This is not to pick on any particular manufacturer – they <u>all</u> have problems.
Our objective: illuminate the general problem and discuss potential improvements!

Introduction

Motorgliders are horribly unreliable. DeRese Survey

Customers expect Toyotas and fly like the motor will work.

The high accident rate shows pilots don't treat landing as plan A, because the motor works just often enough that we're tempted to rely on it. ***This is a major training issue.***

When the motor runs and nothing breaks, we are justifiably astonished. We do post-flight inspections just so we have a prayer of the thing working next time.

Electrics are offered as a panacea but electrics have plenty of problems too.

This discussion will review some of the systemic problems that **guarantee** we have unreliable machines, with plenty of example failures, and offer some ideas and areas of research to potentially improve general reliability.

DeRese survey - Of motorglider pilots surveyed:

- 30% had an engine failure after having performed a successful test-run at the beginning of the flight.
- 30% indicate that some kind of damage was done to the aircraft as a result of having and operating an engine.

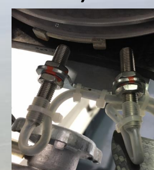
http://www.nadler.com/public/DeRese_2008_Survey_results_engines_in_sailplanes.pdf

Reliability problems become safety problems when pilots assume motor will work.

Vibration-Induced Failures

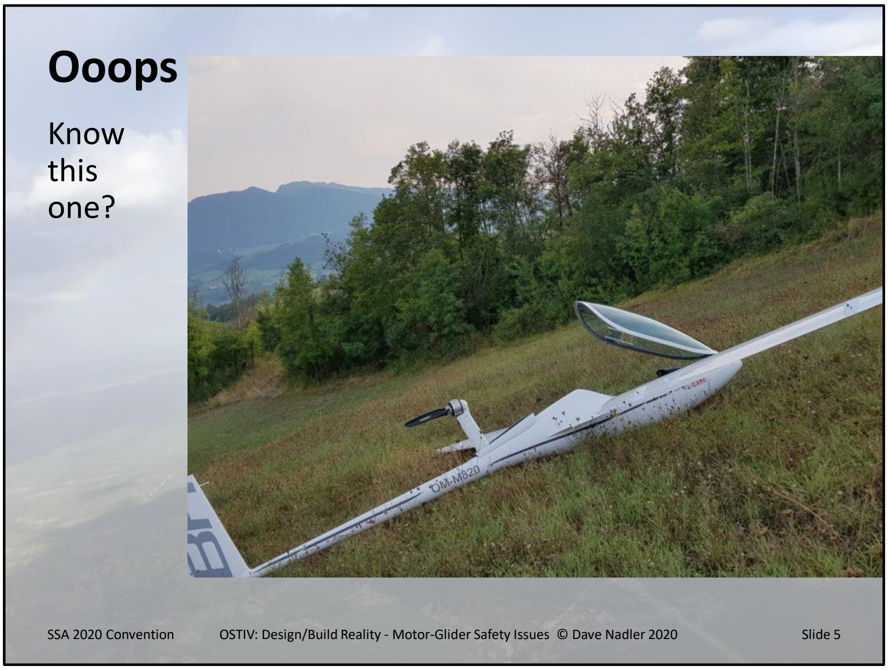
Extremely common with high power-to-weight recip. combustion engines (less so Wankels):

- Exhaust cracking (very common, fire hazard)
- Structural cracking (main and extension mechanism)
- Electrical leads break:
  - Ignition coils
  - Switch (especially magnetic)
  - Linear actuator coils (as used for pylon extension)



