally (or not….)
  - **More than half of EAB accidents involve non-certified engines….**

The Ability to Install Non-Certified Engines is a FUNDAMENTAL Aspect of Homebuilt Aviation

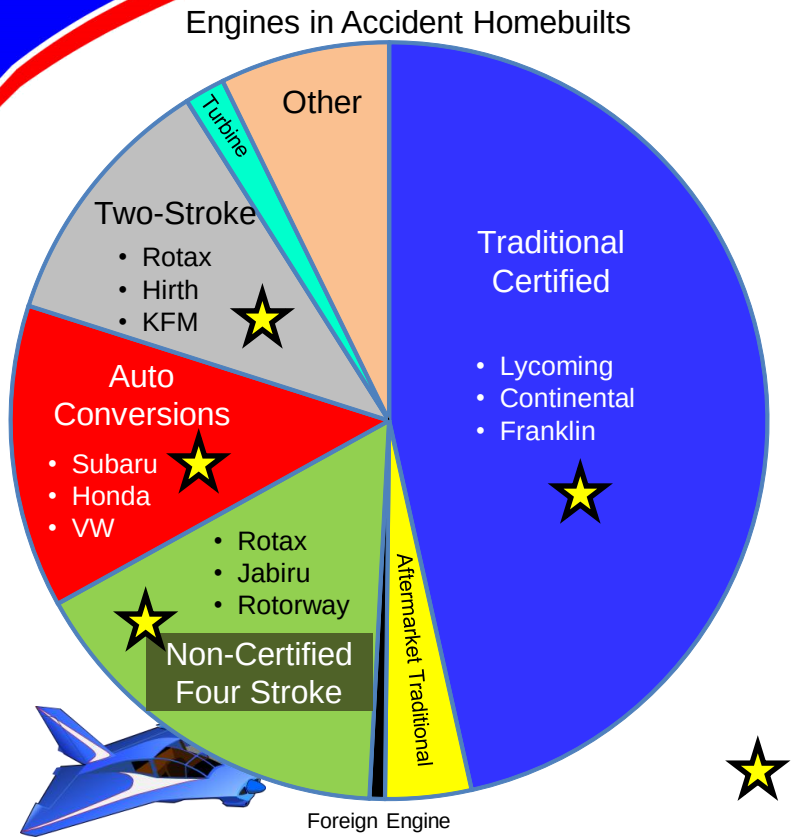
A Look at Overall Engine Reliability

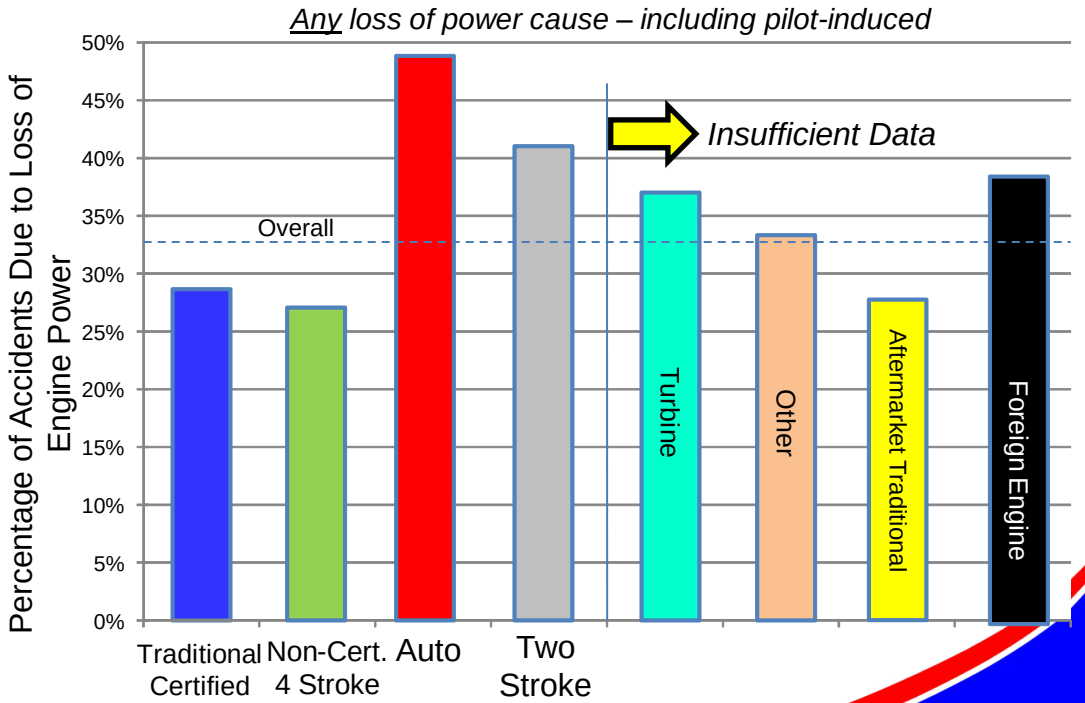
Engine Reliability Analysis

- Looked at the accident data based on “classes” of engine types
  - Traditional certified engines, auto engine conversions, etc.
  - Last is an “other” category for when the engine isn’t listed in the NTSB report
- Determine how many accidents began with engine failure
- Compare the relative reliability aspects between engine classes
  - If sample size is sufficient, look at specific engine types



Comparing Categories





★ = Engines looked at in detail

Sample Size Preference

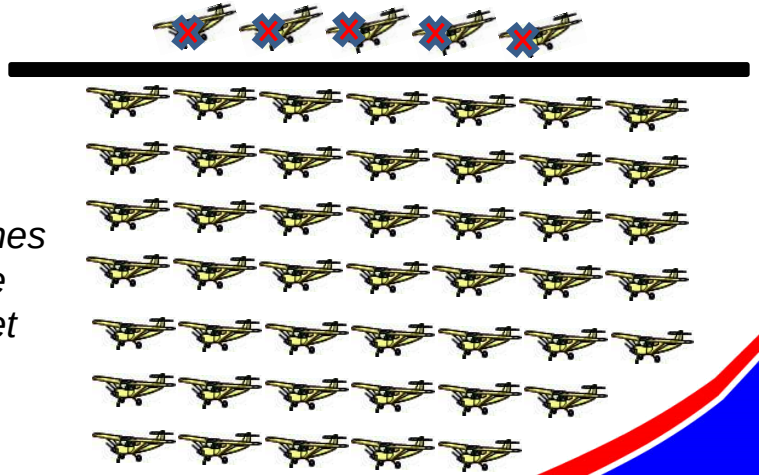
- Not presenting data on “Aftermarket Traditional,” “Foreign Engines,” “Turbines,” and “Other” engine classes
  - Used a 200-accident minimum
- Will include specific engine models as well as overall classes
  - Will not present specific engines by name unless they have 50 or more examples
    - No data at all if <20 engines
  - With a small sample size, one or two more accidents more or less can significantly affect the results
    - Accidents are semi-random
    - New engines have higher accident rate as issues are discovered
    - I also make mistakes!
      - An occasional mistake doesn’t affect a larger data set significantly, but may make a difference with a smaller set

Ideal Analysis Method

- Best method of comparing engines is to compute the “Fleet Accident Rate”
  - Take the number of accidents in EAB mounting those engines, and divide by the total number in the EAB fleet

