Home Built Airplanes &VansAirforce Response

If someone had not sent me an email about the postings on VansAirforce and HomebuiltAirplanes I would not have known about it, and no one would ever know the full facts. This mess has compelled me to set the record straight on several key issues and the problems Andreas had with his gearbox. Since I learned about the HomebuiltAirplanes postings first I will be addressing the postings from there, but they are similar on both sites.
As 'cheapracer' pointed out early in those postings, this amounts to another abuse of social media. What are even worse are the postings from other "experts" from other fields like Ross Farnharm of SDS that chime in with their miss-informed opinions. Survival and success in this industry is hard enough without this sort of fanning the fire.
Let's start out with correcting some confused facts and miss-information. Then I will respond to Andreas and add my summary last.

From rv6ejguy – (Ross)
There have been other failures with these gearboxes. Another in the smaller 200Z unit was a gear failure, possibly again TV related on a 6 cylinder EZ30. The other was in another LS powered RV10, oil seal failure and a forced landing, fortunately with no injuries. The original oil seal retention method was not so good and several people had the same problem.

The new owner has addressed many of the known issues with the BW design but the fact remains, there was never any TV studies done to my knowledge and you never know what's lurking without doing that.

Until a gearbox design has several examples going past 500 hours each with no problems, you just never know.

The only gear tooth failure in the 200Z was traced back to the manufacturer of the gears who had out sourced some of his production without adequate quality control. One tooth on one gear had a small void at the root that developed into a crack resulting in that tooth breaking off. The noise generated by the loose tooth was the only thing that led to discovering the problem. What most people miss is that the gearbox continued to work for several hours without ever failing.
The manufacturer of those gears was no longer used as a source of parts after that, and has since gone out of business. I guess out sourcing didn't improve his business model well enough. This type of out sourcing problem plagues every manufacturer in every industry even if the products are "certified". Check the history of Lycoming and Continental if you don't believe me.
What most people don't know is that this same 200Z gear box, out of an RV-7, was sold to another builder. I helped him to rebuild it with a new set of gears set up with a different gear ratio for his GlaStar and it continued to fly for another 135 hours. It would still be flying but sadly that GlaStar crashed when it suffered fuel starvation during an attempted go-a-around. That gearbox survived the crash in good shape, is for sale, and is very capable of flying again.
There are ten 200Z gearboxes delivered with 8 flying. I surveyed those 8 owners last month. The total on all 8 is over 1100 hours with the top three at, 235, 280, and 320 hours. These flight hours would be higher if it wasn't for 3 of the 8 owners waiting several years for the new FAA requirements on flight physicals.
The RV-10 failure was caused by the case breather getting clogged creating enough internal pressure to blow out the input shaft seal. The lost oil caused the aft propeller shaft bearing to seize up and then the shaft to fail. Despite the failure of the bearing and shaft the gearbox continued to turn the propeller and make that emergency landing easier. I rebuilt that gearbox for the owner and its back in his RV-10. Relocating the breather and developing retainers for the input shaft seal and the propeller shaft seal was all that was needed to correct the problem. Those new features are on all new gearboxes and made available for installation on older gearboxes.

From clanon -
Are those shafts **heat treated**...?

Yes, all of the shafts are heat treated. The 17-4PH stainless steel used for all the shafts is as strong or stronger after heat treating than 4140, 4340, 1541H and other improved and heat treated alloys used in upgraded aftermarket axle shaft designs. Plus, it doesn't rust. Only 300M is stronger by about 11%, but the rarity and high machining difficulties makes it over 10 times more expensive to manufacture parts from it. That turns a $600 part into over $6000 for the same part after heat treating, and both gearboxes use three shafts. Using 300M for all three shafts would add more than $9000 to the sale price of both gearboxes, which makes it too exotic.

From RJW -
The failure could have resulted from torsional vibration. But ordinary loads from a 400HP motor and a heavy prop are enough to destroy these boxes. They use automotive (competition) quick-change gears. The gear teeth are sturdy enough. The machined, 10-spline, 1.25" shafts however are not sufficient to handle the loads in high-power, heavy prop applications. I've been studying gearboxes based on quick-change gears for some time. My analysis has led me to believe that quick-change gears, in an arrangement similar to that in Bud Warren's box, should be limited to about 250HP and use a light wooden or composite prop.

Also, Bud was marketing these boxes as good to somewhere around 450HP. The new owner calls them BW350 boxes and limits them to 350HP IIRC. But even this I think is optimistic.