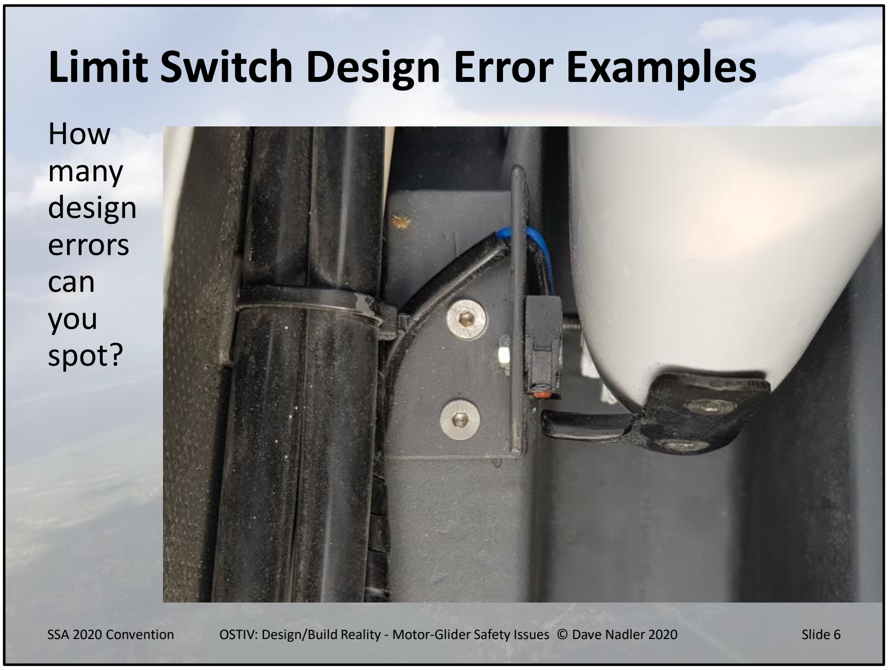
Stupid Limit Switch Tricks

- On common inexpensive units, the hinge pin is plastic nub
- The lever has, surprisingly, leverage
- A tiny side-load will erode hinge!
- Must be protected from travel beyond expected limit in all installations
  - Never install with switch opposing main motion; it will be crushed when main motion exceeds expected travel
  - Actuating slug backside must not pass switch lever, or taper slug on both sides to protect switch
- Poor choice of limit switch, poor actuation schemes, and poor installs lead to failures in many motor-gliders.
- Redundant switches can sometimes help reliability



Let us be very clear: Cause of accident was pilot relying on a motor.
The microswitch failure is only a contributing factor.

Picture courtesy of Sebastian Kawa.



Picture courtesy of Sebastian Kawa.

In addition to light-weight switch:

- Actuator not positionally stable (can roll about screws)
- Actuator can easily bend
- Switch wires not properly supported/protected

Belt-And-Suspenders Single Limit Switch

Note:

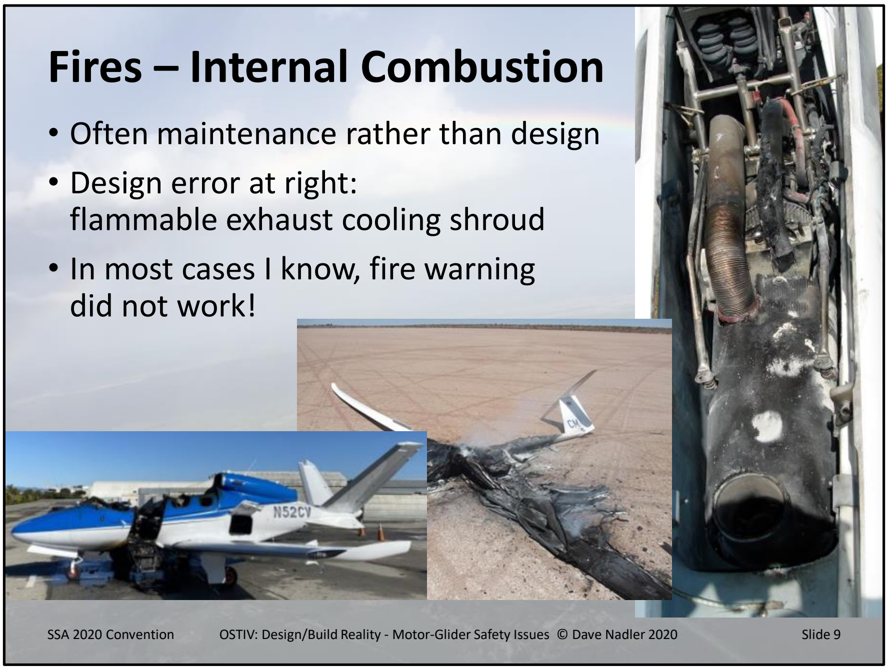
- Heavy-duty switch
- Roller on lever
- Minimal side-load on lever
- Leads properly heat-shrunk and strain-relieved
- Actuating slug cannot go past end of lever
- Slug tapered on both sides

Antares 20E engine bay door position switch.