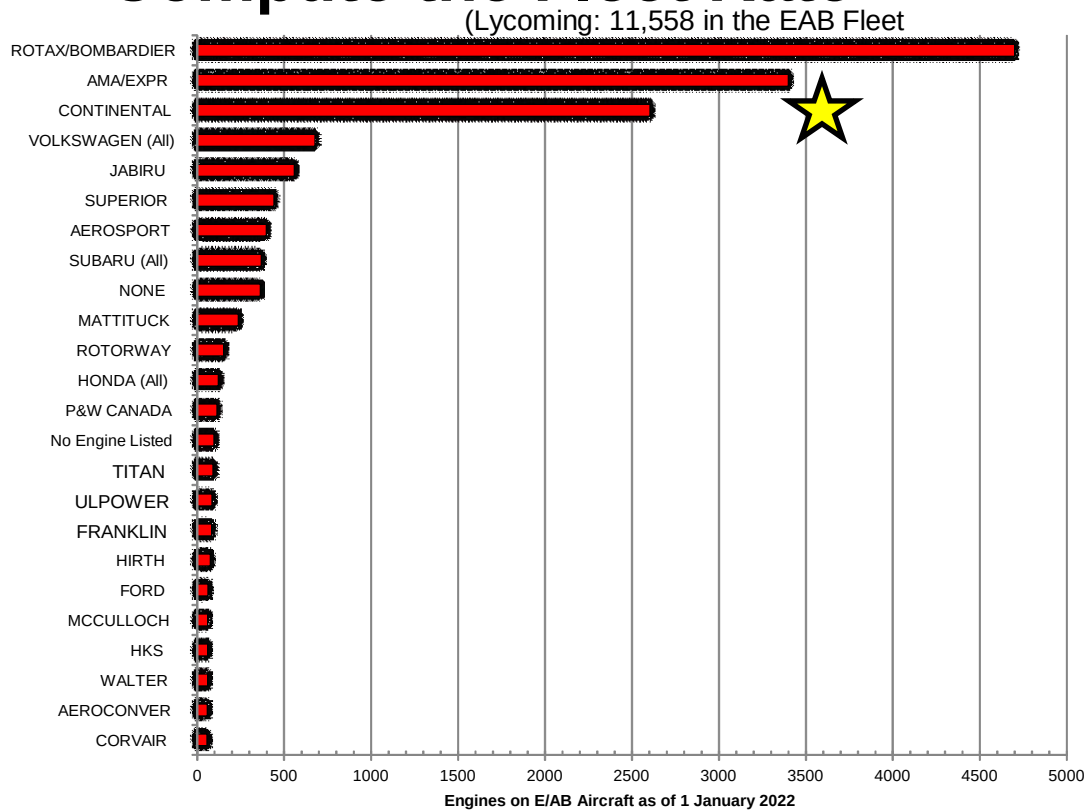
Number of Engines Involved in Accidents

Number of Engines Installed in the Homebuilt Fleet



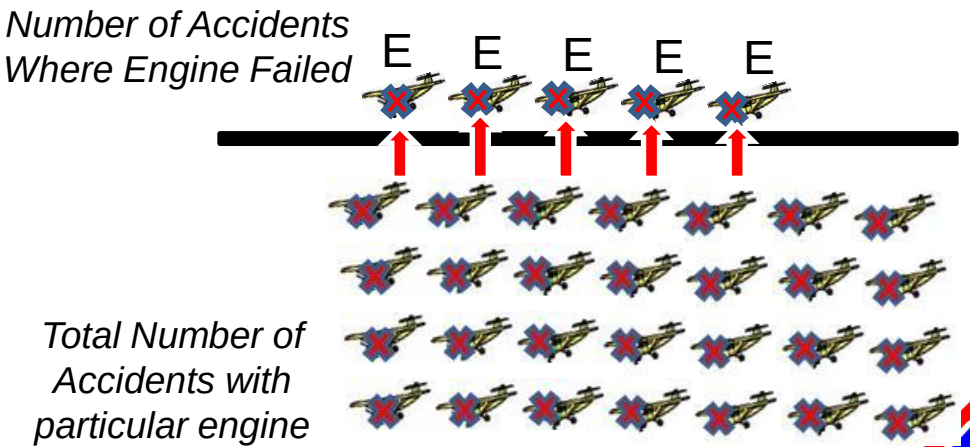
FAA Data Not Accurate Enough to Compute the Fleet Rate

- Over 12% of the EAB in the FAA registry don't specify an engine make or model
- Without accurate data, we can't compute an accurate fleet accident rate!
- Ran a test with ~70 known homebuilts with a certain auto conversion
  - Over half were listed as "AMA/EXPR" engines
- Half the "Rotax" entries don't specify a model, either



The Solution: Compare vs. Other Accidents to Aircraft With the Same Engine

- Find the overall number of accidents for EAB aircraft using that engine
- Compare it to the number of engine failure accidents for that engine type
- Count as an engine-related issue with problems in key accessories (ignition, carburetor, PSRUs, etc.) as well as the base engine
  - Problems with fuel system not included
  - Presence of builder/maintainer error is noted, but does not affect the statistics



Understand What the Statistics Mean

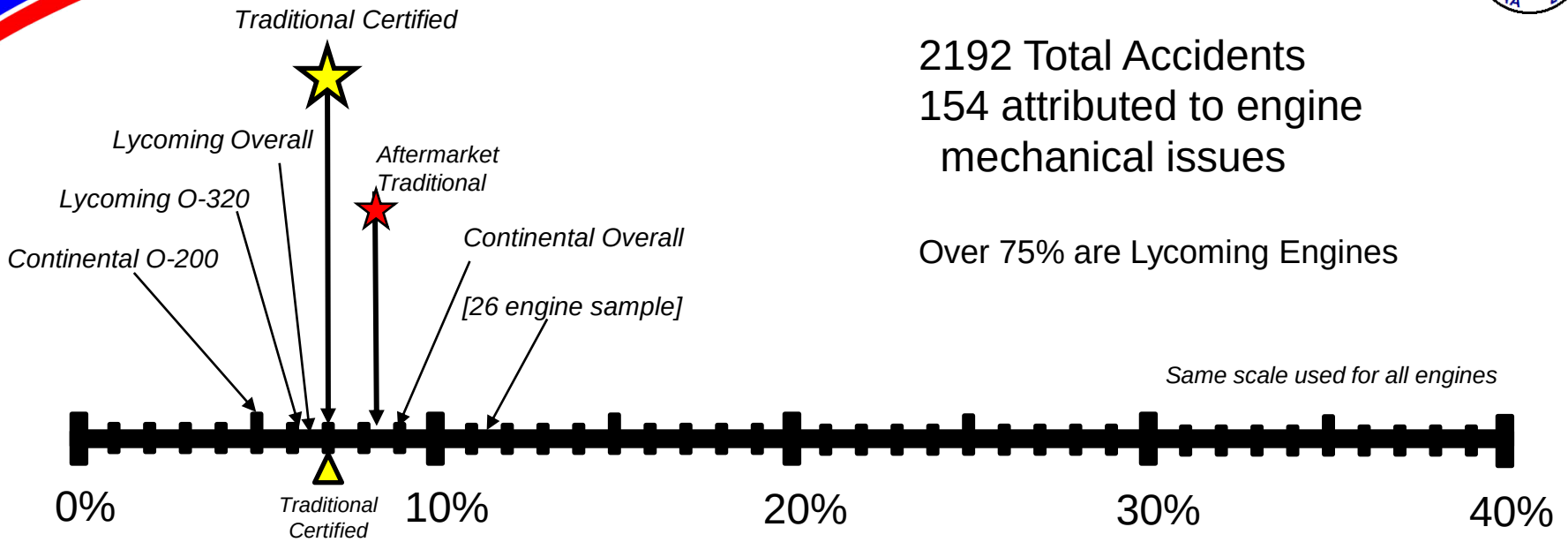
- "10% of the accidents were due to engine mechanical issues"
  - This does NOT mean that 10% of the engines in the fleet are going to fail
  - It means that for airplanes with that engine THAT HAD AN ACCIDENT, 10% of the accidents were due to engine mechanical issues
- Terminology:
  - "Percentage of Loss of Power Accidents": Percentage of the accidents involving a loss of engine power, whether or not it was due to the engine itself
  - "Percentage of Engine Mechanical Accidents": Percentage of accidents that were due to mechanical failures of the engine (even if builder/maintainer induced)

Comparisons to be Presented

1. Compare the percentage of mechanical-issue engine failures vs. the total number of accidents for engine classes
2. Compare the causes of engine mechanical issues across engine classes
3. Look at how many hours are accrued on the engines at the time of the accidents
4. The Effect of Builder and Maintainer Error

