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Defiant to the Finish

THE RUTAN DEFIANT

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EDITOR
Lance Phillips
lance@twinandturbine.com

EDITORIAL OFFICE
2779 Aero Park Drive
Traverse City, MI 49686
Phone: (231) 946-7770

PUBLISHER
Dave Moore

PRESIDENT
Matt Kenny

DIRECTOR OF OPERATIONS
Kurt Bainbridge

PUBLICATIONS DIRECTOR
Jake Smith

GRAPHIC DESIGNER
Marci Moon

TWIN & TURBINE WEBSITE
www.twinandturbine.com

ADVERTISING
Jenna Reid
816-699-8634
Jenna.Reid@VPDCS.com

ADVERTISING COORDINATOR
Betsy Beaudoin
1-800-773-7798
betsybeaudoin@villagepress.com

GENERAL AVIATION ADVERTISING INFORMATION
Aviation.Publications@VPDCS.com

SUBSCRIBER SERVICES
Rhonda Kelly
Jessica Meek
Leah Backus
P.O. Box 968
Traverse City, MI 49685
1-800-447-7367

To change mailing address, email *rhonda.kelly@vpdcs.com*

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The Rutan Defiant, courtesy of author Matthew McDaniel

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Departure

Defiant to the Finish

by **Matthew McDaniel**

Oshkosh AirVenture has been the premier showcase for experimental aircraft for decades. Twin and/or turbine engine designs are rare in that world of "homebuilt" aircraft. Even more rare are such designs that make it past the prototype stage. While hundreds of homebuilt designs have come and gone through the years, one name consistently stood alone among them: Burt Rutan. The prolific designer of all manner of bizarre, fanciful, efficient, cutting-edge flying machines pushed the boundaries for 40+ years. His legacy is rewritten every summer in the trampled grass around examples of his composite, canard designs. At each AirVenture, you'll still find rows of them displayed. It was there that I stumbled upon a small lineup of his Defiant twins and learned of one man's 35-year quest to complete a plane that should have revolutionized the light twin market (but didn't).

Great Expectations Meet Harsh Realities

Rutan first flew his Model 40 design in 1978, naming it "Defiant." It publicly debuted at the National Business Aircraft Association (NBAA) convention, versus Oshkosh. Rutan envisioned a fully certified version, marketed primarily to business aviation. Small businesses loved light and small cabin-class twins at the time, but his Defiant could offer safety and simplicity that no production twin could. Sadly, in spite of his best efforts, sufficient funding to pursue certification never materialized. Burt's sole Model 40 simply became his personal transportation.

However, there was plenty of interest in his selling plans or kits for an Experimental Category version. He demurred, insisting #40 was just a proof-of-concept aircraft and not a prototype. Fred Keller was an Oshkosh award-winning builder of a Rutan VariEze, who lived in Anchorage, Alaska. Rutan later authorized Keller to build an improved version of the Defiant, but only if Keller documented every step of the build and, in doing so, helped develop a complete set of construction plans that might eventually be marketed. Keller did just that (in an astonishingly quick 18 months), while incorporating a

Canard testing

Garage modifications

First start

Fixed-pitch prop and Mooney nose gear

multitude of improvements (all developed with and/or blessed by Rutan). The most obvious change being a modest increase in wing and canard spans. The result was the Model 74 Defiant, completed in 1983. The Rutan Aircraft Factory (RAF; the precursor to Scaled Composites) sold nearly 200 sets of plans in 1984-85, before halting sales.

Many would-be builders were soon overwhelmed by the scope of such a project, especially one based primarily on plans. The tasks of building the structure, scrounging parts for modification, designing systems, and scratch-building all manner of components were daunting to say the least. No one could match Keller's super-human pace. While several did get completed within just a few more years, the majority of Defiants required 15+ years to reach airworthy status. Today, 40+ years after the last set of plans was sold, only about 30 Defiant airframes are believed to have been completed, and roughly 20 remain active.