Magnetic Limit + Position Switches

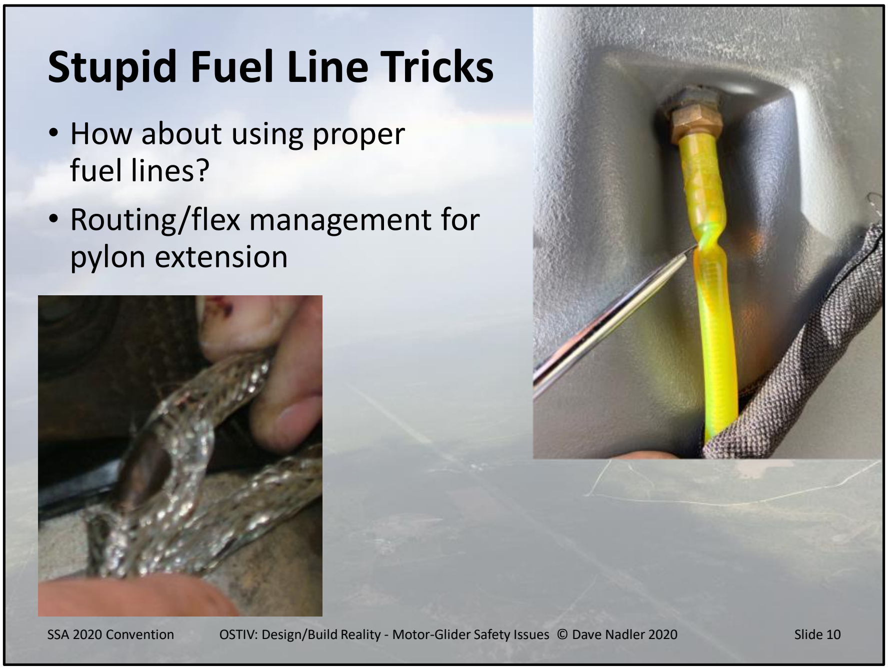
What could possible go wrong?

- Fuzzy actuation point
- Cheap magnets decay (not *really* permanent) …and then actuation point changes
- Sensor leads are typically not vibration-proof



Fortunately major fires aren't that frequent.

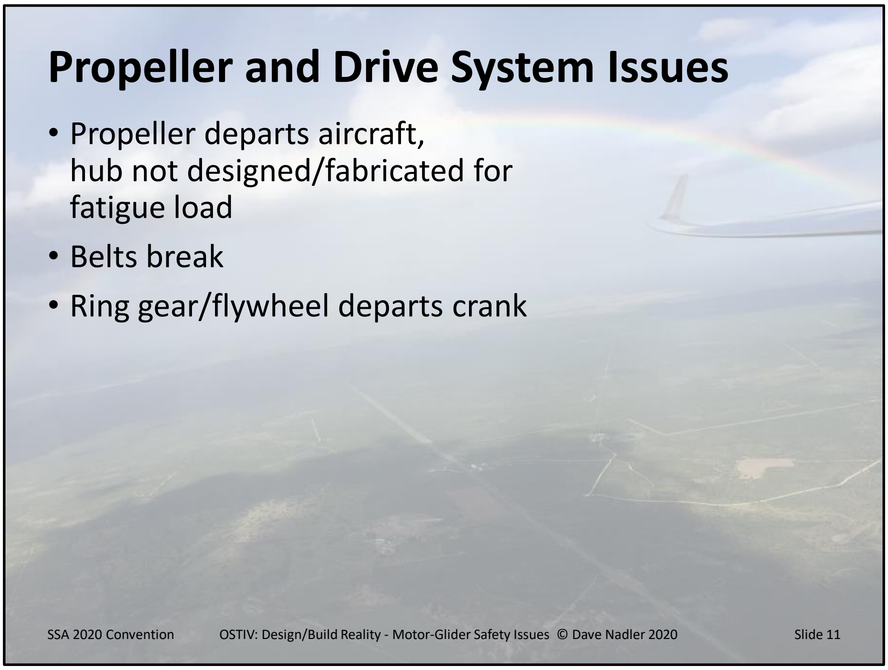
An inflight fire killed my friend Paul Mander,
in his experimental jet-powered ASH-25.
He lent me that same aircraft for PowerFLARM® flight testing.



Many motorgliders have had fuel line leaks or failures:

- Improper material for lines
- Non-fuel fittings
- Chafing
- Crunching/creasing during bending

1) ASW-29ES new 2018
2) Flex line from Nimbus 4DM



Propellers departing:
- AC-4M self-launch
- DG-1000T and Antares-18T sustainer
- Others maintenance related

Belts – long history of failures:
- Current designs are better but still fail
- Older designs violated design guides for belts
- Recip designs have high oscillating loads