Rob
You are thoroughly confused about the gears used in our products and their horsepower limitations. The 200Z uses quick change gears, not the BW350. The BW350 uses custom made gears to handle the higher horsepower and loads. This is done to make sure that the gear sets used in both gearboxes are of the highest quality possible and always have safety margins in excess of 300%. Yes, there is a wide range of quality and prices out there for quick change gears. Only the best quality gears are used. Using the cheap ones are just like using Chinese bearings, you get what you pay for.
Neither Bud nor I have ever advertised anything other than a 400 horsepower limit for the BW350 and a 300 horsepower limit for the 200Z. If one of my guys told you differently let me know so I can correct that source of miss-information. The BW350 name came from Bud Warren and is based on the cubic inch displacement of the 350 V8 engine used to test the original proto-type. It has always been called the BW350. I have added to it BW350a and BW350b as a way to help distinguish the history of individual gearboxes in the development of upgrades added. The 200Z is also referred to as the 200Za for the same reasons.

From Turd Ferguson -
So would a TV failure be sudden and catastrophic or would there be cracking and slow(er) propagating failures that lead up to the final failure? Could a tear down and inspection revealed this was coming?
And rv6ejguy response to him -
The failure is sudden but there is almost always something cracking over some time before the failure. TV can impose loads 10-30 times over the peak torque output of the engine. If you have this happening in a constant operational range, no gearbox which would be a reasonable weight in an aircraft can withstand those forces for long.

As Dan H stated on VAF, the shaft design does not follow best practice and a 1.25 inch shaft for this level of torque and the usually heavy C/S props, is likely inadequate.

I tell people, any time you fly with a geared auto conversion, it's truly experimental as they've rarely been professionally developed or adequately tested. Eyeball engineering does not always work out well in this field. Basing your purchase on outside looks, cool factor, nice powder coated and anodized parts does not always turn out well. It's what's inside all those nice CNC'd cases that counts.

To be fair, I believe the high time user has something over 500 hours on his gearbox in another RV10. As far as I know, he's not had any serious issues to date. However TV is insideous- a different engine or prop combination often changes the TV signature dramatically so what worked in a similar case might be unreliable when changes to engine torque or propeller inertia occur.

Only the first paragraph of Ross' response is mostly valid. TV is the basic source of the loads, but its harmonics that multiply those loads to destructive levels.
The quote from DH on VAF is based on the same assumption that everyone else makes from just looking at the shaft damage. Everyone focuses on this small area without considering the big picture, or the root cause. That will be covered in detail later, so keep reading.
Ross' third paragraph is an inaccurate mixture of the business practices used by Jan Eggenfellner and not part of the topic of this tread all together. Neither Bud nor I have ever resorted to eyeball engineering, pretty outside looks, cool factor, powder coating, or anodizing major parts. Bud and I both are probably too open about what is inside our gearboxes. But I would rather be open about everything and answer any questions up front than to hide things and deceive my customers. The way Ross worded his remark about this sounds more like a slam made by a professional politician. I don't want to sound over sensitive here but that was a cheap shot!
My booth at Oshkosh this year was the second one south of Jan's for Viking Aircraft. It was obvious to me just looking at his engine package that he still doesn't understand why maintaining shaft alignments is important, or how to structurally mount the gearbox to the engine to handle propeller gyroscopic loads. But they are very pretty with lots of anodizing and great color coordination. Those good looks sold several engine packages for him at the show. His continued success shows he is onto a great marketing method. How very sad for the future problems our industry will suffer. It's just more proof that P.T. Barnum has been right for over 150 years.
Your attempt to be fair in your last paragraph was close. The highest time gearbox was in Buds' Wheeler Express with over 800 hours on the cast aluminum version. Very few people know that Bud tore that gearbox down every 100 hours and inspected it for any signs of a problem. That airplane was lost due to the fuel line splitting open near the engine shortly after takeoff. The resulting fire forced an immediate landing with everyone getting out of the aircraft safely. That fire also completely destroyed the aircraft. All three of the Hartzell metal propeller blades were bent back at 90 degrees about 30% out from the hub. This sort of hard propeller strike would have destroyed a certified aircraft engine. The gearbox was torn down and inspected afterwards and nothing was found to be wrong with it. Even the propeller shaft was straight and true.
Currently there are 34 BW350 gearboxes sold, and the best information I have is that 22 have flown. That is over 64% and I think that's a better completion rate than for most airframe kit manufacturers. When it comes to hours on other BW350 gearboxes it's really hard to tell what they are. I seldom hear anything from our customers unless they have a question or an issue, which is very infrequent. Usually the calls are about maintenance requirements regarding oil changes, spark plugs, air filters, etc. Other issues are the result of something else like the fuel starvation during an attempted go-around. I do know that three of the BW350's have over 300 hours and one more has over 400 hours.

From BoKu -
There's some good material in the entire VAF thread on this topic:

BW 350 PSRU Failure, please share the word! - VAF Forums

A couple of notes and speulationisms:
* @Billski, I think we would really benefit from your input, based on what's here and in the VAF thread.
* I'm among those keeping a big ol' grain of salt handy regarding any statement that these boxes not being designed to handle a 3g load factor. If it's in their published specs, well, I'm wrong. Hopefully someone on their side with have their say on it one way or the other.
* The shaft for which Dan Horton links a picture is like the poster child for a torsional stiffness gradient concentration. It

sure would be interesting to get this thing into a real FEA system and see where it goes red, and at what torque.