Early writings about the Models 40 & 74 are filled with superlatives and visions of a future awash in simpler, safer, certified twins. Those were, after all, Rutan's primary design goals. The simple part was using low-horsepower, normally-aspirated, carbureted engines, turning fixed-pitch props, and basic, lightweight, user-friendly systems. The safer part was multifaceted. Centerline thrust made the threat of control loss after an engine failure practically nonexistent. Fixed-pitch props meant easy engine management (normal and otherwise). The canard design lowered the fear and danger of stalls, as both the main wing and the canard are lifting surfaces. However, the canard reaches its critical angle of attack (AoA) first and, when it does, causes the nose to fall (lowering the AoA on both the canard and the main wing). Thus, the main wing isn't typically able to achieve a stalling AoA. Other systems (gear, fuel, electrical, etc.) are elementary in function and non-catastrophic in failure events.

What if the Defiant had achieved certification and production (in some further refined form) and then been scaled up into larger twins with similarly safe handling and operational characteristics? There is little doubt their accident rate would have been

Author and owner


Rear engine cooling scoop

Don Mrowzinski

Custom folding canard tip

Detail of the folding canard tip

lower than that of more traditional twins. However, that simply didn't happen. As is often the case when innovative designs are forced to battle for limited development dollars within small markets, the winner is usually the more traditional choice.

The M Isn't Silent

Don Mrowzinski grew up the son of an electrician, helping his dad wire houses. His mechanical mind was further stimulated by a blue-collar family working in the plumbing, HVAC, and well-drilling trades. As a teen, Popular Mechanics provided his first exposure to homebuilt aircraft articles. His degree in Business and Accounting led to learning early computer programming and software development. Eventually, he started his own consulting business, designing systems for large companies and managing large-scale projects.

In the early 1980s, Don's career moved him from his native upstate New York to Ohio. There, he learned to fly, earning his Private Pilot Certificate in 1982. While attending the Dayton Airshow with his then-girlfriend, he was looking at the Glasair Aircraft display and expressed a desire to build something similar. She asked where the two kids would sit (this, prior to them having seriously discussed marriage, much less children). Seeing this was the woman for him, they soon married, and Don shifted his aircraft search to 4-seaters.

A couple of years later, he met Burt Rutan at Oshkosh and saw the Defiant. The hook was set instantly. He purchased the plans in 1985 and started construction. Little did he know that the never-ending need for more tools and bigger shops would consume time and money of their own. Then, the kids came along, his flying stopped altogether, and the build slowed to a few hundred hours per year.

Three and One-Half Decades in the Making

It is unlikely that anyone enters into a project anticipating it will take them 35 years to complete. Don is no exception. Nonetheless, he always believed he was fully capable of building and flying the aircraft. Initially, he logged his build time religiously. At 2,500 hours, his logging became less specific. At 4,000, it became sporadic, at best. In the end, he estimates he invested 7,500-8,000 hours building. By 1989, it was time for a new house for his family, and airplane building stopped for 2+ years. In 1992, he headed back into the shop, but soon took a detour.

One challenge of Defiant ownership is hangaring. They don't fit into standard T-hangars, because the span of the canard is much wider than both the tail span of similarly sized twins and the back of most T-hangars. Checking all the airports in his Columbus, OH home area, none offered affordable hangaring that fit the Defiant's dimensions. So, he devised an unconventional solution. He would build his canard with folding tips. The reduced/folded span (about six feet less) would be sufficient to utilize standard T-hangars. He pitched his idea to Rutan directly, who was unenthusiastic. Don was convinced it could work and pressed. Burt's response was, "Okay, but if you're going to do it, you must do it right! Which means subjecting the whole assembly to static load testing." Don agreed, and Rutan provided all the necessary testing criteria.

Don's folding tip mechanism incorporates custom-milled locking hardware to carry the spar load, plus fore and aft locks that prevent twisting. His Rutan-approved static load tests required locking the tips in their extended position, then loading each tip with 750 lbs. (challenging in itself, just to stack so much weight onto such a small surface). That equated to 7.6 Gs, outside of the fold mechanism alone, or double the maximum G-load of a Normal Category aircraft. To date, no other Defiant builder has tackled such a modification, and it was Don's only significant departure from the RAF plans. That single modification, however, added over a year to the build. He completed the canard in 1995.

Rutan's Model 40 and the prototype Model 74 both utilized Lycoming O-320 engines of 150-160hp. The only larger engine the plans approved was the Lycoming O-360 (180-200hp). Don chose the latter, buying two, overhauled/pickled, 180hp versions in the late 90s. As the plans also recommended, he stuck with fixed-pitch props. Initially, choosing 3-bladed wooden units, carved to climb pitch.

