One Man's Personal Skunk Works:

A push-pull Zenith 801 ala Cessna 337?

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It will not come as a big surprise to many readers that the Cessna Aircraft Company played a major role in the Vietnam War. The 1988 movie, 'Bat*21', starring Gene Hackman and Danny Glover, in part depicts this fact. It's based on the true story of Lieutenant Colonel Iceal Hambleton (Gene Hackman), whose reconnaissance aircraft is shot down over enemy Vietnamese territory. Hambleton is befriended (by radio) by fellow pilot Bartholomew "Bird Dog" Clark (Danny Glover), who cannot land to pick up the downed pilot but keeps him company while flying over his position. The Forward Control Platform which Clark pilots is a familiar sight at Warbird gatherings, famous not only because of its civilian roots, but also because of its unique centerline-thrust twin engine configuration— the Cessna 337 Skymaster, or in its military guise, the 0-2 'Oscar Deuce'.

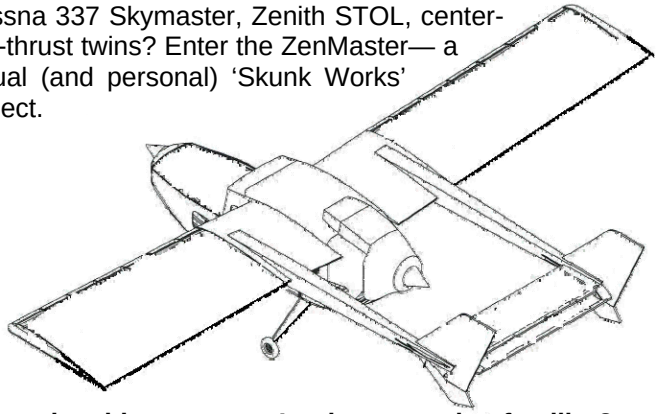
The O2 'Oscar Deuce', Military Version of the Cessna 337 Skymaster.

Introduced in 1963, the 337 Skymaster (and later, Super Skymaster) has very different single-engine handling characteristics from a conventional twin-engine aircraft. The push-pull engine setup (symmetrical redundancy) ensures that it will not yaw into the dead engine as would be the case with wing-mounted engines. The oft quoted terms like 'asymmetric yaw', 'critical engine' and 'dead foot, dead engine' do not apply to push-pull twins. As a consequence, the aircraft does not tend to depart the runway if an engine fails on the takeoff roll, nor does it roll on its back with a situationally unaware pilot faced with a single fan fail. The Skymaster is also controllable at lower airspeeds than a comparable conventional twin and there is no minimum controllable speed (Vmc). Nevertheless, the Skymaster requires a multi-engine-rating, although many countries (alas, not the USA) have a special "centerline-thrust rating" for aircraft like the 337.

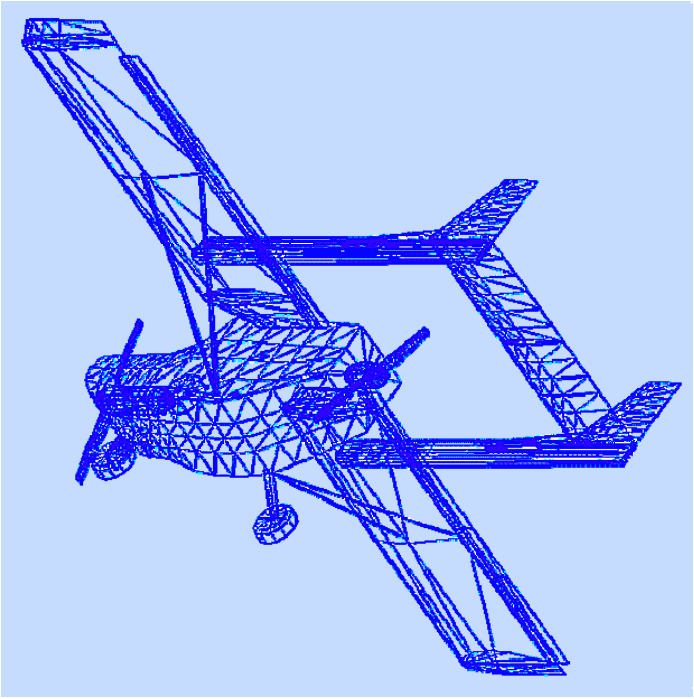
THE ZENITH 801

Form follows function. Nothing curvaceous, teardrop, tadpole or dart-like about it. With STOL (short take-off and landing) capability, inspired by the Fieseler Storch Fi-156— itself famous for extracting Mussolini from his San Grasso mountain lair in 1943— the CH-801 was introduced in 1998 by Chris Heintz, the head of the Zenith Aircraft dynastic organization. A prolific designer in his own right, we could fill an entire article— correction, an entire book— with his designs (certified, S-LSA, and experimental) and his design philosophy. Readers may recall the Gemini CH-620 project, a twin engine derivative of the CH-601. *CONTACT! Magazine* has followed many of Chris' designs over the years; he has an almost cult following and was inducted in to the EAA Hall of Fame in 1999. He and his sons own and operate several aviation related businesses in the USA and Canada.