[warning: off-topic sermon ahead]

Getting philosophically wider afield, designing highly loaded power transmission equipment is not rocket science, but only until it is. At issue is that pretty much anybody with a Boston Gear catalog can eventually arrive at a set of gears and shafts and bearings that move 400hp between two RPMs. It only gets really difficult when you go to do it with less than a couple hundred pounds of iron. That's when the stresses and strains start to approach the levels at which you must expect fatigue. The trouble, of course, is knowing where to expect it. That's when some experience really shines.

During WWII, engineers all over the world got a pretty good handle on what it takes to move these great gobs of horsepower out of a reciprocating engine and into a propeller, and they did it without FEA. But it did take a lot of math and physics and engineering, and it also took a lot of broken engines and gearboxes. Probably the biggest thing we learned was that it is a thorny problem not particularly amenable to universal solutions, and that every different engine is a different challenge. But with the free world at stake, we invested what it took.

What's interesting is noting that in the wake of WWII, after we'd developed all this geared engine technology at great cost, geared aircraft engine development pretty much fell off a cliff. The big guys were all using turbines inside about 20 years, and in the General Aviation realm of 100hp to 300hp the vast majority of reciprocating engines remained direct drive motors that accommodate a (relatively) low output speed by throwing lots of displacement at the problem.

Of course, the usual mistake is seeing how an O-360 gets only about 1/2 hp per cubic inch and assuming that it must be a very inefficient solution. Which might be true if for whatever reason you have a fetish for hp/displacement. But airplanes don't care about that. They only really care about hp per installed mass, hp per installed volume, and specific fuel consumption. And factoring in their reliability and robustness, the O-360 does pretty darn well at those things.

Thanks, Bob K.

I wish I had the resources to do a complete FEA analysis, but these gearboxes aren't for an FAA certification or a NASA launch to Mars. Designing and building geared reduction drives for automotive engines isn't easy and Boston Gear is the worst place to get gears from for aircraft use. Their catalog of gears is great for industrial and locomotive type applications. The vast history of development during WWII is a great source of data. Failures and successes of previous attempts made by EAA'ers during the 80's and 90's can also teach volumes on what does and doesn't work. Bud did all that research to solve that long list of designs issues and then took it to another level. Were his designs perfect? They were pretty close. He was continuously testing, inspecting, and making refinements too. I don't think anything is ever perfect. If they were perfect we would never have to deal with manufacturer recalls or Air Worthiness Directives. I do as much verification of Bud's designs relative to the CNC gearboxes and my refinement ideas as possible using empirical analysis methods instead of FEA. That analysis is then followed up with lots of testing. I once worked with a stress manager that said "I'll take a stress engineer that can do a good 'hand job' any day over reams of computer output". You can probably relate to that too. We never let him forget his accidental pun.

From moto-
This is a sad reminder of a local accident In that case, Terry Kronk's 80% scale, LS-powered P-51 broke the same shaft as described here, with the loss of both the aircraft and Terry. I have pictures of the broken shaft. The redrive had only just returned from Bud Warren.
There does not seem to have been enough testing of these units for them to be making the claims they do...

Marty

I know very few details about the failure of Terry's gearbox. I know he burned up the first gearbox when changing pitch on his large PT-6 propeller sucked all the oil out of the gearbox and his second gearbox was built with double the oil capacity. I was surprised to hear that the Australian version of our NTSB does not investigate experimental aircraft accidents. Getting any information or pictures, official or unofficial, has been

extremely difficult. I heard that there was a website with pictures on it that was up for a while but was gone by the time I got involved. I did receive some limited information via email but not enough to tell what happened. If you have some pictures please share them with me. The more data I can get the more likely it will be to come up with the correct changes. For some reason Andreas thinks that posting just two pictures on a website is the correct way to do this.

Again from rv6ejguy -

The clutch design on these drives which decouples the engine from prop during startup does little to alleviate high amplitude TV further up the rpm range. I've never been a fan of this design or any other which uses a clutch inside unless it's a breakaway clutch designed to protect the engine in the event of a prop strike.

TV is inadequately dealt with on most Experimental drives. I'm not saying that's what caused these failures but it's caused lots of problems in lots of drives.

Many vendors also don't understand that they need to do plenty of testing before release and that they should insist that the same prop and engine combination used during that testing is used by every customer of their drive. The testing is fairly meaningless otherwise.

Again, another criticizing general opinion without any details, information, or background of the products, what Bud did, or I have done. This clutch design has been around now for over 15 years. You would think that after working successfully for that long racking up thousands of flight hours everyone would give up on “it doesn’t work” or “it can’t work”. A lot of effort has gone into explaining and showing how the clutch concept works, but we can do it again.

