

A New Block on the Kit – More or Less -- TWINSTARRlite :



Moving the TWINSTARRlite into position at Wallis Days 2002.

Introduction : Concept

The Twinstarr (note the correct spelling) is the brain-child of the late Don Farrington who, after several years intensively trying out several models of two-seat open gyroplane designs for training in his fulltime gyroplane school, came to the conclusion that there actually wasn't anything out there satisfying his requirements. So he set out custom-designing a specific gyroplane trainer meeting the following requirements:

-SAFE TO FLY!!!!!!

- Flight characteristics and performance similar to or better than the typical two-bladed single seat gyro planes on the market.
- Stability comparable to fixed-wing
- Reliable engine and airframe structure
- Capable of withstanding the daily abuse of student training
- Good pilot comfort and crash protection
- Minimum 500 lbs payload
- Minimum maintenance
- Available in kit form at an affordable price
- Easy to build
- Compact size for storage (removable mast)

Being a trained aerodynamicist in disguise as a pilot/instructor/examiner he came up with a purposely designed and properly stress-analyzed tandem-design with a TIG-welded 4130 steel tubing airframe sitting on an ingenious spring steel undercarriage calculated to withstand "student landings" at 1400 lbs Max Gross Weight (although the publicized weight was initially restricted to 1200 lbs). Twin fins and rudders of conventional riveted aluminum construction made for a very compact and light-

weight airframe. Engine of choice was the Lycoming O-320 of 150/160 HP, with it's reliability and performance. Comfortable seats in a streamlined fiberglass enclosure tailored to accept 2 full-sized pilots weighing over 230 lbs each with controls readily at hand in addition to a well laid-out instrument panel with radio, transponder and intercom.

The very promising maiden flight of the pre-production prototype took place in 1992 with a smaller engine. Every now and then in aviation an extraordinary design rolls out of the hangar and even during the first flight it is apparent that the designers did their homework well and got it right first time. So it was with the Twinstarr. From the first flight it was quite clear it was a winner: excellent stability and handling with exceptional performance. Whenever/wherever it was demonstrated, favorable comments on the stability and solid feel were made by both novices and "old hands" alike. This stability and behavior rapidly earned it an excellent reputation, which was in no small part due to its centerline thrust (years before the Gyroplane Stability Research Program by the University of Glasgow)

The prototype was used in the daily training of students and quickly showed its value in terms of student progress, ease of maintenance and reliability. It was a new generation of gyroplane trainer, setting a new standard for two-seat gyroplanes.

In the editorial of the September 2002 issue of the PRA Rotorcraft magazine five recommendations were made for gyroplane design/manufacturing standards to increase stability and hence safety. They are: installation of a horizon indicator, centerline thrust aligning the propeller thrustline with the vertical center of gravity, proper control ratio, and proper disk-loading. The Twinstarr already met, exceeded and incorporated these recommendations even



Side view of the new TWINSTARRlite



Woody, flying the TWINSTARRlite at Wallis Days 2002, in Farnborough, England.

years before they came to light. Please read also the PRA board of directors article (including addenda) in the Dec2002/Jan2003 issue of Rotorcraft. The conclusion speaks for itself.

I was fortunate enough to instruct for several years at the Farrington Aircraft Flight School (Paducah, Kentucky) in the original Twinstarr and to have been closely involved with its design from the very beginning.

TWINSTARR - Data:

Empty Weight	650 - 700 lbs
Max Gross Weight	1200 (1400) lbs
Engine Power	120-200 HP
Rotor Diameter	30 ft
Vc	65 Mph
Fuel	16 US Gallons
Endurance	2 ½ Hours (+20 Mins legal reserve)

Now begins the early story of the TWINSTARRlite, its inception and development. I hope this will give you information about 1. my follow-on machine to the Twinstarr and 2. an overview of one process for new design development.

Twinstarrlite : Pregnancy

My plan early-on was to promote the safety of the gyroplane in Europe (especially in Belgium). It will thus



The TWINSTARRlite's engine in installed position.

come as no surprise that as soon as I returned to Europe after 3 ½ very enjoyable and successful years at Farrington Aircraft, plans were made to operate a Twinstarr over here since there was a need for a stable gyroplane trainer.