Nearly all of the construction was conducted in a pole barn adjacent to his house. He was at the 50% done with 90% to go stage when progress stalled (around the year 2000). Career and fatherhood took priority, and the project languished for nearly 15 years. Yet, unlike so many builders, Don never gave up, never contemplated selling it, never quit dreaming. He always felt that if he lived long enough, he would complete it. After his two sons were grown, he resumed construction around 2014. After retirement (in 2016), he dove back in with a defiant push to the finish line. Finally, the day came in 2019 to extract the Defiant from the pole barn and move it to the airport. He removed a wall and cut a slot in a support post between the two single-car garage doors to allow the wing-strake to pass through. After all those years of labor, needing to repair the hole in his garage was the least of his concerns.

Don's Model 74 arrived at its T-hangar as a complete, but disassembled, aircraft. The engines and props were the only components of N171D that Don did not build or modify himself (with only the occasional aid of his wife or sons to lend extra hands when

A thoroughly modern panel

necessary). That included designing and building the redundant electrical systems, the modern panel layout, all the finish and paint work, and sewing every stitch of the interior on a 1920s industrial Singer. By Autumn of 2020, final assembly and engine test runs were complete.

Defying Gravity

As the reality that he might actually finish his Herculean task set in, Don resumed flying. First earning an Instrument Rating and then flew multiple types to sharpen his skills. Next, adding a Multi-Engine Rating (in a standard twin, to avoid centerline-thrust limitations). With the help of the tight-knit Defiant community, he also flew other Defiants into his home airport in preparation for his own maiden flight. After a few weeks of low and high-speed taxi tests and a few "crow hops" over the runway, it was time.

That first flight in May 2021 was successful, but far from trouble-free. The speed of the Defiant challenged Don, and the rear engine was both over-revving and overheating. Don pulled the rear engine to idle, abbreviated his flight agenda, and finished the flight essentially single-engine. The rear engine's P-51 style belly scoop was replaced with two "armpit" scoops, which rammed air into each bank of cylinders from the lower wing/fuselage intersection. That resolved the CHT issues, while the installation of new 2-bladed composite props, designed to optimize the Defiant's wide speed envelope, resolved the high RPM issues.

A Tranquil Twin

Flying the Defiant was not my first experience behind the controls of a Rutan-esque canard design. I'd previously flown Cozy Mk.III & Mk.IV models and the Quickie 2. So, the oddities of canard flying were not totally foreign to me. A second engine just added to the intrigue. Like all canard designs, the Defiant initially scrambles a pilot's sense of airplane form and function. Everything seems backwards. The elevator is at the front (on the canard). So, when the stick is pulled, the elevators move down (not up) to increase lift on the canard and raise the nose. The rudder is mounted below the forward fuselage, so when a pedal is pushed, it's controlling yaw from the nose, rather than tail (it's nicknamed a "rhino rudder"). Both engines incorporate updraft cooling, versus the far more common downdraft. The ailerons are on the main wings, but inboard, versus outboard (mainly to shorten and lighten their control rods). There are no flaps. Finally, the Defiant is taxied into the rear of a standard parking-T.

Like Cessna's Skymaster line, the Defiant is a centerline thrust twin. Because the rear engine is out of sight, it is started first (when it can be heard). After the rear engine is running and stable, the front engine is started normally. Taxiing out is standard, using the steerable nosewheel and differential braking. Run-up is equally standard, with the only unusual aspect being verification that the canard-tips are extended (visually) and locked (via the absence of two red flashing warning lights).


The Defiant requires a capable tug

On takeoff, throttle #2 (rear engine) is opened first. Once it is obvious through both pilot-senses and engine indications that it is developing full power, throttle #1 (forward engine) is brought up to match (at which point all turning tendencies cancel each other out). Rotation occurs around 75 KIAS and requires just a slight pull on the side-stick. Typical takeoff rolls are 1,600' under standard weights/conditions and slightly longer at higher weights and/or density altitudes. N171D's custom props increased takeoff roll over 100', but also increased cruise speed 15 knots (a trade-off any pilot would welcome). The pitch sensitivity common to canard designs is apparent almost immediately after liftoff. However, once pilot control inputs are dialed in accordingly, pitch control is quite manageable. The recycled Mooney nosewheel is retracted via a simple, manually operated, over-center mechanism, while the mains are fixed.