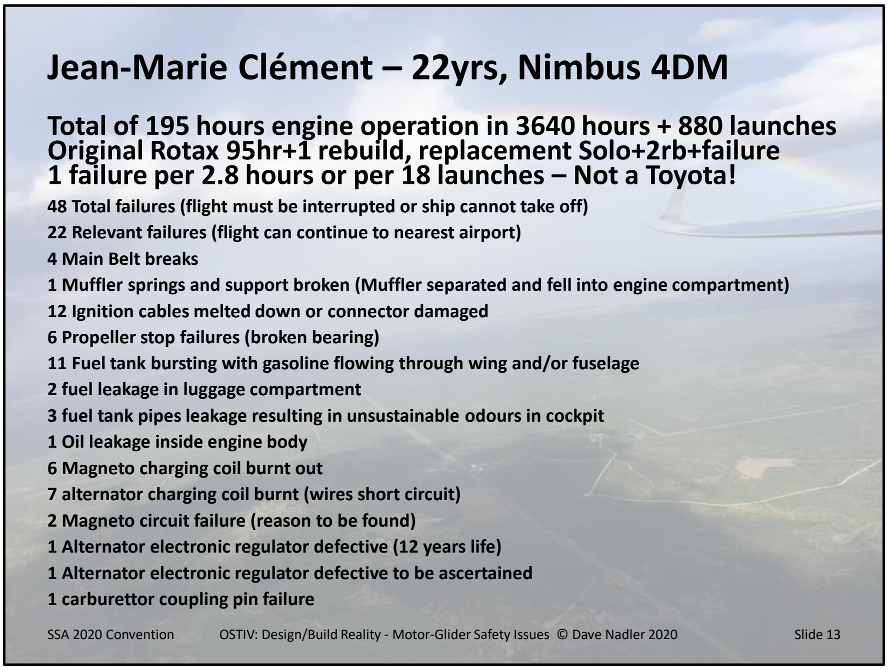
Sorry I didn’t provide pictures here…

Fabrication Errors

- Lack of quality control?
  - Except sometimes design errors contribute to fabrication errors
- Electrical connectors:
  - Pin not fully inserted
  - Pin incorrectly crimped on wire
  - Lead insulation, strain relief, and support
  - Stressed by improper cable routing
  - Improper ground connections, ground management
- Fuel system leaks

Is first picture a design or fabrication error?
Screw is bottomed out in hole, bracket is loose and fretting.

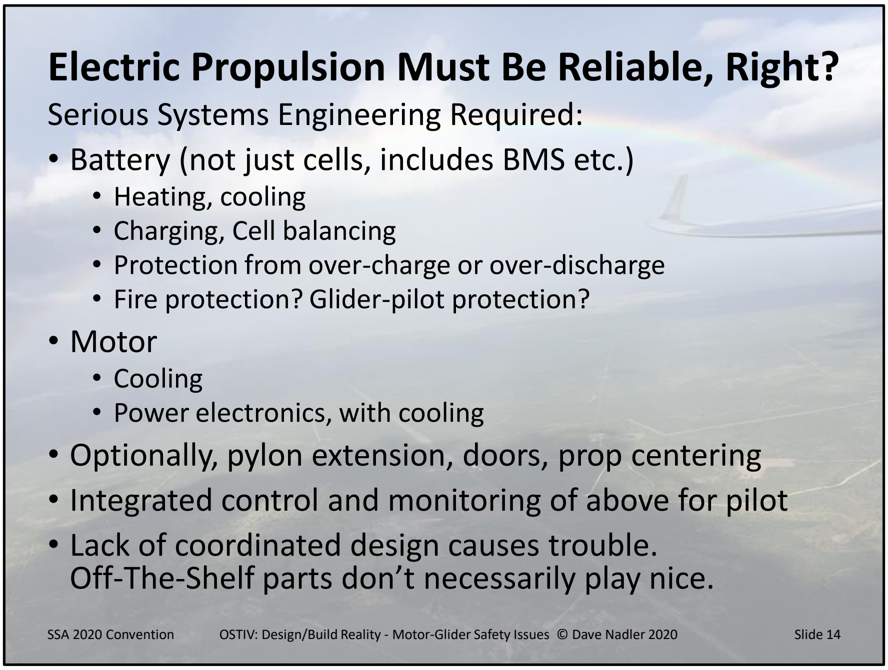
I have personally had every problem on this page, many more than once, and from multiple manufacturers.



Jean-Marie Clément is a famous wave pilot, and author of “Dancing with the Wind”.
His most recent takeoff had piston fail; complete engine rebuild now needed.

Around half of problems vibration-related.
Remainder design errors, fabrication errors, a few unknown.