A quick situation-check showed that a European ultralight category for gyroplanes would soon be established with a Max Take-Off Weight (MTOW) of 450 Kg (990 lbs). This weight included two occupants of 78 Kg (172 lbs) each, as well as fuel for a flight of minimum one

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TWINSTARRlite rotor head, up close and detailed.

hour duration at cruise power setting. There was also a maximum allowable horsepower requirement in France where my Twinstarr was to be registered. Unfortunately the original Twinstarr-design clearly would not meet these requirements (and only very few European gyroplanes would, for that matter). It was too heavy and too powerful to be legal over here.

But I had an idea. My close involvement with the Twinstarr project at Farrington Aircraft had brought a very intimate first-hand knowledge of gyroplane design parameters and those of the Twinstarr in particular. Together with my brother who holds a degree in Aerospace Technology, we made some preliminary calculations and put our idea to Don, who approved and cleared it immediately.

Bones and Body : Airframe, Empennage and Landing Gear

The TWINSTARR-airframe is a time-proven factory TIG-welded space frame of tubular (4130) steel. Anyone knowledgeable about aircraft (or even racing cars for that matter) structures knows this is probably the best strength/weight combination without sacrificing repairability or affordability. We decided to retain the fuselage and twin empennage in its entirety. Since the original structure was designed for 1400 LBS, the safety factors would be well beyond those required (990 lbs MTOW in Europe). The only weight-saving change we made was using honeycomb floorboards instead of the standard plywood ones.

The landing gear is also the original tubular spring steel one, well known for its unequalled ruggedness. In about seven years of everyday training, nobody had ever been able to damage this landing gear (despite many excellent attempts by students!!!!). The original Cleveland wheels and disc brakes complete the high-quality construction.

The Heart of the Matter : Engine and Propeller

We all know that gyroplane performance is quite dramatically adversely affected by weight. The lighter, the better. (For a good example of how important light weight accompanied by strength is, take a good look at a Wallis autogyro.)

The idea was to use a light engine to bring the empty weight down and the horsepower within the legal allowed range. Looking at the figures one will soon realize we would have to lose one third of the empty weight, which meant something in the region of 200 lbs! Not easy to do.

So the quest was on for a lightweight engine of sufficient output.

I had a personal preference for air-cooled four-stroke engines for simplicity and reliability (safety). Our calculations showed that an engine with weight and horsepower similar to the Rotax 912 would do it. We researched a number of possible alternatives. After some study and comparison, we found the perfect combination of "desirable" and "affordable": The Verner SVS1400. Made in the Czech

Republic (well known for its quality aviation products), of larger capacity than the Rotax 912, air-cooled, dual ignition, 78 HP, almost 30 % more torque than the Rotax 912, but at substantially lower price (including everything, even engine instruments!!!), we decided to try it. (see website information at end of article).

We now had an engine of half the weight, half the size, half the cylinders and half the horsepower of the original Lycoming O-320. The question was how to keep the CG within range? This is where the original Twinstarr design again shows its superiority. Without changing the truss-constructed removable mast, the Twinstarr design will accept a very large range of CG, allowing lightweight engine installations without structural changes to fuselage or landing gear. We designed and constructed a 4130 steel engine-mount that still allowed a front seat weight of a sizeable pilot. The hang test showed that the difference between single pilot/empty tank and dual pilot/full tank is only 0.1 degree (not a misprint: one tenth [1/10th] of a degree!!). That means that just as in the original Twinstarr there will be no perceivable CG shift between a full tank and an empty tank, with either two pilots or one pilot on board. Another very important feature retained from the original Twinstarr is the location of the thrustline, located to pass as close as possible through the vertical C of G, resulting in a very positively stable aircraft.

Transforming this engine power into useful thrust is the task of the propeller. Following the old Bensen rule of thumb to have half as much thrust as the Maximum All Up Weight (MAUW), we selected a very efficient propeller of French manufacture (DUC Windspoon), designed for the Rotax-912 series of engines.