The obvious outward advantages are the disengaged clutch makes it easier to start the engine and prevents burning the starter up. Disengaging the clutch when the engine is turned off prevents the inertia of the propeller from turning the now dead engine through compression strokes, which would cause damaging vibrations to the whole aircraft. The centrifugal weights and springs in the pressure plate are sized to engage and disengage the clutch automatically and smoothly. As nice as all this is these are the secondary advantages of the clutch concept.

Standard transmissions have been out of favor for so long many people forget that there is a dampening hub in the center of the clutch disk. The dampening hub was developed over a century ago to take out all sorts of TV throughout the entire RPM range in a car and increase the longevity of the entire drive train. Without it a standard transmission car would eat up gears in the transmission, the U-joints, the differential gears, and bearings throughout the drive train. Just ask any crew chief of any racing team that uses a solid clutch disk. By the way, the torque converter in an automatic transmission helps to do this as well. The clutch disks used are heavy duty with dampening hubs designed to handle with widest range of TV possible. As good as they are they won’t make up for a bad design. Before anyone starts quoting how the sidewall of the driven tires also dampens out TV in a car remember that the aerodynamic slippage of a propeller through the air does the same thing even better.

TV is always present in everything and a lot of it can be reduced by balancing the rotating masses. The key is preventing all the sources of TV from generating excessive loads are to control the harmonics in the system by preventing those harmonics from coupling up. Harmonics coupling together is what causes the TV loads to multiply quickly until something fails. The number one factor in preventing first order harmonics (the worst one) in any reduction drive is to NEVER use a reduction ratio of 2.0:1. This was the major cause of bad harmonics in the Jan Eggenfellner gearbox for Subaru engines. Jan had several other bad design features as well, like not controlling the input shaft alignment between the engine and gearbox, and putting a snap ring groove across the splines to hold a floating input shaft in place. Between the bad first order harmonics, miss alignment issues, and the snap ring groove providing a weak point to focus everything at it’s a real wonder that the input shafts last very long at all. None of these features have ever been and will never be used in our gearboxes.

The BW350 has used a 1.75:1 in the past, and currently uses a 1.667:1 gear ratio. The 200Z is capable of many gear ratios but anything too close to 2.0:1 will never be installed in it. The dampening hub in the clutch prevents the second and third order of harmonics from coupling with the first order of harmonics. This is nothing more than a simple and elegant design approach to solve the problem of harmonics in a gearbox.

Both of these gearboxes were tested by Bud for hundreds of hours before selling them to anyone. I test all of my changes to extremes first for many hours as well. Ross, you have harped on testing several examples of gearboxes for at least 500 hours twice in your postings. How many examples does it take? Where do you get 500 hours from? How many hours of testing are required for experimental aircraft? Is 200, 300, 400, 500, or 1000 hours enough? Who has the knowledge or authority to say? The FAA won't touch the subject and I'm sure you don't have anything other than just your personal opinion. It's too easy to sit back and spit out a number bigger than you think anyone has ever achieved and say "he should have done more." That seems a bit hypocritical to me. Don't get me wrong, I am a firm believer that anyone in this business should thoroughly flight test and demonstrate their products so customers will know that what they are buying is safe and performs as promised. I have already outlined all the hours and testing that Bud and I have done and the hours accumulated across multiple gearboxes of both designs in multiple airframes. If that's not enough for anybody to be comfortable with then they should reconsider what their fears and insecurities are really based on. So Ross, can you provide a more rational justification for your requirements?

Theory and good practices are fine but actual test results are where the proof is, especially when it comes to TV and harmonics. I have had several customers ask how to do dynamic balancing of their propellers. No one had been successful in their attempts because it's complicated by the propeller changing its rotational alignment relative to the crankshaft due to the clutch reengaging in a different position every time the engine is started. It is also complicated by the equipment designed for horizontally opposed engines being mounted on a V8 which generates new data to process. I saw this as an opportunity to take care of two issues at the same time. So I talked to our local propeller balancer and he said he was up for the challenge. He has been doing this for several years and has excellent equipment. We started this back in May using the LS V8 and CNC BW350 gearbox on my test stand. Anyone that has had this done knows that a harmonic survey is part of the results. I had the harmonic surveys done before, while testing different solutions, and after successfully dynamically balancing the propeller. There were a total of four tests done over a period of two months. Several things were tried to eliminate balancing errors and perfect different methods. These tests proved how well the TV's and harmonics are handled by the clutch system and our design methods. When comparing those results to a typical Lycoming IO-540 test (both prior to balancing) the differences are truly amazing. As you would expect, after balancing the results for both are similar. The principles and methods developed are universal to both gearboxes and I hope to conduct the same balancing tests and harmonic surveys on a 200Z/Subaru installation soon. The results of this testing with the harmonic survey charts were part of my forum presentation at Oshkosh this year. That same presentation is posted on our Yahoo users group and on my website. I know that most of you missed it (only about 18 people found the forum) so look on my website, www.autopsrus.com. The presentation can be found under the Builders Articles menu, then select "Why Use an Alternative Engine" and click on the link to open or download it. If you don't want to read the whole presentation just skip to pages 17 thru 25.
FYI, on certified aircraft harmonic surveys, configuration control, and operating restrictions to control TV and harmonics are all done by the airframe manufacture based on ground and flight testing as part of the certification process. The engine and propeller manufactures, and other suppliers all support those tests and certification efforts. These are very expensive tests that result in hundreds of hours of work performed by many highly trained engineers and technicians. Usually only one test aircraft is dedicated to this testing.
If any company involved in converting auto engines did that for every possible combination of engine, propeller, airframe, etc., that a builder might use they would end up pricing themselves out of business or go