Comparing Reliability of the Engine Classes

Traditional Aircraft Engines

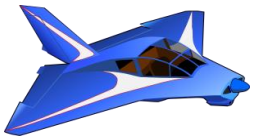


2192 Total Accidents
154 attributed to engine mechanical issues

Over 75% are Lycoming Engines

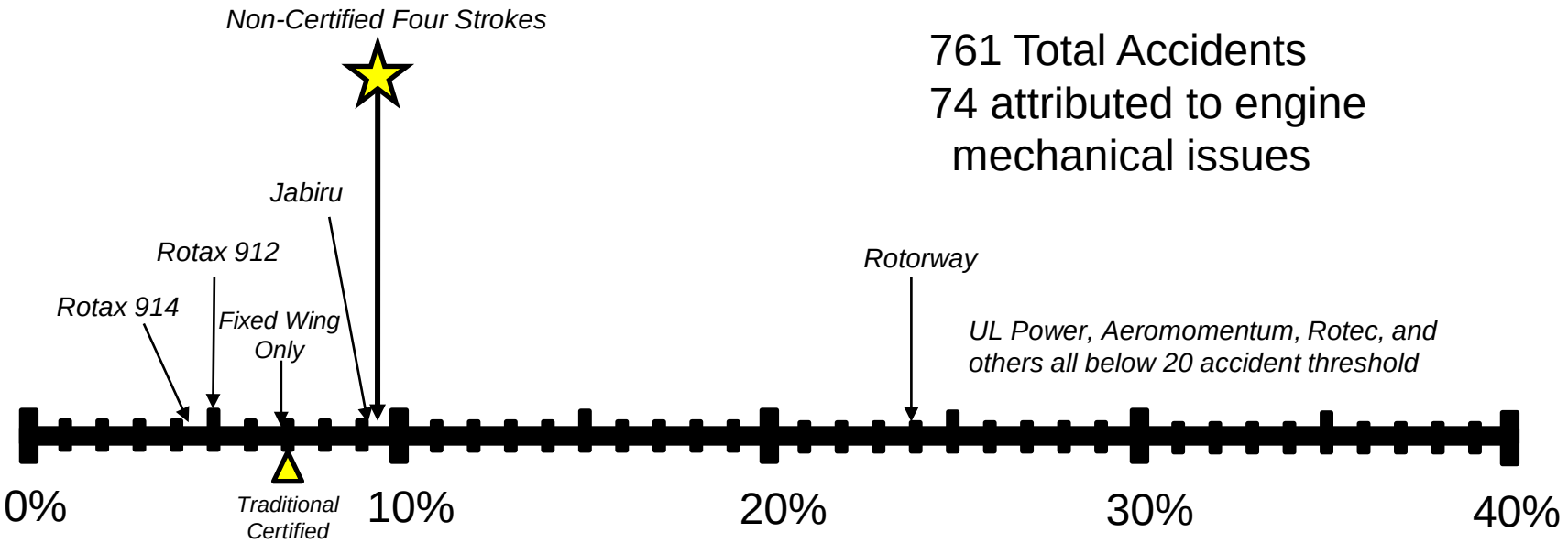
Percentage of Accidents Due to Engine Mechanical Issues

Specific Engine Types Labeled only for Those with a 50+ sample set



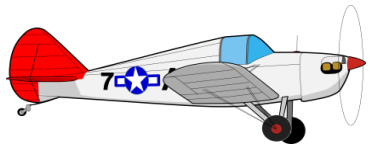
Based on EAB Accident Data 1998-2021

Non-Certified Four Strokes



Percentage of Accidents Due to Engine Mechanical Issues

Specific Engine Types Labeled only for Those with a 50+ sample set



Based on EAB Accident Data 1998-2021

Auto Conversions

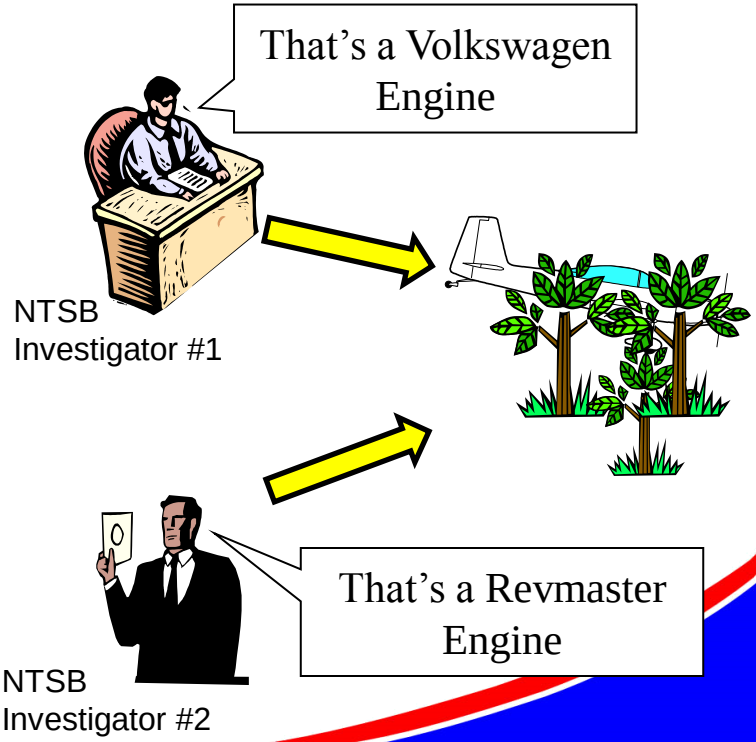
- Auto conversions are different from the other engines
  - There is a base engine, plus a “conversion package” of some sort
- Complicates the engine reliability analysis
  - “Problems that affect other conversions of this engine can’t happen to our conversion, so why are you lumping us in with them?”

Example of Data Difficulties

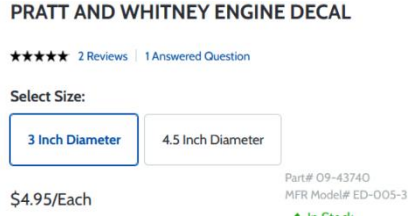
- There are 208 accidents (1998-2021) involving EAB aircraft with Volkswagen or VW-derived engines
  - 65% of the NTSB reports don't include any conversion information
- None of the common VW conversions meet my 50-accident threshold for reporting!
  - Two are less than my 20-accident threshold for even generic reporting

If the NTSB Report Just Says "VW"…What Does that Mean?

- Two NTSB investigators looking at same accident may report the engine type differently
- What constitutes a given conversion engine?
  - Did the owner just pick up a free sticker at AirVenture?



Aircraft Spruce and Specialty



Auto Engine Groupings

VW
- Volkswagen
- Revmaster
- Great Plains
- Aerovee

Subaru
- Subaru
- NSI
- Eggenfelner
- Stratus

Honda
- Honda
- CAM 100
- Viking Honda
- Ram Racing

Corvair
- Corvair
- Wynne

Chevrolet
- NOT Corvair

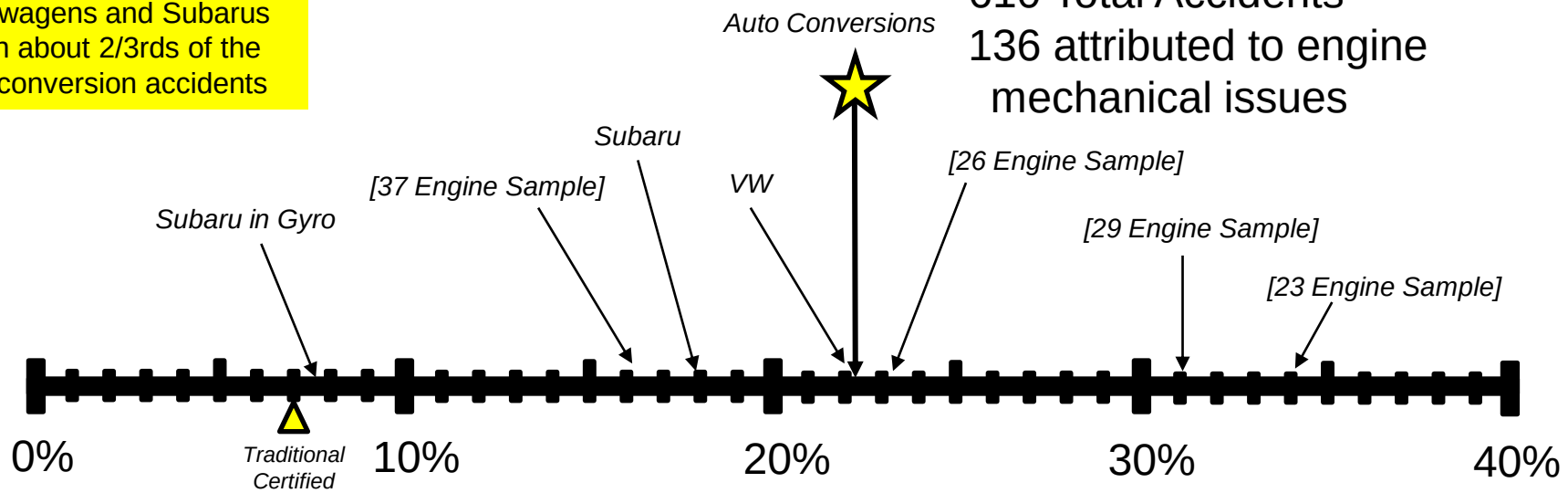
Ford
- Any Ford (including Model A)