Problem rate similar with newer motor installation,
though manufacturers certainly have made improvements



Glider-pilot protection is a serious issue. Glider pilots ***will***:

- Physically abuse removable batteries.
- Ignore warnings about overheating or imminent damage

Electric Propulsion Reliability

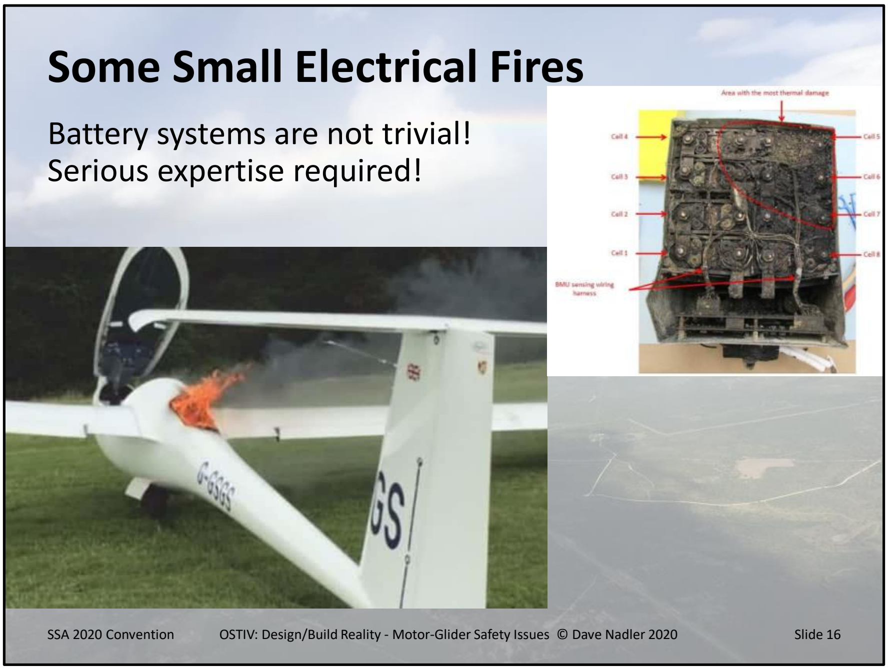
Dave's experience with Lange Antares 20E:

- 1,350 hours and 61,228 miles XC in 11 years operation
- typical 4 minute engine runs;
  4.5 minutes is ~1500ft launch
- 168 self-launch, 103 air restarts, total 271 runs
- 22 failures, in 37.5 hours of motor time (includes lots of taxi)
  Failures includes 7 thermal fuses, charger, etc.

Antares: 1.7 hours or 12.3 motor runs/failure

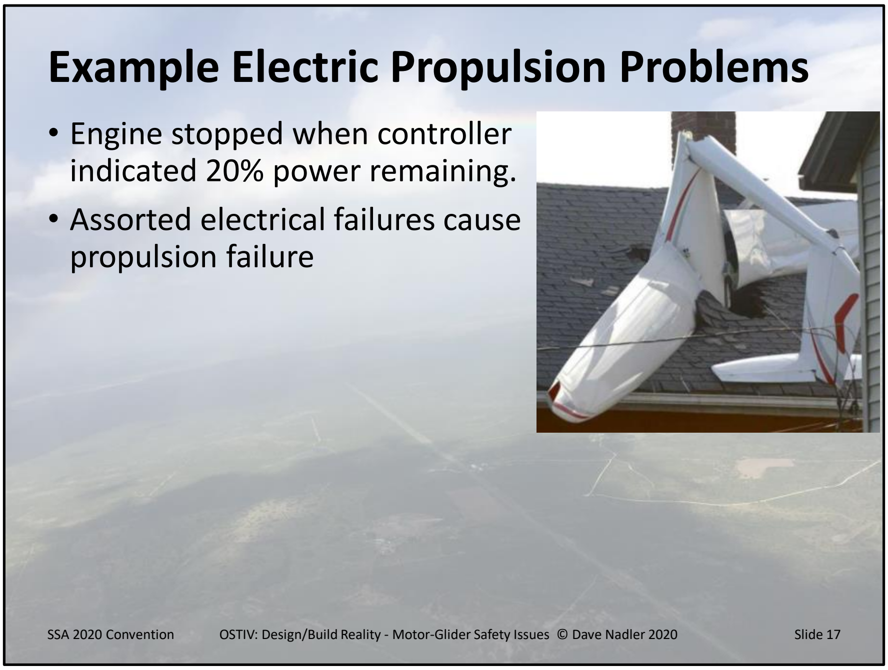
Compare to Jean-Marie's experience (with much higher typical run time and climb altitude):
Nimbus 4DM: **2.8 hours or 18 launches/failure**