So where is all this taking us? Push-pull engines, Cessna 337 Skymaster, Zenith STOL, centerline-thrust twins? Enter the ZenMaster— a virtual (and personal) 'Skunk Works' project.



First sketching attempt. Looks somewhat familiar?



ZenMaster - First X-Plane 3D Wireframe Rendering.

WHO IS MIKE FRANCIS?

I'm a 54 year old transplant to the USA from the UK, a private pilot, a Manufacturing Automation / Process Control Engineer by day and like many of you reading this, I play host to a lively imagination and mechanical urge to fix and/or build things most evenings and weekends. I don't hold IA, or A&P certificates, but I do have a computer engineering degree from the days when single computers occupied entire rooms rather than sat on desks. In other words, just a plain ordinary airplane nut. A new member of EAA Chapter 663, Livermore CA, I live with my wife and daughter near Indianapolis, Indiana, but work in Northern California. The AM commute is brutal.

Oh, but I do have a patent for a highly conformable tape substrate and edge design (S-T-R-E-T-C-H duct tape) Yes, stretchable duct tape, useful stuff, believe it or not. And right off the bat, lets make it clear that I have no connection with Zenith (other than attending one of their factory rudder workshops), and Zenith (at the time of writing) has no connection with the ZenMaster design. That could all change of course.

DREAMING

The long morning commute (joking!) does tend to be conducive to all sorts of 'What-if' propositions, crazy things like "What if I made duct tape stretchable, conformable and better at sticking to compound curves?" and "What if a Zenith CH-801 had two engines?" Well, I solved the former, so after that, the latter proposition was relatively easy. Some very smart software tools exist to convert "What-if" to "It's-Possible". Now you see where this piece is headed— the airframe from the firewall to the aft cockpit bulkhead is all stock CH-801. The twin booms, vertical stabs, elevator and rudders are all from the Skymaster playbook (though not actual Cessna certified items). Engines (in the simulation) are two, 100 HP Corvair conversions. As both the engines rotate in opposite directions, in a push-pull configuration, torque forces and P-factor are opposed and, thus, equal. Two engines means forget the typical four seats for the CH-801— this will be a two seater, or a 2+1 at best. Simulations show that at full 801 gross weight, single engine rate of climb is still positive at 500-800 FPM, depending on which engine is used, and this is with a fixed-pitch prop! Twin engine climb rate and sustainable climb angle is nothing short of even more amazing, even for a Zenith type STOL aircraft. Dare I even mention the ugly duckling/ beautiful swan comparison between the CH-801 and the proposed twin engine ZenMaster?

ZenMaster - Rear Engine is mounted higher than the front for steep climb rotation.

ZenMaster TWIN ENGINE CLIMBOUT

The math reads like this (those readers who faint at the sight of 'gazintas' should look away— now!): If you take the loss of power in an engine, in flight, to be a random process of uniform distribution with probability *P*, then for a single engine plane the probability of being without power is simply *P*, but for a twin it becomes P^2.

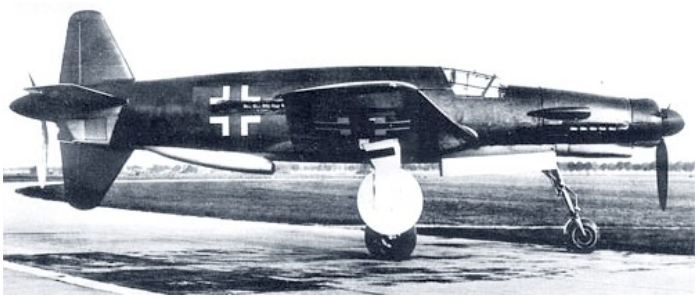
So to plug in some real numbers (for the reader who can stomach both algebra and gazintas), if we take the probability of total loss of power in a single engine aircraft during a particular flight *P* to be 1/1,000 for example, then for a twin the odds of a total loss of power are (1/1,000)*(1/1,000) = 1/1,000,000. Don't you just love those odds? But as Professor Stephen Hawking (if he was reading this) would undoubtedly note, the probability of losing *ONE* engine in a twin is in fact double that of a single-engine plane (P^2), but for an adequately powered twin, this does not mean that falling out of the sky is inevitable. But, I hear you ask, if you lose one engine in a twin, won't the other one just carry you to the scene of the accident? Well, below a certain airspeed (the minimum controllable airspeed or Vmc referred to earlier), and particularly at low altitudes, it can be dangerous, but this is exclusively a significant challenge for the wing mounted port/starboard traditional twin, not the push-pull centerline-thrust twin. *Phew*!