Mazda
- Any Mazda

Auto Conversions

Volkswagens and Subarus are in about 2/3rds of the auto-conversion accidents

610 Total Accidents
136 attributed to engine mechanical issues



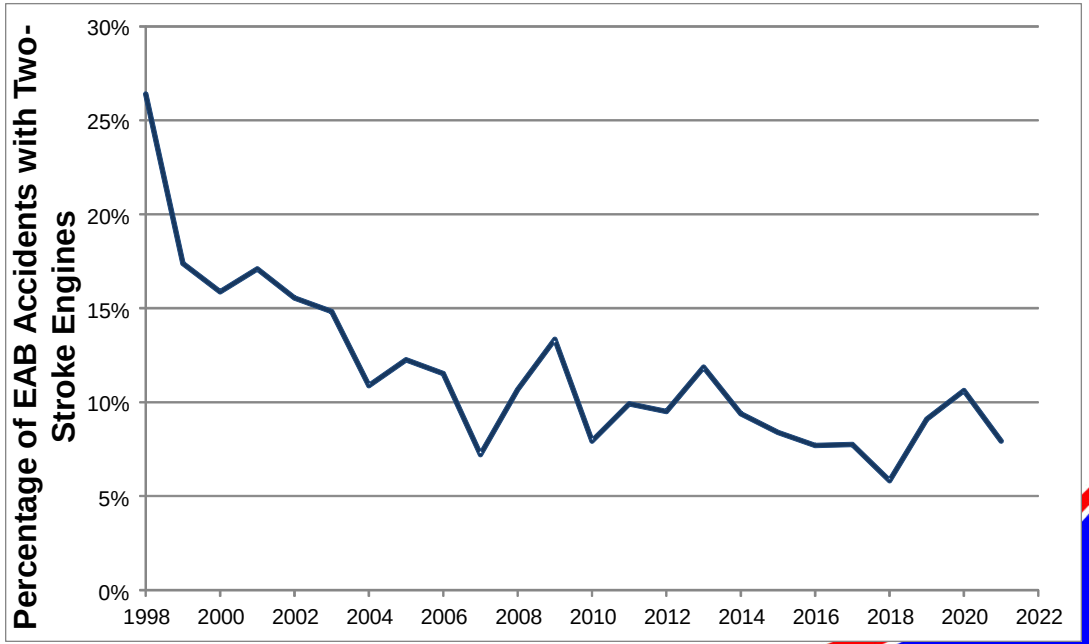
Percentage of Accidents Due to Engine Mechanical Issues

Specific Engine Types Labeled only for Those with a 50+ sample set

Based on EAB Accident Data 1998-2021

Two-Stroke Engines

- Number of EAB accident aircraft with two-stroke engines had dropped dramatically in the past 25 years
  - My database doesn't include ultralights
- Probably reflects less use
- Database shows overwhelming prevalence of Rotax engines



Two Stroke Engines

Two-Strokes have better mechanical reliability than auto conversions!

524 Total Accidents
95 attributed to engine mechanical issues

Two-Strokes

Rotax 503

[23 Engine Sample]

Rotax 582

[34 Engine Sample]

Usually smaller, lighter aircraft—less likely to get damaged or reported to NTSB

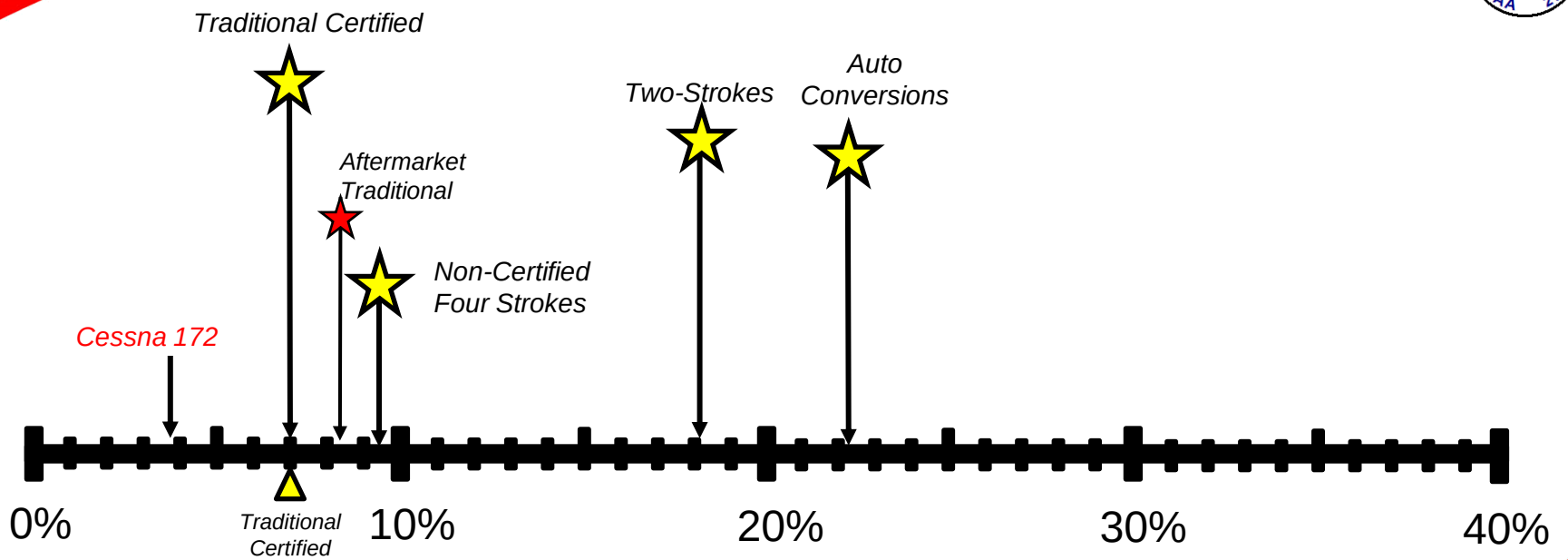
0% *Traditional Certified* 10% 20% 30% 40%

Percentage of Accidents Due to Engine Mechanical Issues

Specific Engine Types Labeled only for Those with a 50+ sample set

Based on EAB Accident Data 1998-2021

Overall Comparison



Percentage of Accidents Due to Engine Mechanical Issues

Specific Engine Types Labeled only for Those with a 50+ sample set

Based on EAB Accident Data 1998-2021

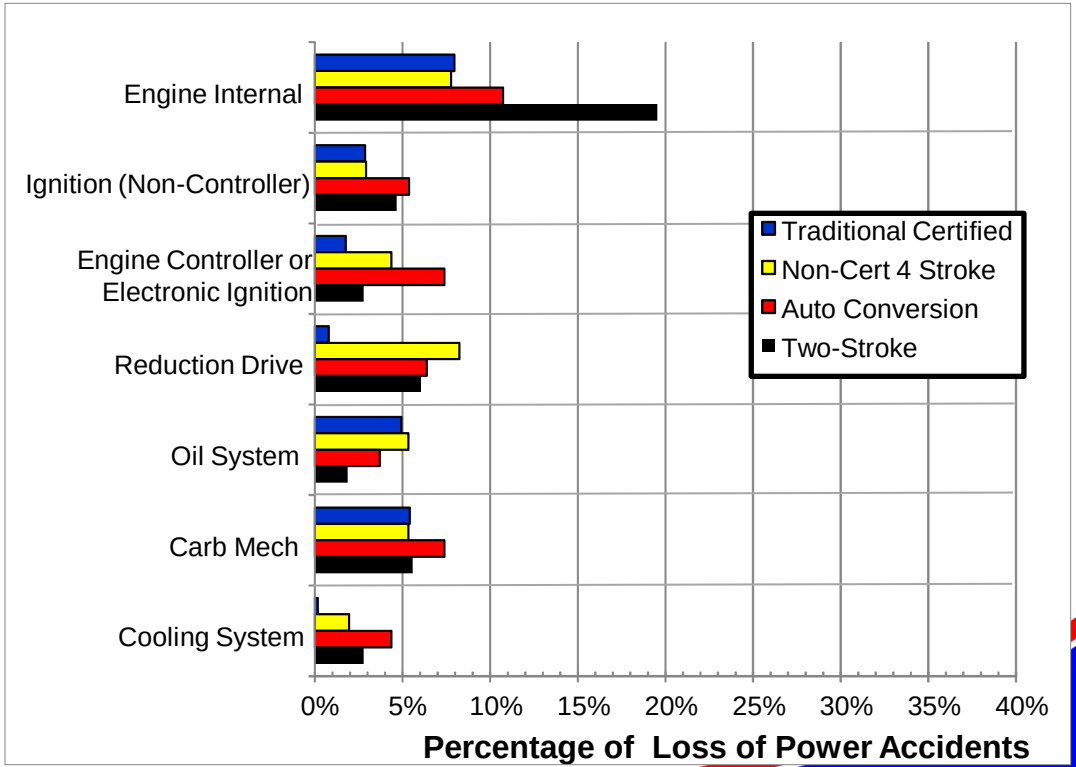
Mechanical Issues Comparison

Mechanical Issues Studied

- “Engine Internal”
  - Issues with valves, crankshaft, pistons, cylinders, bearings, etc.
- “Ignition Non-Controller”
  - A magneto issue or a case where the NTSB references the ignition system without noting the type
- “Engine Controller or Electronic Ignition”
  - Electronic ignition, or a controller that failed or was starved of electricity
- “Reduction Drive”
  - Propeller Speed Reduction Units or helicopter belt power-transfer systems
- “Oil System”
  - Any issue with retention of engine oil
- “Carb Mechanical”
  - Related to the carburetion or engine power control, including carburetors, throttle cables coming free, blocked air induction
- “Cooling”
  - Liquid cooling and baffle-type cooling on an air-cooled engine