bankrupt. There is no one to control any of the results of that testing in experimental aircraft because there is no FAA enforced certification. Because of this none of the other suppliers would support such an effort. The builder is the manufacturer and only he holds himself responsible for following all manufacturers' recommendations and instructions. No matter what advice is given by any supplier the builder is free to do whatever he wants. This is why every business in this industry has some sort of liability disclaimer in their purchase agreements. As long as the FAA or DER signs off on it for having followed all the standard safety practices and requirements, and all the paperwork are in order, he is free to go fly and experiment, unless it looks really weird. This is the situation that got out of control with Andreas.

I'm not going to copy Andreas' post as all of you have already read it. In this case looking at the pictures and postulating its cause and flaws of the design is like blaming a snake bite on the snake and ignoring that it was stepped on. Andreas' original post containing just the results shows only that he was bitten by the snake and not that he was warned about stepping on it.
Andreas accepts only partial blame for this in his last posting when he admits to his concept of high G's is between 5-6 G's based on his fighter pilot experience. His quest for the highest possible performance in a piston engine aircraft is his real undoing in this situation. Over the previous 2+ years working with Andreas I warned him about several things that he was attempting to do, including pulling high G's in an accelerated maneuver. I told him in an email (Andreas, all of this is backed up on saved emails) that two of Bud's previous customers with the same cast aluminum case had fatal failures doing accelerated high G maneuvers with engines over the horsepower limit, just like his RV-10. Those two incidents involved Terry Kronk's 80% P-51 replica in Australia with a custom bored and stroked LS6, and Dr. Moss' Glasiar III in Kentucky with a supercharged LS1. In addition to having engines above the horsepower limits of the gearbox they also had larger and heavier modified propellers off of turbo shaft engines. Both of them did the same high G pull-up at the end of a high speed pass down the runway. Although Andreas used a much lighter weight composite propeller when he did his high G turn he was knowingly stepping on the snake that he was warned about. Now he acts surprised to the rest of the world that the snake bit him. He was very lucky that his maneuver was not a sudden failure, probably due to his lighter propeller. Instead he got a partial failure of the shaft that continued to operate for another 18 to 20 flights before total failure. I find it amazing how a damaged shaft that everyone thinks is poorly designed managed to last that much longer. I am very happy that he was able to recover and land safely when the shaft finally failed during takeoff under full power.
I want to make two points perfectly clear, I did NOT sell this gearbox to Andreas, and this was NOT one of our Firewall Forward Installations! Andreas embarked on this experiment on his own based on his own concepts of what would make a great combination of parts. Andreas bought his gearbox used from one of Bud's old customers. The gearbox was at least 9 years old when he got it, was never installed on an engine, but based on the rusty parts found inside during repairs (too rusty to be reused) it apparently had sat neglected all those years. He also bought his LS7 used. Both purchases and doing the installation himself were driven by the desire to save money. His dedication to this older gearbox was based on his claimed that the 1.75:1 gear ratio used in it was better than the 1.667:1 gear ratio currently used because it would allow his engine to develop more horsepower. If you do the math based on a 2700 RPM limit for the propeller his engine would turn at 4725 RPM instead of 4500 RPM. Checking the factory dyno chart published online for LS7's the extra 225 RPM in that RPM range nets a zero increase in torque and only about 7 to 8 more horsepower. I told Andreas this but he would not change his mind. I don't have a problem with trying to save money except for when it comes to pushing major components of an installation beyond their published design limits. In this case the propeller, the RV-10's airframe, and the gearbox are not designed for this much horsepower and torque. Also the RV-10 is not designed for an engine installation that is 50+ pounds heavier than the Lycoming IO-540. The LS7 engine and cast gearbox weighs 63 pounds more than the CNC gearbox and an LS3, but he saved some weight with his composite propeller. When Andreas first called me I pointed all of these issues out to him, but he wanted to climb and go faster than everyone else.