No Toyotas anywhere in sight…



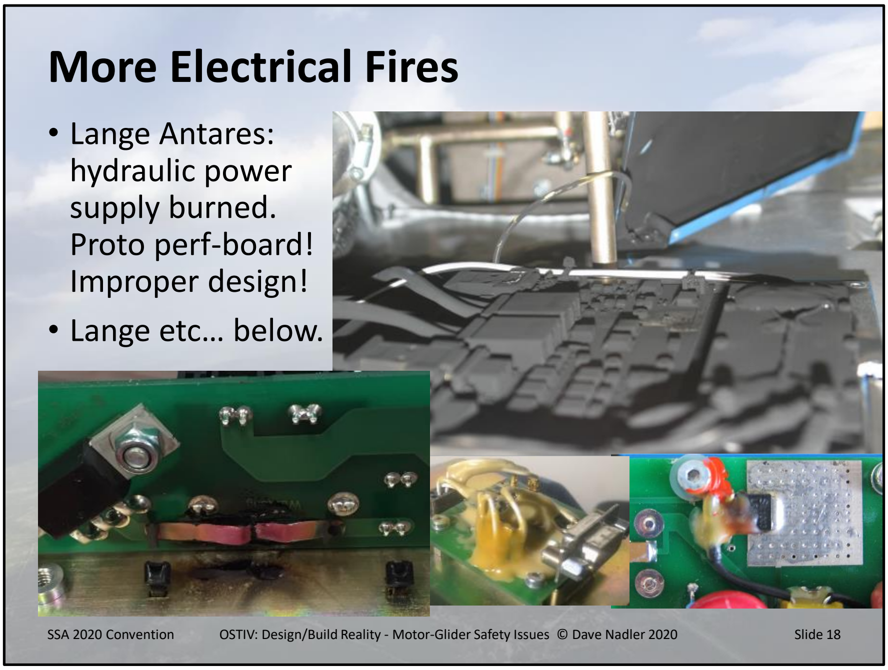
1) A lithium-ion battery that caught fire aboard a parked Boeing 787 in 2013 in Boston had design flaws and it should not have been certified by the U.S. Federal Aviation Administration, U.S. accident investigators said. Boeing 787s were grounded world-wide while this was sorted.

2) 4 FES fires led to battery pack manufacturing and design-safety improvements. No fires since improvements?



Make no mistake: Alisport Silent 2 FES crash was caused by pilot relying on engine!
Poor monitoring system was only a contributing factor.
It is very hard to accurately determine remaining power in lithium cells.

Controller and other electronic failures have caused propulsion failure.



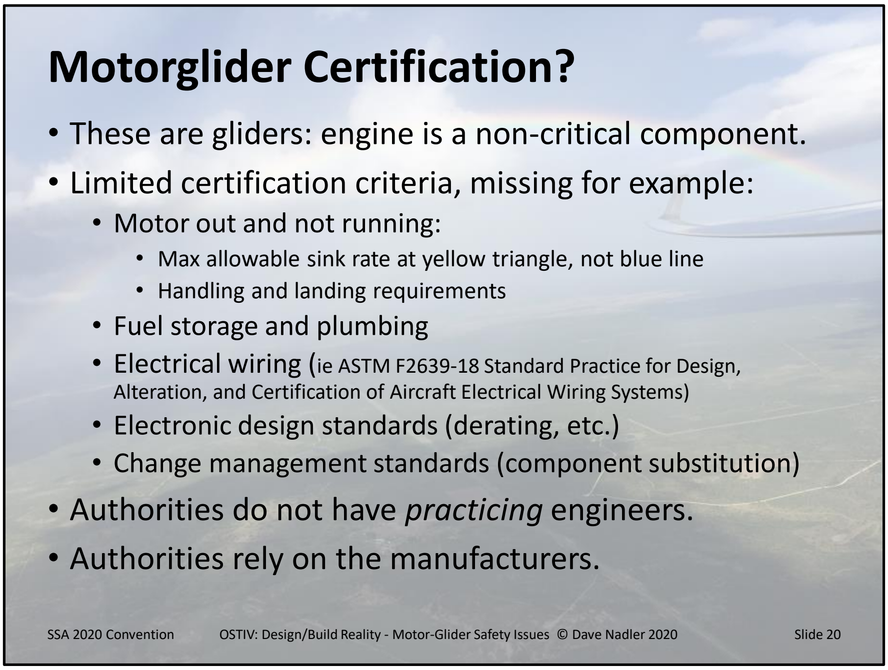
Discolored epoxy slobber in lower right pictures shows severe overheating.