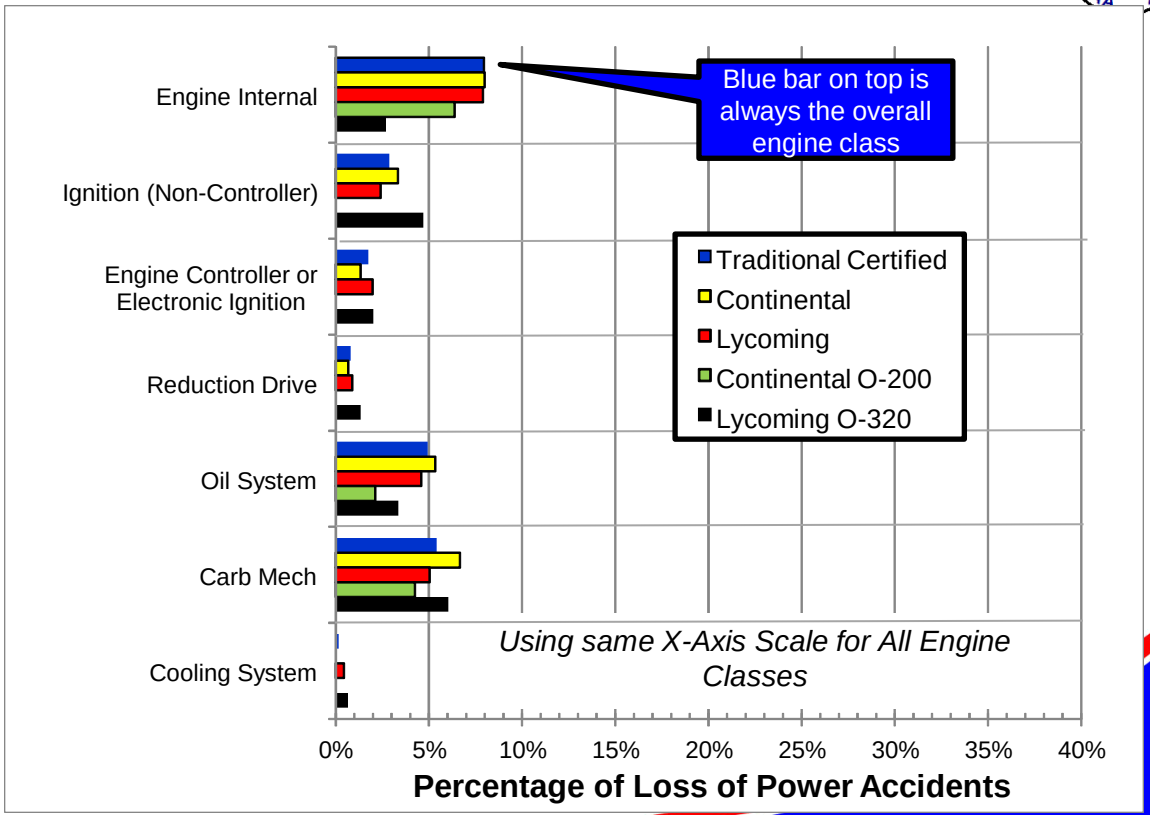
Overall Engine Class Comparison

- Remember there are proportionately more Auto Conversion and Two-Stroke accidents



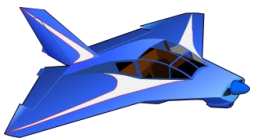
Traditional Engines

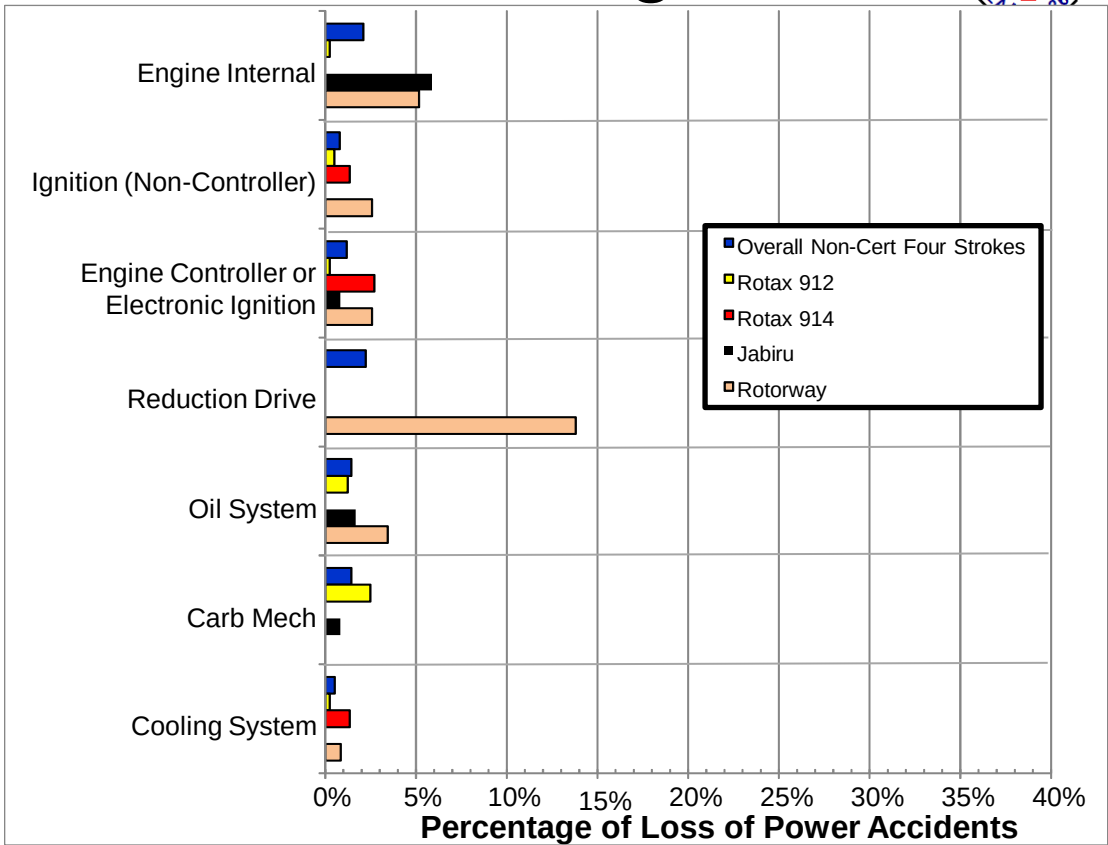
- Using this as a baseline for comparison



Non-Certified Four Stroke Engines

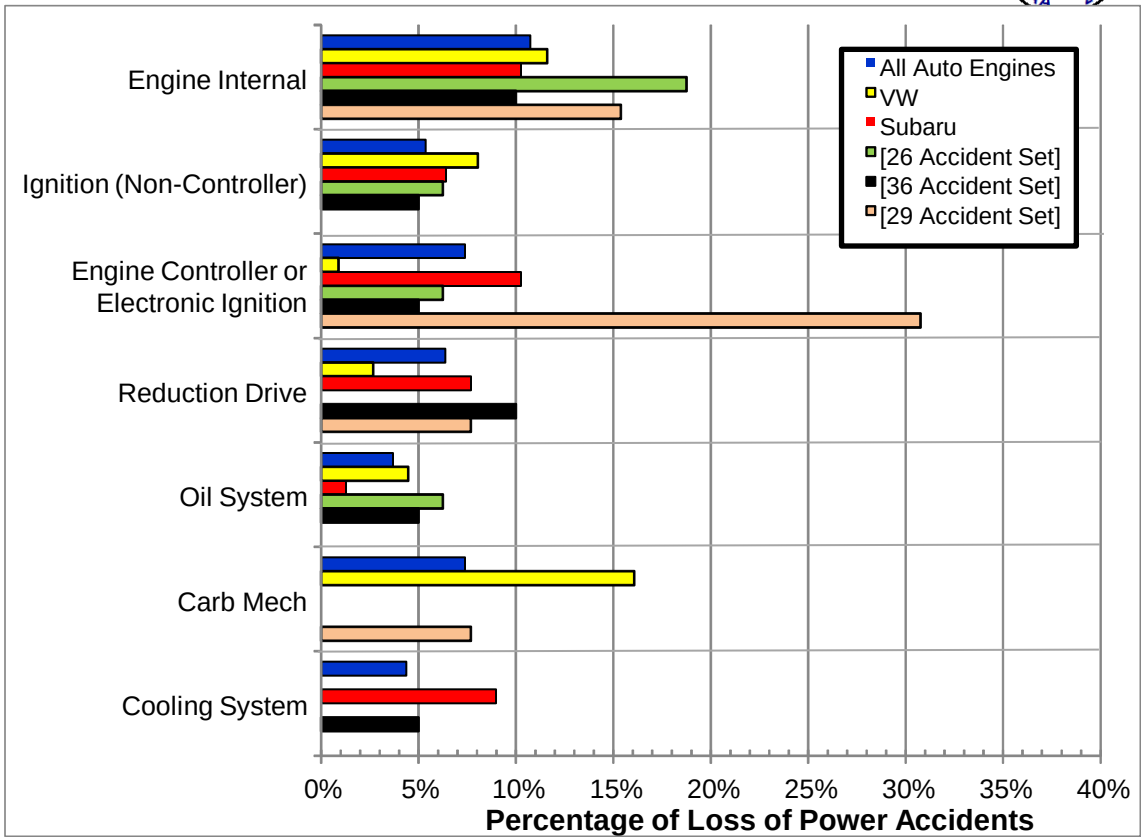
- Most types have low failure rates in most areas
- Major contributor to this category is the Rotorway helicopter engines
  - All the reduction drive issues are Rotorway ones!
  - Helicopter is a much different environment to fixed-wing aircraft
- Jabiru engines had some infant mortality issues in the past, related to “through bolts and flywheel bolts”
  - Accidents peaked in ~2010, have decreased since