The "Headgear":

Rotorhead, Blades and Prerotator

Preliminary weighing showed we were in the ballpark. Weight reduction also meant we could use a smaller diameter rotor. We opted for a 8.20 m (27 ft) rotorsystem of French manufacture by Mr Averso, a well-known French gyroplane pioneer. These rotors are made to a very high standard and can be bolted directly onto the hub bar. (See pictures) Forget stringing the blades on assembly, just put in the bolts, tighten to the proper torque and go fly! Anytime I strung those blades to check whether they were aligned correctly showed that there really is no need for stringing anymore. These rotors also impressed us with their lifting capability and smoothness (the well-designed advanced elastomerically-mounted rotorhead from Averso Aviation takes most of the credit for that).

The Twinstarr used an electric prerotator but we wanted more than the usual 120 RPM one could get out of that system. We designed a mechanical prerotator using off-the-shelf available components and double V-belts to cope with the power transmitted. Activated by a cockpit-mounted lever, it weighs less than the electric one and also eliminates the need for a heavy-duty battery.

Finally, a rotor brake is incorporated which can also be used as a parking brake for the rotor.

A Twinstarrlite is Born

After this pregnancy full of adventure, belly-aches and bouts of nausea often caused by "stillborn-predictions" (It'll never fly!) from self-proclaimed "experts", the birth was announced: Empty weight of the new baby is just under 250 Kg (550 lbs) including oil, intercom, radio and transponder. That is almost 200 lbs less than a typical Twinstarr!!!

What this means in everyday terms is that we can take two occupants of the legal weight and full fuel which would give us almost 4 hours endurance (see further).

Empty Weight under 220 Kg (490 lbs) is possible (see further), which would mean two occupants of 93 Kg (205 lbs = well over the legal European defined weight) each and still take full fuel, without exceeding either C of G or Maximum Take Off Weight (MTOW) limits!!!! I think one would be hard pressed to find another two-seat fourstroke-engined gyroplane that matches those figures.

Christening and Namegiving

Not only have we been able to retain the flight characteristics of the original despite shedding a significant amount of weight, but in the process also added the following useful features: powerful prerotator, in-flight adjustable trims, increased range and less vibration (= more comfort). We therefore thought it only fitting to name our newborn Twinstarrlite and on its nose proudly display its "Spirit Of Paducah"-signature in respectful tribute to Don Farrington and his whole crew.

The good got even better, and the "Twinstarrlite" certainly is worthy of its name.

First steps

A typical take-off goes like this: after completing checks, line up, engage prerotator smoothly and let rotors accelerate to about 260 RPM before releasing the differential Cleveland brakes and starting the actual take-off roll. Acceleration is swift and straight, lift-off occurs very shortly thereafter and the machine settles in a 55-60 MPH climb at 700-750 Ft/Min solo. With a 220 lbs passenger on board 500-550 ft/Min is indicated. Not bad on only 78 HP!!! Handling is smooth (stickshake is negligible) and very stable with nicely harmonised controls, replicating the behavior of its bigger brother Twinstarr. Cruise speed is indicated as 55 Mph IAS, but tests have shown there is a position error of the pitot tube resulting in an low IAS. 60-65 Mph CAS is a more realistic figure.

The engine sounds very nice and quiet, singing a pleasant note as it flies along. Fuel burn is less than 15 L/h (4 US Gallons/h). That's right; less than FOUR US Gallons per hour, folks!! With a 60 L (16 US Gal) tank this results in an endurance which almost doubled to 4 hours!! This may be beyond many a bladder range. The Verner burns auto fuel, quite a bit cheaper than avgas. Direct operating cost per hour have fallen to less than half. Indirect costs are also lower because of less frequent oil changes, less expensive maintenance and a lower purchase price. All this

results in more affordable training without sacrificing safety (see the special report from the PRA Board of Directors in Dec 2002/Jan 2003 edition of the PRA magazine Rotorcraft, regarding safety-implications of high training costs).

We can indeed fly more for less money. Not a bad deal if you ask me.

Normal approach is flown at around 55 Mph CAS followed by a soft, smooth and accurate landing with little or no roll-out. The whole machine retains the Twinstarr's comfortable characteristics and solid stability.