ARE CHUCK YEAGER SKILLS REQUIRED?

Centerline-thrust twins don't require instant and correctly applied hard rudder (and therefore drag) to counteract asymmetrical thrust in the event of single engine failure. So provided you don't attempt a single engine take off (Cessna states in the 337 POH to always roll on the

throttle with the rear engine only first, to prove the hamsters in the back really are providing thrust, before rolling on the forward throttle) you will have air under your wheels in less time than it takes to say *"WHICH $200 HAMBURGER BAR DID YOU SAY WE ARE HEADED FOR?"*. In other words, the 'push in the back' that you'll feel in the ZenMaster would be like having two Lance Armstrongs on a racing tandem. Incidentally, the vortex airflow peeling away from the fuselage and entering the rear prop disc makes for a very rich and unique sound, for those who have ever witnessed a 337 fly over.

Trivia Question: Why '337' ?
Answer: The first Cessna with this configuration was actually the '336', because Cessna wanted to acknowledge it's Dornier '335' predecessor.



The Dornier Do 335 Pfeil ("Arrow"), unofficially also Ameisenbär ("anteater"), was a German twin-engine, push/pull World War II heavy fighter built by the Dornier company. The Luftwaffe was desperate to get the design into squadron use, but delays in engine deliveries meant only a handful were delivered before the war ended.

What do the Feds think of centerline-thrust twins? Well, with current FAA requirements, a multi-engine license is required for a twin engine centerline-thrust aircraft, and no, you can't do as one particularly resourceful (but sadly misguided) individual attempted when he took off and flew a Skymaster with only the front engine turning, as (he explained later) he "only had a single engine license". I imagine he now has a very special single engine license— for a car only, that is. *Being experimental, one can fly solo without a multi-engine rating, as long as the operating limits don't require it.* *~Pat*

WHERE IS THE ZenMaster DESIGN NOW?

It exists only virtually. It flies in simulation pretty much the same as a *stock* CH-801, albeit a 200 HP CH-801. It performs well under every adverse condition I could throw at it and is currently under evaluation for further development. You can't buy one; Zenith won't build you one; and it may never see the light of day. But if you want to know what true 'Experimental' is all about— here is a grass-roots example of just that, only done in the relative safety of your home, at your computer.

The plane has been developed so far in the very powerful (although very inexpensive) computer simulator, X-Plane version 7. It just so happens that X-Plane V7 plays nicely with, and happily swaps files with, another great simulator program whose claim-to-fame is more in the physical design of aircraft as opposed to the flying of your virtual creation, AirplanePDQ from PDQ Technologies. The current version of X-Plane (V9) does not interface with PDQ at all, but it is substantially more user friendly than V7— as a self-confessed Luddite, I would even lobby for bringing back MS-DOS if anyone would listen (Apple users can snigger here).

At this point, the next step is probably to look at the airframe structural design elements. For example X-Plane, being a virtual wind tunnel, doesn't care if the wing/tailboom/wingspar design doesn't make engineering sense, it's only concerned with the air flowing past its outside surfaces. So the expansive all-glass cockpit roof will probably disappear in favor of a full pass-through main spar, requiring individual view ports instead of a greenhouse. The wing struts will probably intersect at the wing/tailboom joint (proven engineering sense) where the rules governing triangulated structures applies. The sustainable climb angle is going to need some major thought around pilot visibility (I hear there are some spare Concorde snouts now available) and with a Corvair installation, particularly with a fifth bearing or a redrive, a fully-feathering prop is feasible.

	Airspeed	Rate of Climb/ Descent
Twin Engine Climb	100 Kts	+1400 fpm
Best Glide	40 Kts	- 400 fpm
Front Engine Only Climb	50 Kts	+ 500 fpm
Rear Engine Only Climb	60 Kts	+800 fpm

Simulations were conducted at gross weight, standard temperature and pressure, non-feathering fixed pitch props. All data derived from X-Plane instrument panel readings.

One development option being talked about is an open-design, multi-partner joint venture platform, a sort of airplane equivalent of Linux.

POTENTIAL MARKET?

Outside the realm of the obvious attraction to a twin, the ZenMaster is well suited to be a flying testbed for engine conversions, new engine designs, redrives, props, engine systems, manufacturers, etc. Simply install the system under test at the front, a conventional/proven installation in the rear (or vice versa) and have a backup system to get you home safely in the event that the test fails.

If nothing else, it's an insight into the process of realizing one man's personal and fun adventure into airplane design, and experimental aviation.

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Reference Websites:
www.zenithair.com/stolch801/index1.html
www.x-plane.com
www.davincitechnologies.com
gazintas: Jethro Bodine, Beverly Hillbillies