What was truly amazing is that this was the fourth time that Andreas damaged his gearbox due to not following specific instructions and ignoring warnings. The first and second damages happened before I ever met Andreas. They were caused by ignoring the installation manual warning to never starting the engine without a propeller or without verifying that the throttle linkage was hooked up correctly. This has happened to two other customers who, like Andreas, got in a big hurry to hear their engine run. Andreas had the throttle linkage backwards and without a propeller there was no load on the engine to slow it down. When he started it for the first time with the throttle at full open instead of at idle the engine accelerated past the rev limiter to well over 6500 RPM. This was at least 1700 RPM beyond the limits of the old pressure plate design and it came apart, destroying the back half of the gearbox case, just like it did to the previous two customers. The second area of damage caused by Andreas on the same engine start-up was when he also disconnected two oil lines. These oil lines go to the nose section of the gearbox just behind the propeller flange. Thinking that both of them were for the propeller governor, and without a propeller installed, he knew that oil would be pumped out of the end of the propeller shaft. Capping the one line from the propeller governor could possibly damage it but the risk is low. However, he never checked with anyone about the function of the other oil line, which lubricates the thrust bearings for the propeller shaft. He also "forgot" to tell me about disconnecting both oil lines. The damaged caused by this was discovered later while I was repairing his gearbox. That sort of damage could be caused by only one thing and he admitted to doing it only after I asked him why he did it. When Andreas first brought me his gearbox and I saw it for the first time there was a lot of visible external damage. He did not want to throw everything away, loose his 1.75:1 gear ratio, and start over. I have always had a policy of supporting all of Buds' old customers and products. So I took it home where I could inspect it better. It turned out that I had "old new stock" spares from an extra cast aluminum case and it was possible to modify the aft half to fit his front case half. If you didn't catch that, the cast parts are not interchangeable like the CNC parts are. After reviewing all the details with him we came to an agreement to repair all the damages. Everything was repaired to at least as good as it was originally, and in some areas a little better. Many of the external upgrades I had developed were added to Andreas' gearbox during these repairs as well, like the shaft seal retainers, a better case breather, the new improved pressure plate assembly, etc. Due to internal differences between the cast and CNC cases upgrades to the inside of his gearbox were not possible. If those were possible it would have required changing the gear ratio. Andreas was told all these details and he accepted it. I also told him that over revving his engine may have damaged the valve train and he should have it checked out by a trained mechanic. He didn't agree with spending the money for that and according to what he told me the valve train was never checked out. Based on this history, the engine he was using, his reluctance to follow instructions and advice, and his tendency to withhold information, I told him I would not give him any warranty on the repairs. He accepted all of this prior to getting his gearbox back. He understood that he was totally responsible for his experimenting that he was determined to do and the dangers to avoid. The third time Andreas damaged his gearbox resulted in something that happened to the oil pump after he got his gearbox back. Andreas has never told me the full details of what happened or what he may have done to cause this problem. My policy for all the products I build and sell is to thoroughly test them before delivering them. His rebuilt gearbox was successfully tested on my test stand for over 3 hours without any issues and it passed all post testing inspections before I shipped it to him. That testing included the proper function of the lubrication system all the way through the propeller governor and propeller. Somehow his oil pump lost the ability to produce adequate oil pressure very shortly after he got his gearbox back. Instead of returning it to me Andreas attempted to replace the oil pump with a rebuilt one (to save money) but it didn't work much better. He finally went to a new larger volume version of the original oil pump which according to Andreas solved all the problems. By this time Andreas had put considerable time on the gearbox with limited lubrication which concerned me. I was under the impression that some of that time was flight time not just ground testing. I advised him to drain and inspect the oil and the oil filter to make sure there weren't any signs of damage before he continued flight testing. I am not exactly sure if he did that or the details of what he found but he judged that everything was good enough to continue flying.

Instead of sending me his gearbox after he damaged it for the fourth time to do a proper inspection and failure analysis on it he tore it apart himself and just sent me pictures, some of them out of focus, so I have limited details about the current condition of his gearbox and the total level of damages. Andreas did share flight data with me that he had recorded and posted online for his last 15 flights. However, those recorded flights started several weeks after the high G maneuver so I don't know exactly how many G's he really pulled. These flight recordings did show that the oil pressure problem had come back but was inconsistent, yet he continued to fly. The end of the shaft that broke off drives the oil pump indicating that the shaft was damaged prior to the flight recordings. From the limited information I got from Andreas the new oil pressure problems started up about the same time as his high G test. I also noted that the RPM data for all the flights recorded was erratic or flat lined at a very low RPM. Andreas told me that was because of the way he had somehow tapped into the alternator to get RPM data and unless the alternator was charging the battery there was no RPM output. WHAT?!?!? Yeah, you read that right. I have never heard of anyone doing this, can't begin to understand how this could be done successfully, or why anyone would want to use such a jury-rigged method of measuring engine RPM's when it is so easy to get it accurately directly from an electronic ignition. I have no clue how Andreas knew what his engine RPM actually was most of the time, or how he knew he was getting that extra 225 RPM's. He could only judge RPM's by ear or by the seat of his pants. Maybe that was based on his fighter pilot experience, but how does someone trained on jet engines accurately judge the RPM of a piston engine?