The Twinstarrlite made its public debut last year and flew at several gyroplane fly-ins in Europe creating loads of interest, the Wallis Days being the most notable one. Reportedly it was quieter than and out-climbed a well-known two-seater design of almost twice the horsepower. The Twinstarrlite was quieter, too. We think noise will become an increasingly more important issue in the next years, so we addressed that as well.

Don Farrington would have been very proud!!!!

Adolescence Further weight loss

We have now a machine that has an Empty Weight (EW) less than 550 lbs, which is almost 200 lbs less than the original. Weight can be reduced further by using a lighter rotorsystem (e.g. Dragonwings will save another 15 Kg (33 lbs)), lighter wheels (instead of the original Cleveland wheels and brakes suitable for a 2065 Kg (4550 lbs) limit load), no radio or transponder, and the recently released new Verner engine (with integral gearbox) tips the scales at 10 Kg (22 lbs) less than our older version. These combined weight reductions eventually result in an EW of less than 220 Kg (490 lbs). Lighter EW means increased performance and/or more payload. All this without losing any of the strength of the 635 Kg (1400 lbs) AUW of the original structure!!!!!!

The Twinstarrlite is in all probability the lightest practical fourstroke-engined trainer available with good performance and 4 hours cross-country capability in relaxing comfort.

Mobility : Engine/propeller

We have not finalised testing the best engine/prop combination. Other propellers may yield higher cruise speeds and/or higher rates of climb.

Other engine options are: Rotax 912, 912S and even 914 (those albeit at a significantly higher cost and increasingly longer lists of mandatory service bulletins), as well as light Subaru-adaptations (at a slight weight penalty) are among the possibilities.

Direction in life

A nitrogen-pressurised fuselage structure is already being developed, a safety-feature found only on some type-certified aircraft, but very rarely on experimental category aircraft.

TWINSTARRLITE CONT. NEXT PAGE

Teleneop indicators on primary bearings will warn of possible impending failure.

Accurate (and lighter) capacitive fuel indicator, incorporating low fuel level warning light.

These are but a few inexpensive safety-enhancing features that will be incorporated.

What lies ahead ?

Availability, production and manufacture:

Production of the Twinstar-kits ceased about 2 years ago with the untimely demise of Don Farrington who suffered a heart attack.

However, all tooling, production welding jigs and fixtures, fiberglass mouldings, files, fully illustrated construction manual, etc. are all available to rapidly start up kit production again. At \$2000 less (completed with Lycoming O-320 aircraft engine) than a popular side-by-side gyroplane, the rugged Twinstar has always been known for its very high quality-for-money ratio. With the Twinstarlike meeting the European ultralight requirements now also on the scene using an identical airframe and sub-assemblies, two versions could be taken into production almost instantly.

Both Twinstar and Twinstarlike more than likely meet and exceed the stringent British Civil Airworthiness Requirements (section "T") on par with the American Part 23 Standard Category certification rules (which it was designed to meet from the very beginning anyhow!), an important benefit in the near future.

The Twinstar also fits the Light Sport Gyroplane category nicely as a ready-to-fly gyroplane with an AUW of 1200 lbs (545 Kg) (sounds familiar?).

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In addition to the foregoing article, Mr. DeSaar appends the following data for any readers wishing to follow up on his article.

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Specifications :

Dimensions

	Twinstarr	Twinstarrlite
Height	260 cm 102"	270 cm 104"
Storage Height	173 cm 68"	173 cm 68"
Length	397 cm 156"	397 cm 156"
Gear Tread/width	216 cm 85"	216 cm 85"
Rotor Diameter	854 – 914 cm 28 – 30 ft	823 – 854 cm 27 – 28 ft
<i>Weights</i>		
Design Empty Weight	320 Kg 700 Lbs (Typ 740 Lbs)	250 (220) Kg 550 (490) Lbs
Design Gross Weight	545 Kg 1200 Lbs	450 Kg 990 Lbs
Average Useful Load	225 Kg 500 Lbs	215 Kg 475 Lbs
Fuel	60 L 16 US Gal.	60 L 16 US Gal.
Endurance	2 ½ Hours	4 Hours
Range	160 sm	260 sm