Why??? Why isn't it a Toyota?

Enough with the highlight reel, though I could continue for days and days...

Why and How do these things keep happening?

- Certification
- People
- Processes
- Ongoing maintenance, especially older aircraft. Lack of sensible manufacturer-supported:
  - Consolidated inspection checklists, updated with real-life service experience
  - Component replacement schedules



Non-practicing means:

- Not familiar with industry best practices
- Not current with technology which changes rapidly,
- Not familiar with practical real-world design considerations,

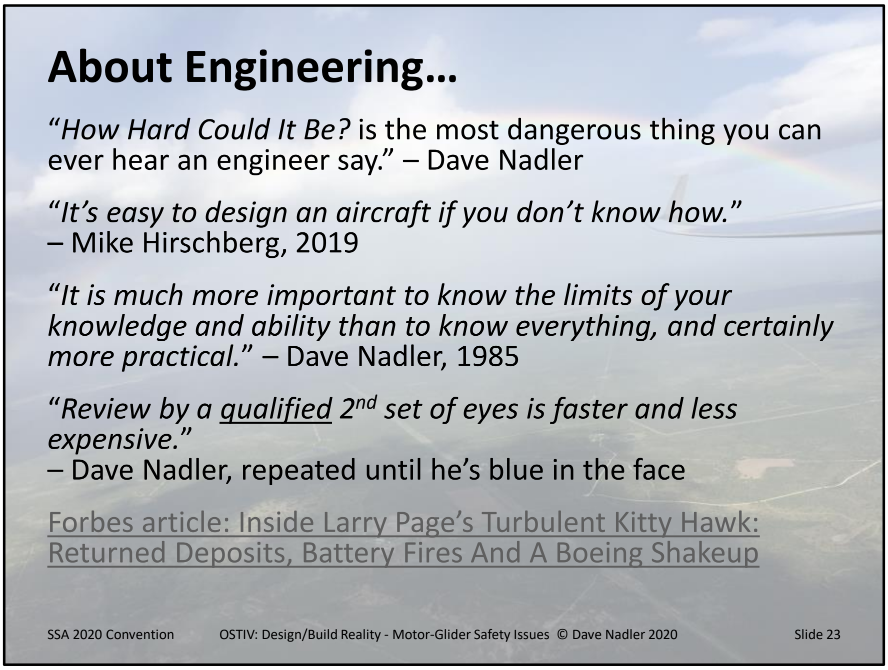
Delegating responsibility to manufacturers can be problematic – current headlines

Pressures on Manufacturers…

- Those damn customers want it ***<u>now</u>***.
  Better yet, **<u>yesterday</u>**.
  And we promised to deliver it
  - more than two years ago…
- Very limited financial resources…
- …Lead to limited engineering resources and expertise.
- Worries about competition (perception anyway)
- Besides, how hard could it be?
  - Underestimate difficulty
  - Overestimate available skills and ability
- Out of money – try to get by…

Who Is Doing The Engineering?

- Have they done it before?
- Is it “*Joe in the back*”?
- Are they actually qualified?
- Is designer using a ***qualified*** reviewer (2nd set of eyes)?
  - Structural calculations require 2nd sign-off
  - Some production processes require check by inspector
  - Unfortunately, most engineering is not checked!
- Have they run an example system through 500 cycles?
- Glider manufacturers have difficulty hiring and cannot pay competitive salaries.



Mike Hirschberg is Executive Director of The Vertical Flight Society (formerly American Helicopter Society)

Cost of fixing something is:

- low when its just a design,
- moderate after prototype built,
- Really expensive after shipped to customers.

I'd much rather have a colleague find my mistake than a customer!

https://www.forbes.com/sites/jeremybogaisky/2019/12/01/inside-larry-pages-kitty-hawk-returned-deposits-battery-fires-boeing-cora/#7ddd643958ab

We’ve ***Never*** Seen ***That*** Before!

- Unfortunately, manufacturers often claim ignorance of known problems.
- Ego, fear for reputation, fear of liability ??
- It infuriates a customer to be told a problem is new, then find out it is not. And customers will find out.