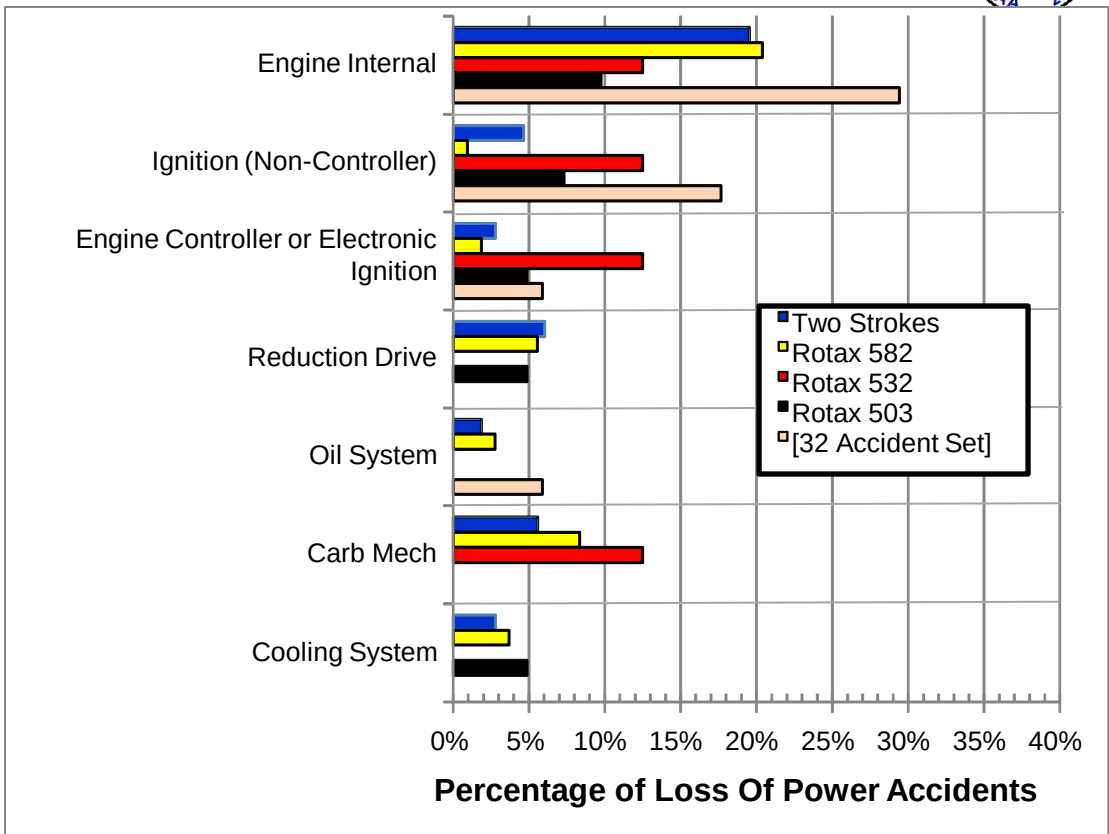
Auto Conversions

- Rate of fail of ignition/ engine controllers is quite high
  - Combination is 3x higher than Traditional engines
- Carb/induction issues with VWs



Two-Stroke Engines

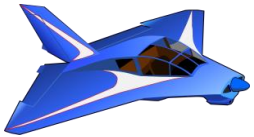
- Many two-stroke failure cases involve seizing, which would be entered as “Engine Internal”



Some Specific Notes

- Seeing a lot of problems with engine controllers
  - Issues are not necessarily with the controllers themselves, but with builders failing to ensure a continuous source of power
  - Velocity in picture had dual spark plugs and dual controllers…both attached to a single battery through a single set of wires/crimps
  - Understand what “redundancy” means!
- VW “Carb Mechanical” cases are a mix of induction issues, throttle cable attachment, and mixture/jetting
- Looked at two-stroke “seizing” cases, and didn’t find any major common factors