What I didn't know was that he was also asking all his friends to inspect his gearbox and was collecting their opinions. Without any knowledge of the design, interactions, loads, etc. there is no chance that any of them could understand the true cause. However, the committee had been formed and all sorts of hypotheses' were made and none considered the fact that Andreas was exceeding the limitations of the gearbox. When several of these amateur analysts came to my booth at Oshkosh to argue their theories with me it became very clear that I could no longer trust Andreas or continue to work with him. My next conversation with him ended with my refusal to provide him any further help with his great experiment. From what I have heard his attempt to make a successful insurance claim was rejected shortly after Oshkosh. He then made the same posting on this site and vansairforce.com shortly after that, as already noted above.

Let's look back at the high G maneuver that Andreas did. When he called me about his latest damages it took more than one phone call and a lot of questioning before he admitted to doing this maneuver. He first told me it was a 3.5G to 4.0G sustained turn intended to test the structural integrity of the engine mounting frame that he built, or had built for him. He said that he climbed to about 4000 ft above his home airport to do this test, like that made it any safer. I'm not sure why he has retracted this maneuver down to just 3 G's, or why 3 G's would make it better. Since there is no fight data recording of this flight the actual G's pulled is based on his judgment. However, anybody with any knowledge of structural testing of airframes knows that this is a test done on the ground, <u>not in flight</u>! Failure of the engine mounting frame almost always results in the total loss of control of the aircraft. He conducted a very dangerous test without telling anyone in advance, any regard for his own safety, the impact to his family if he died, or the safety of everyone on the ground below him. That fighter pilot background just keeps popping up. Would the FAA consider grounding a pilot for doing something like this?

Another one of Andreas' friends talked to me at Oshkosh. He was not very happy with Andreas over an incident when he allowed Andreas to fly his RV-9. Those of you that are familiar with the RV-9 know that due to its longer wing Vans has restricted it from doing aerobatics. He informed Andreas of that restriction but Andreas performed aerobatics in it anyway. I know that many perfectly performed aerobatic maneuvers can be done with only 1.0 to 1.5 G's exerted on the airframe. But why would you do this to a friend's airplane after he asked you not to do it? That fighter pilot thing got out of control.

If any of you belong to or read vansairforce.com check out the excellent comments made by N395V, johngoodman, and others regarding the much higher torque of the LS7 over the LS1. Basically they remind Andreas that he "moved into uncharted territory" with the LS7. Andreas knew that neither Bud nor I have ever done any testing with an LS7, and he knew we both published recommendations against it. This cast version of

the gearbox was originally intended for use with an LS1, which at 4500 RPM puts out 315Hp/370TQ. At the same maximum RPM the LS2 does 306HP/398TQ, and the LS6 does 312HP/395TQ. These three are within 7% of each other so it doesn't matter which is used. At 4750 RPM the LS7 puts out an extra 100 horsepower (+32%) and an extra 90 ft-lbs of torque (+24%) over an LS1. But when you look at the power delivered to the propeller shaft with his gear ratio Andreas' LS7 was delivering 805 ft-lb of torque versus 617 ft-lb of torque for an LS1 on a weaker cast gearbox. That's an extra 188 ft-lb of torque or 30% more. The IO-540D4A5 Vans recommends for the RV-10 that is rated at 260 HP at 2700 RPM, which calculates out to 505 ft-lb of torque. Andreas' LS7 installation was cranking out 155 extra horsepower and an extra 300 ft-lb of torque more than the airframe and propeller are intended for. That gives you the true picture of how far Andreas went into uncharted territory on everything, not just the gearbox! If you think about it Andreas was lucky that the propeller shaft failed the way it did. If it had been a propeller blade or airframe structure that failed he most likely would not have survived.

Anyone that has listened to my forums on engine selection has heard me say that selecting an LS7 is a very impractical choice. It costs $8,600 more new (over twice as much), weighs an extra 49 pounds, and makes most of its' higher horsepower between 4500 and 6200 RPM which puts it beyond the RPM range that the BW350 gearbox was designed to use. Even with a 1.75 gear ratio it doesn't take much above 4725 RPM to exceed the RPM limits of the propeller, and throwing blades out of the hub is never a good thing. This simply doesn't justify the extra expense or extra weight. I don't believe that Andreas has ever attended one of my forums, but he also didn't take any of my advice when I told him about this either. He didn't take my suggestion to sell his LS7 and old gearbox and buy a smaller LS V8 and new CNC gearbox as well. The cost difference would have netted him cash in his pocket and a successful engine installation instead of being in his current predicament. He has even admitted to me over the phone that in hind sight this would have saved him a lot of time, trouble, money, and all those "I told you so" comments from all his friends. Odd that he didn't include any of that in his postings. In hind sight I wish I had never agreed to help someone that turned out to be so reckless and while not taking responsibility for his own choices and actions.