Climb rates are generally 1,500 feet per minute (FPM) at 120 KIAS. Airflow over the rhino rudder is slightly modified by the adjacent nose gear, making a rudder trim adjustment necessary after retraction. Otherwise, there is little to fiddle with in climb, without cowl flap or prop controls. Mixtures can be leaned on-schedule, of course. The Defiant is equally happy in low or mid-altitude cruise, and N171D averages 150-155 KTAS down low on 18-20 GPH (total) and 160-165 KTAS in the teens, burning 15-17 GPH. Numbers no conventional twin of its generation, with similar horsepower, 4 seats, and a generous baggage area could achieve (especially while carrying 108 gallons of fuel, for a 5-hour range with reserves).

Maneuvers are sedate, but control forces are not harmonious. Pitch forces remain very light, while roll forces are heavier (in comparison) with virtually no adverse yaw apparent. Yaw forces are somewhere in between. Stalls are benign, as the canard is effectively "self-recovering." It stalls, the nose drops, and it's flying again, without the main wing ever having stalled. The aircraft could stall and recover like this, in repetition, if the stick were simply held aft. Of course, a steady altitude loss would result in that situation if no other control or power changes were made.

One Engine Inoperative (OEI) flight is where the Defiant's simplicity shines. There is no published minimum safe single-engine (Vsse) speed, as there is no minimum control (Vmc) speed. The airplane is totally controllable throughout the entire flight envelope, whether flying on one engine or two. With the loss of either engine, the Defiant simply flies along as before, in terms of control. To maintain altitude, pitch will increase, and IAS will slow (with Vy and Vyse both being around 105 KIAS in N171D). There is no need to rapid-fire through memory items to identify, verify, and secure the troubled engine. No uncommanded yawing or rolling happens. No drama at all, really. Set

the power on the good engine to correspond to the required performance, then sort out the problematic engine and secure it, if necessary.

Single-engine performance is far from stellar, but it is absolutely on par or better than similar category, conventional twins. At about 400 lbs. under gross, on a near-standard day, I began by pulling the rear engine to idle. Once trimmed, we were still climbing at 150-250 FPM, passing through 4,500' MSL, at 110 KIAS (slightly above Vyse). Repeating the exercise with the front engine at idle, the climb rate improved to 350-400 FPM. This disparity in OEI performance is mainly attributed to different prop efficiencies. While both props are pitched the same, the front prop's wash (thrust) is less efficient, as it is broken up passing across the canard, fuselage, and wing strake. Conversely, the rear prop's thrust is allowed to escape cleanly behind the aircraft. Additionally, when the front engine is silent (or idled), the air reaching the rear prop arrives less disturbed, further improving the rear prop's efficiency. Obviously, OEI climb numbers would likely improve

Defiant N171D Data [Table 1]

Main Wing Span/Area	30.75 feet / 90.5 feet^2
Canard Span/Area	24.16 feet / 48.9 feet^2 (18.1 feet with tips folded)
Total Wing Area	139.4 feet^2
Length	22.8 feet
Height	9.33 feet
Cabin Dimensions	Width: 43.0" tapering to 41.5" Length: 66.0" (front), 56.0" (rear) Height: 42.0" tapering to 38.0"
Baggage Area	16.5 feet^3 (rear seats upright) 41.0 feet^3 (rear seats folded)
Empty Weight	1,900 lbs.
Max. Gross Weight	3,100 lbs.
Useful Load	1,200 lbs.
Fuel Capacity	108 Gallons (648 lbs.)
Fuel System	50 Gal. Per Wing Strake 4 Gal. Per Sump Tank Right Tanks Feeds Rear Engine Left Tanks Feeds Front Engine Crossfeed Available for Emergencies
Electrical System	12 Volts 2 x Batteries 2 x Alternators 2 x Main Busses (1=Front, 2=Rear) Normally Isolated Main Bus Tie Available for Emergencies
Avionics System	Dynon PFD & MFD Dual Engine Monitors (within Dynons) PS Engineering Audio Panel Avidyne IFD-440 IFR & WAAS Nav/Comm Dynon #2 Comm Dynon Autopilot & Flight Director

Defiant N171D V-Speeds [Table 2]
All Speed In Knots Indicated Airspeed (KIAS)