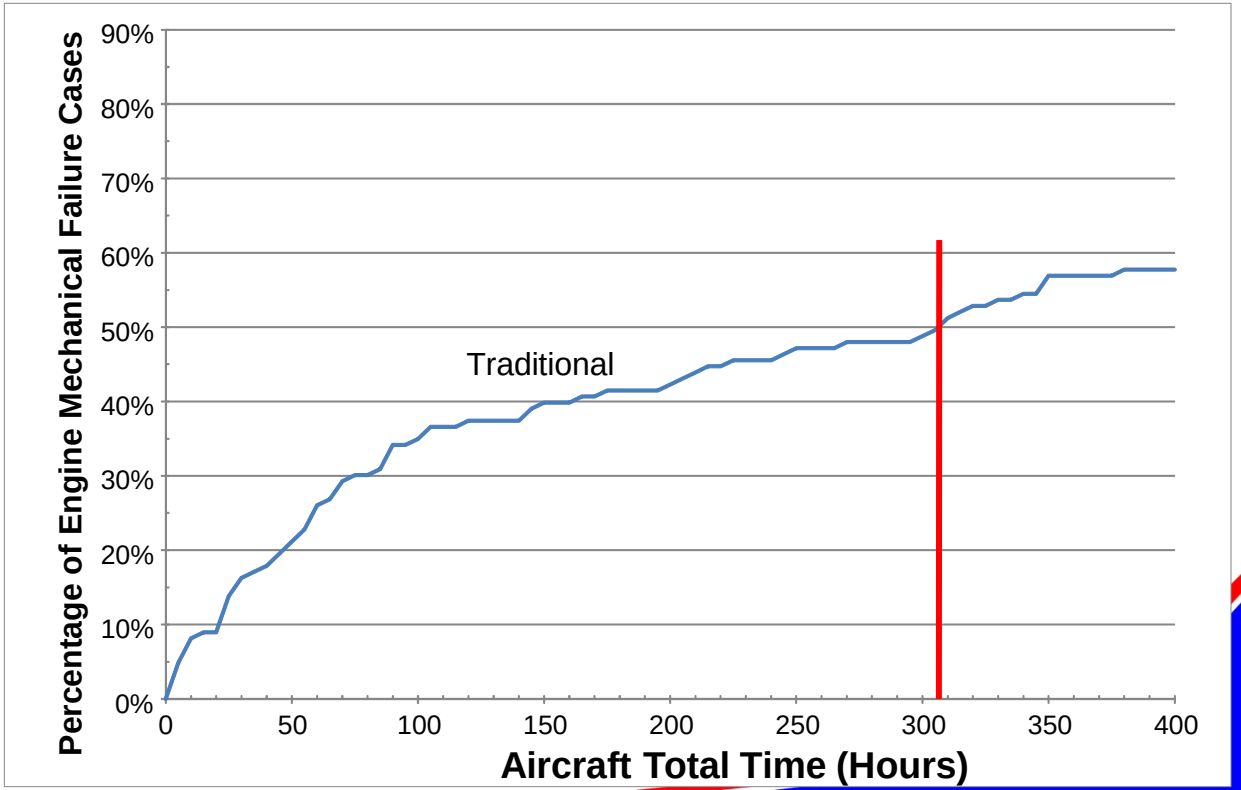
Separate toggle switches for mags



When the Engine Failures Occur

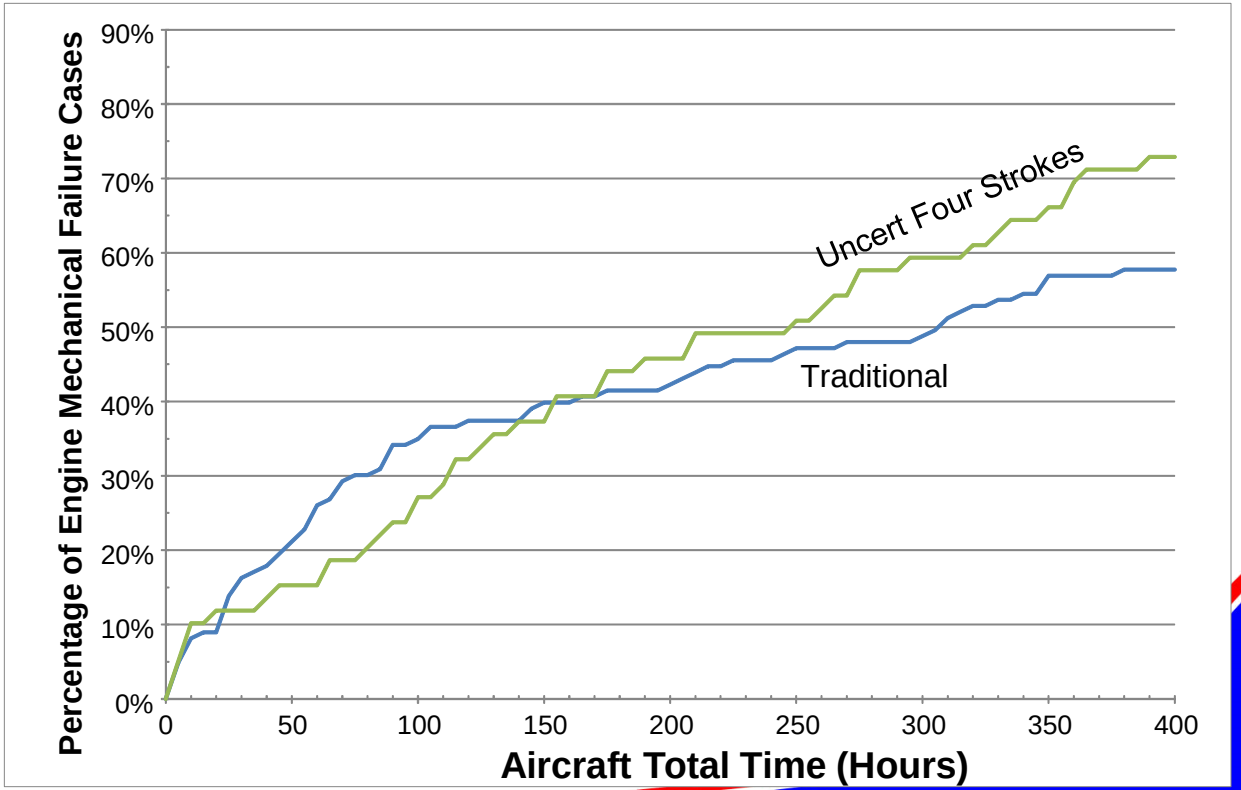
Traditional Engines

- Not every accident report includes the aircraft total flight time
- Assumes engine time is the same as aircraft time
  - Many traditional-engined EAB install used engines
- 50% of accidents involving EAB with traditional engines occur within the first ~315 hours
  - Note that this is NOT saying, “Half of ALL the aircraft suffer an engine failure in the first 300 hours!
  - **IF** an accident happens, there’s a 50% probability the plane has 315 hours or less



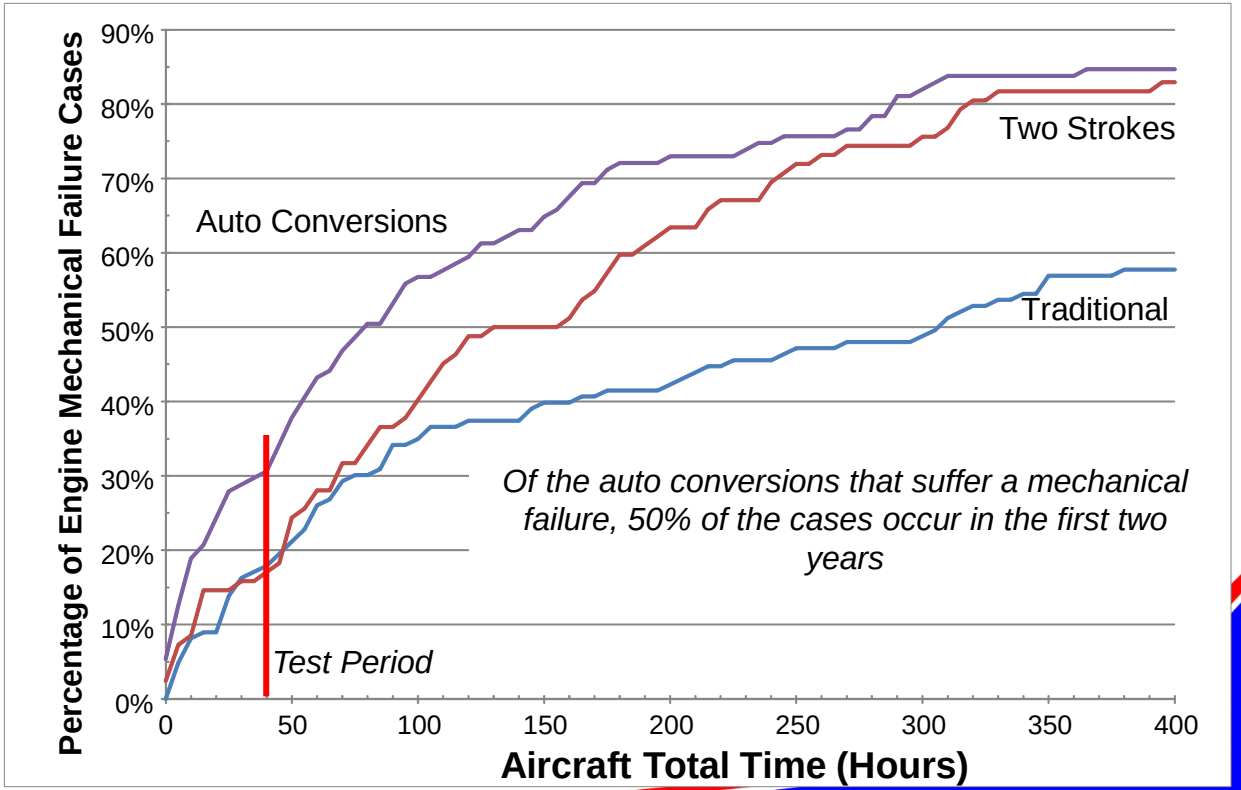
Uncertified Four Strokes

- Actually have better reliability during early flight time
  - More “new” engines vs. used Continentals and Lycomings?
- Hit the 50% point at about 250 hours
  - Close to Traditional, probably within the error margin
- Rotorway engines not a major driver