Suggestions

- The objectives of the OSTIV are to encourage and co-ordinate internationally the science and technology of soaring and … the design, airworthiness and operation of gliders of all types…
- Improving design and safety of Motorgliders seems squarely within OSTIV objectives.
- Motorgliders are an ever-increasing percentage…
- Is OSTIV up to this challenge?
- Shining a light on issues is a prerequisite to correcting them

1) Shine a light #1

12 years have passed since the DeRese survey.
Repeat with more detail and reach:

- Record issue make, model, sn, date, details
- Details:
  - Fuel system, drivetrain, switches, controller, other
  - Design problem?
  - Fabrication problem?
  - Vibration related?
  - Maintenance related (missed wear caused failure)?
  - Recommended addition to inspection (daily or?)
  - Expected to be common across what other types?

2) Shine a light #2

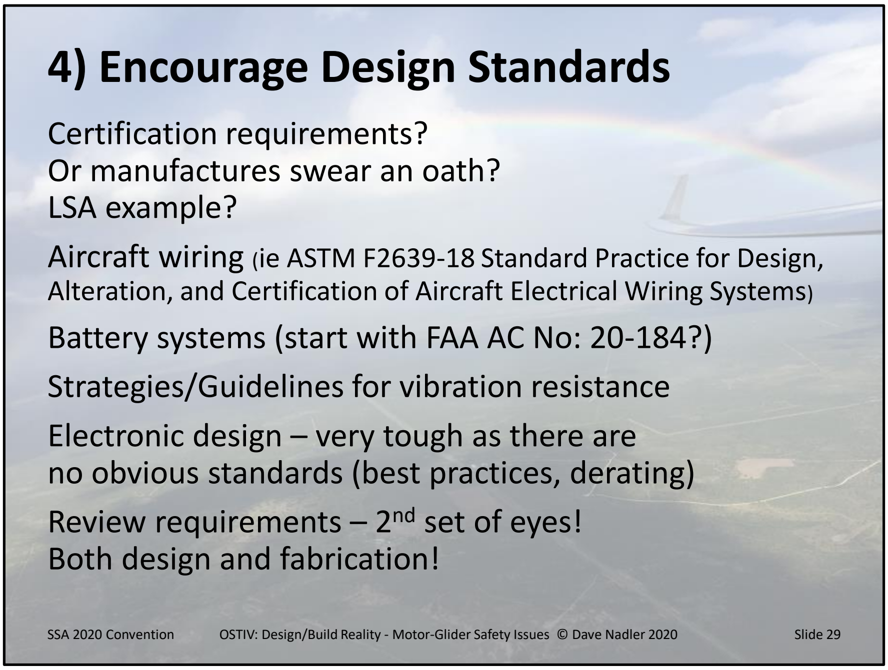
Create a web site for pilots to record
all issues, detailed as above.

Get all manufacturers to <u>encourage</u> their
customers to report and stop hiding problems!
Leadership challenge but doable!

3) Prizes for vibration reduction

A. Organize research sponsorship with $$ prizes for reducing vibration of most common engines

B. Research vibration of existing systems.
Use high-speed photography to show motion of major components and blade/hub flapping/flexing



Seems crazy but do we need standards for limit switch installations?
After all, How Hard Could it Be?

Example electronic standard: use of capacitors (types, required derating value/voltage/etc).
Large corporations have internal standards, constantly changing as components change.

Fabrication example: inspector checks on all connector pins prior heat-shrink.
Cable testers for all wiring looms.

5) Research Fire Detection+Suppression

Engine bay fire detection is hard with inflight airflow. Research ways to get reliable detection.

Ignition source can be electrical fault, oil leak onto a hot component and, of course, raw fuel or fuel vapor ignition.

Putting out fires is hard too.

6) Improve Motorglider Training

Develop a standard curriculum!

- Focus on **<u>Landing is Plan A</u>**
- Regular practical checks:
  - Landing with motor out after simulated failed start
- Decision making:
  - Take-off abort point planning
  - Air restart abort planning
  - Ready at any time for motor failure with no retraction
  - Minimum field lengths for take-off or air-restart assuming motor runs then fails
- Inspections and maintenance

7) OSTIV MG Manufacturer Meeting

Regular OSTIV motorglider manufacturer meeting to share best safety practices across design, testing, tools and processes related to reliability.

Each manufacturer expected to share:

- Info on failures, whether with customer or during internal testing.
- For each failure explain new implemented design and process improvements.
- Take group suggestions on additional improvements.

Include Solo, Binder, Austro, LZ Design, ILEC, etc.

Leadership challenge: get all to **commit** to this!

Will OSTIV Help?

Motorglider reliability is **unacceptable**.
OSTIV can provide a forum, tools and research to help!