Rotation (Vr)	75-80
Best Angle of Climb (Vx)	95
Best Rate of Climb (Vy)	105
Best Rate of Climb, Single-Engine (Vyse)	105
Min. Control, Single-Engine (Vmc)	N/A
Maneuvering (Va) @MGW	130
Normal Cruise (Vnc)	150-165
Never Exceed (Vne)	195
Max. Landing Gear Operation (Vlo)	130
Max. Landing Gear Extended (Vle)	150
Max. Flap Extension (Vfe)	N/A
Landing Reference (Vref – Final)	80
Clean Stall (Vs)	67

slightly if the failed engine's prop could be stopped to reduce windmilling drag. With fixed-pitched props, full stoppage is not assured. Regardless, OEI situations in the Defiant are low pilot workload with sufficient performance margins to allow safe outcomes.

Descents are one of the few instances where pilot workload in a Defiant is slightly higher than that of a typical twin with constant-speed props. Like any high-performance aircraft capable of flying in the oxygen levels, the pilot can choose to trade altitude for airspeed during descent. However, since Defiants typically utilize fixed-pitch props, engine RPM will rise as airspeed increases unless the pilot adjusts power accordingly.

In the pattern, the Defiant remains simple, but different. The nosewheel's maximum operation speed (Vlo) of 130 KIAS (150 once locked – Vle) allows it to be extended early if using it as as peed brake is desired. When proper descent planning makes that unnecessary, it is typically lowered on downwind. The verification of "Gear Down, One Green" is peculiar, but appropriate ("Two Green" could be used, if incorporating the adjacent canopy lock annunciation). Application of carb heat isn't typically necessary. Instead, glance at the right Dynon display to verify safe readings on the carb temp gauges. Don typically targets a minimum speed of 100 on downwind and 90 on base into final. With no flaps and no belly speedbrake (as some canard designs have), the Defiant is challenging to slow on final. A common technique is to pull the rear engine to idle and allow its windmilling prop to act as a speed brake. The front engine is then used alone to control speed and sink rate. Eighty knots works well on final, with a threshold crossing speed of 75. While a small flare is acceptable and safe, the Defiant is best flown onto the runway in a stabilized pitch attitude and descent rate. Since it lacks flaps, it will already be in a slightly nose-up attitude if stabilized on-speed. Since the rudder pedals control both the rhino rudder and nosewheel steering, the pilot should anticipate the nosewheel to be slightly askew upon initial contact, if any significant crosswind requires sustained rudder input throughout the touchdown and rollout.

None of Rutan's canard designs that made it into the homebuilt market could be accused of being STOL-machines. The Defiant is better than most in that it has a sturdy nose wheel and a reasonable main-gear width. Nonetheless, Don prefers to avoid runways under 3,000' long to preserve appropriate safety margins.

Taxi-in can be accomplished on either or both engines. Otherwise, there is almost nothing for the pilot to do. Don likes to insert a small blocking device behind his gear release trigger, as an extra layer of protection against inadvertent nosegear unlocking (though, even with the trigger depressed, one would still have to give a mighty lift over-center on the manual gear handle to actually retract it).

Oddly pointed directly at the hangar door, the twin is shut down and secured. Egress is a delicate affair using a slightly blind step below the fuselage. However, there is ample structure to grasp throughout the process. Then the one-of-a-kind Mrowzinski folding canard tips can be unlocked and lowered into their dangling (folded) positions. Being a twin, the Defiant is a bit much to muscle around with just a hand-towbar. So, the sturdy electric tug is maneuvered into position, the motorized cams lock onto the nosegear tow-lugs, and the short tow into the hangar begins. Yes, Don designed and built the custom tug, too! T&T

Matthew McDaniel *is a Master & Gold Seal CFII, ATP, MEI, AGI, & IGI and Platinum CSIP. In 34 years of flying, he has logged nearly 22,000 hours total and over 5,900 hours of instruction given. As owner of Progressive Aviation Services, LLC (www.progaviation.com), he has specialized in Technically Advanced Aircraft and Glass Cockpit instruction since 2001. McDaniel is also a Boeing 737-series Captain for an international airline, holds eight turbine aircraft type ratings, and has flown over 135 aircraft types. Matt is one of less than 15 instructors worldwide to have earned the Master CFI designation for 11 consecutive two-year terms. He can be reached at* **matt@progaviation.com** *or 414-339-4990.*