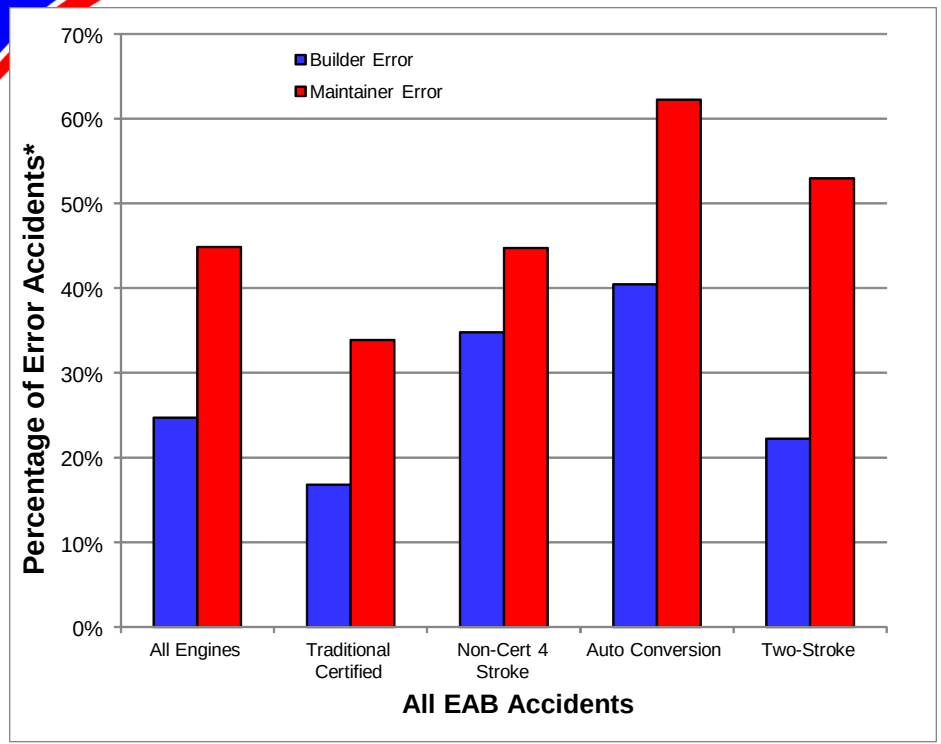
Auto Conversions and Two Strokes

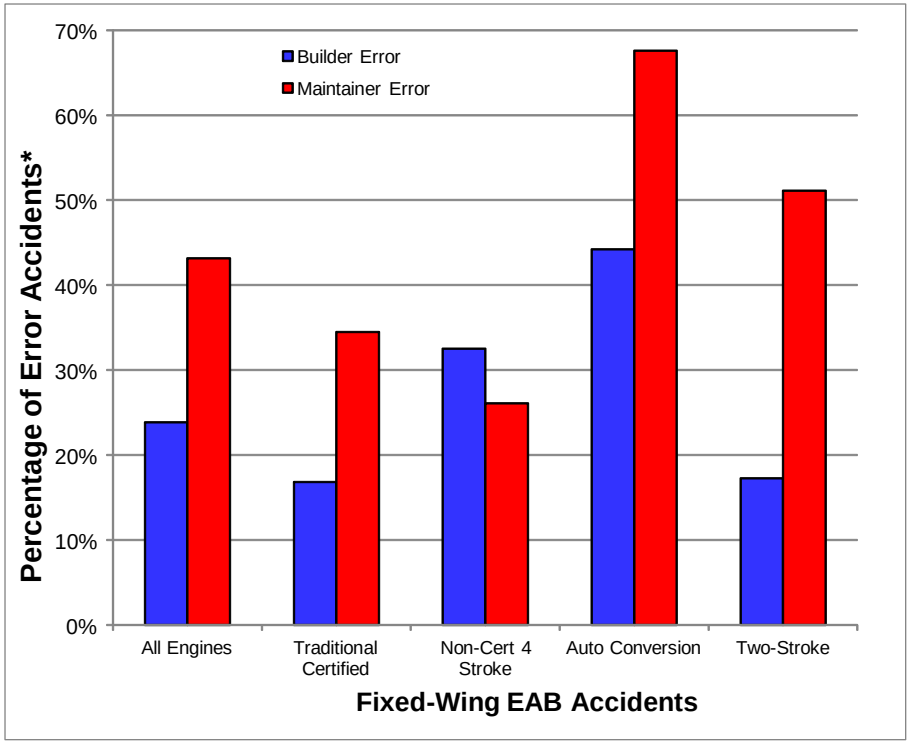
- Auto conversions have more early failures
  - Problems appearing early
  - ~30% of the accidents occur during the Phase 1 test period
- Two Stroke engines closely match Traditional engines for first year or so, then rate increases



Builder and Maintainer Error

What Percentage of Builder and Maintainer Error Accidents Involve Engine Mechanical Failures?

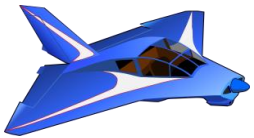




* Percentage of Builder (or Maintainer) error cases which led to a mechanical issues with the engine

“The Engine is OK, It’s Those %&^$@ Builders at Fault”

- Too easy to blame the builders (or maintainers)
- But the goal for ANY homebuilt engine installation is a reliable engine
- Statistics mean that the average homebuilder is having trouble with reliability, especially with some alternate engines
  - Their goal is a reliable engine, NOT a technological demonstration!



Conclusions

Need I remind you….

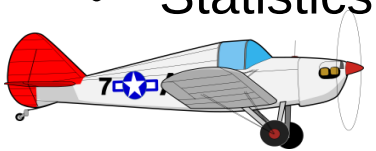
The Ability to Install Non-Certified Engines is a FUNDAMENTAL Aspect of Homebuilt Aviation

Alternate Engines

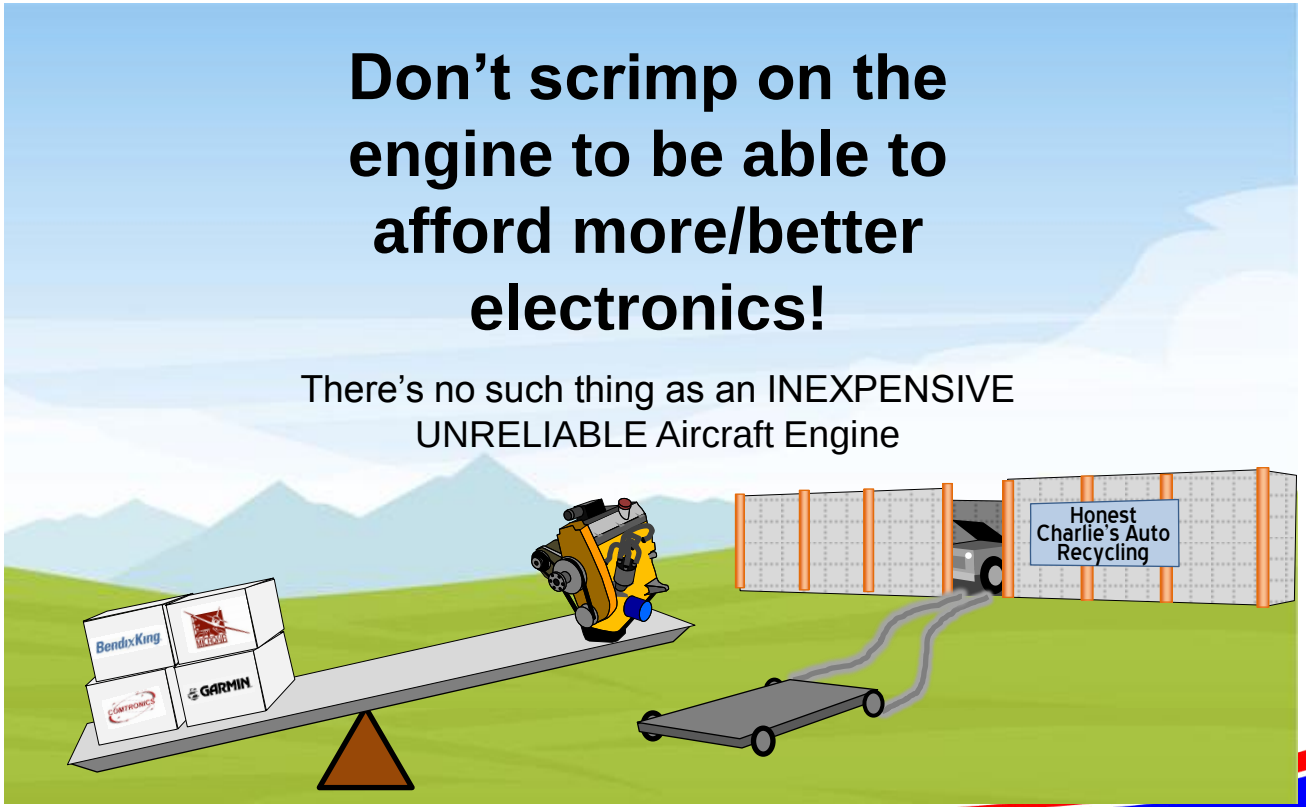
- There are many good airplanes designed for non-traditional engines
- There are many good people whose wallets cannot afford expensive engines
- Remember, much of the aircraft is tolerant of less-skilled labor…**but not the engine!**
  - Spinning at 2,000-6,000 RPM, hundreds of gasoline/air explosions per second, needs air, needs spark, needs fuel, and needs to expel hot exhaust gasses
- How can builders maximize engine reliability?

Ron's General Recommendations

- Buy as good of an engine as you can afford
  - Got the money for a ready-to-install engine? Great!
- If you don't have a background/history of working in engines, find a design where more of the major engineering has either been done for you, or clearly explained what is necessary
  - For self-assembly/kit designs, buy the manual early and study it
  - Go online to find others working with the same engine
    - This isn't the sixties anymore!
  - Include level of company support in the decision process
- Important to get detailed maintenance instructions, too
- Statistics predict the group, not <u>you</u>



Mind the Balance!



Finally: Remember the Definition of "Experimental"

- Too much these days, people view "Experimental Aircraft" only from the "FAA leaves you alone" point of view
  - "Experimental" means "We're not sure what's going to happen"
  - Not all outcomes are positive
- With true "Experimentals," have to anticipate something bad will happen, and continually work to avoid or mitigate the issues
  - If you can, select aircraft that can support unexpected forced landings
  - Pick a test area with wide open spaces
  - TRAIN for potential forced landings
    - Expect problems ANY TIME!
    - EAA Flight Advisor program
  - Auto conversions have a greater occurrence of problems early in the life cycle
    - Inspect, fly, and INSPECT AGAIN
      - Problems can develop gradually

For More Information

- Contact me at ron@wanttaja.com
  - Also on multiple aviation forums, such as the EAA Forums, the Homebuilt Aviation Forum, Pilots of America, and several Facebook homebuilder's groups
- These charts can be downloaded at:
  - http://www.wanttaja.com/eaa23.pdf
- A version of my accident database containing Loss of Power cases can be downloaded at:
  - http://www.wanttaja.com/lop.zip