Regarding shaft design, both websites commented on proper design of shaft splines based on multi-spline automotive axle shafts which are a close comparison but not a 100% correlation, because it's the wrong shaft. The attached picture is one of the shafts from a quick change differential that uses these gears designed and machined the same way. It takes a lot more abuse in its racing application with high horsepower and maximum torque at the rear axle plus impact loads fed back from the road, tires, and suspension.

The existing shaft design has proven to be very tough. If it wasn't it would not have continued for so many flights for Andreas after being damaged. However, no shaft design will tolerate excessive bending under excessive loads if the case or housing that supports it flexes too much. Even upgraded axle shafts are usually not installed in stock rear axle housings. By piecing together the limited information from the three gearboxes with this shaft failure this is what I believe happened all three times with the cast aluminum case when pushed beyond its' limits. Of course being able to inspect Andreas' gearbox would help a lot, even if it has been overly exposed to too many hands. The evidence that we do have indicates that the excessive combination of loads under these conditions causes the nose of the cast case to flex downward eliminating the gear lash clearances between the gears causing the gears to bind against each other. This puts the propeller shaft in bending at the gear concentrating this NEW load into the smallest cross section of the shaft aft of the gear. Under the combination of excessive power, torque, high G's, extreme gyroscopic loads from the propeller, and this new load into the shaft during this maneuver makes the overall condition so bad the shaft has no choice about breaking. Remember, all of this is caused by miss use and abuse beyond the design limitations. If the shaft were a lot stronger those loads would only move on to somewhere else and cause something else to fail. This is always the case when the issue is the miss use and abuse of anything. In this situation it's not just how high the G's are, it's the excessive horsepower and torque that was added on top of the high G's.
There is nothing unsafe about the cast aluminum case gearboxes when used the way they were intended to be used within the published limitations they were designed for. There are at least 14 more cast aluminum gearboxes just like Andreas' flying just fine with hundreds of hours installed on stock LS1, LS2, and LS6 engines mounted in RV-10s and other airframes without any issues with the shafts, cases, gears, bearings, etc. Jumping to the conclusion that all of these gearboxes are unsafe for any G's or flying into turbulence is based on a lot of false logic ignoring the abuses and miss use involved in this unusual case. Point of fact here, sustained G loads in a turn and a load generated by a spike in G's from turbulence are not the same. They generate different criteria for designing a part, and are not analyzed the same for stress and safety margins. I hate to over simplify the difference but think of turbulence as generating the loads and cycles used for a fatigue spectrum analysis versus sustained loads used for analyzing the strength of a part.

Anyone that has followed the history of Auto PSRU's after I purchased the assets of Geared Drives would have noticed that I have made several design changes over the last 4+ years to improve the safety, reliability, ease of installation, and ease of regular maintenance. All of these improvements were tested for several hours to extreme limits on my test stand before being released for purchase. Case in point is the new pressure plate assembly that was tested to 6000+ RPM three times with no signs of any type of failure to prove that the old RPM limit of 4800 RPM had been increased well above the 4500 RPM used for max take-off performance. While this doesn't make it idiot proof it does make it a lot safer. Andreas got this upgraded pressure plate assembly with his repairs. The current BW350 CNC case is much stronger than the old cast aluminum case, and both the BW350 and 200Z gearboxes exceed all normal category G loading requirements with generous safety margins when installed within their published limitations, and per their respective installation manual.

Just because previously announced improvements have not included anything about the CNC cases or shafts doesn't mean they are not being looked at or worked on for other reasons. Customer requests for propeller extensions up to 2 inches or the ability to do basic aerobatic maneuvers are the motivation behind these improvements in the next generation of CNC cases. Obviously this increase in capabilities also requires improvements in the shafts too. These improvements will provide the option to use a propeller extension or do basic aerobatics but not both! As with all previous improvements these changes will be incorporated into both gear boxes where possible and practical. FYI, the lubrication systems of both gearboxes will not accommodate sustained negative G maneuvers as the only oil pickup is at the bottom of both cases.

I have consistently rejected requests for using the current gearbox designs for competition air racing, and aerobatics. These applications are totally different beasts compared to normal category flying. They require new development programs for a totally different and stronger design. So far no one has been willing to fund that or do any sort of joint venture. That also goes for several other crazy applications I have gotten inquiries about. It's very true that dreamers don't have money and want as much as they can get for free.

I think that judging the design of an early Geared Drives cast aluminum case based on the miss use and abuses that Andreas gave it is very unfair and more than harsh to Bud and his efforts. I also think that judging the current designs based on the same abuses to an older design is an even more unfair and harsher judgment against Auto PSRU's and my efforts.

Anyone that reads website postings has to keep several things in mind. They should question the history, facts, and motivation behind anyone's complaints. They should keep a neutral perspective until more information comes out or checkout the facts themselves. They need to remember that research shows the motivation to post complaints outweighs posting compliments by a ratio of over 20 to 1. Checking to find out more from the other side of the story could also fill in a lot of missing information.

Thank you,
Stuart Davis
Auto PSRU's