Never say never

Not so long ago, if I had asked Frank Robinson whether there would be a turbine-engine powered Robinson helicopter, Frank would have said: "You know, Dick, that turbine engine is just too damned expensive." The phrase 'never say never' comes to mind as I start a pre-flight inspection with Doug Tompkins, Robinson Helicopter Company's chief test pilot, prior to my pilot checkout in a Robinson helicopter with a turbine engine – the Robinson R66.

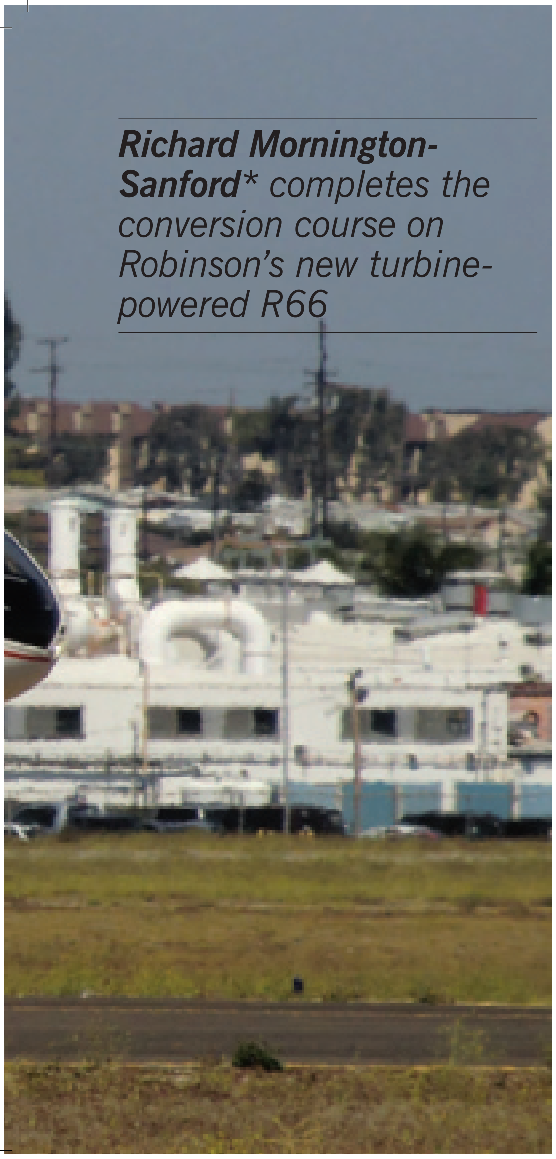
At the end of the pilot checkout, I have to say it's an absolute winner. Easy to start, easy to fly, powerful, fast, benign in autorotation, it's a step change up in safety from the R44, which was itself a major flight safety improvement on the R22 due to its docile handling qualities.

The Robinson R66 helicopter is a five-place (two front, three rear, single main rotor, single turbine engine helicopter constructed primarily of metal with some fibreglass and thermoplastics. The helicopter is equipped with skid type landing gear. The R66 is approximately 8ins higher that its brother, the R44, and has an 8ins wider cabin. Nose to tail it is only one inch longer. The centre rear seat is cosy – choose the smallest passenger. I am 6ft and can sit in the seat without a problem, but you would not want to travel any great distance. One of the biggest problems with the R44 is the lack of baggage space; you could put a 45gal drum in the baggage compartment of the R66, if it would go through the door, so this should no longer be an issue. There is still a small amount of storage space under four of the cabin seats but this is limited due to the special energy-absorbing seat fitted to the R66. Robinson have put a 'water mark' or 'fill line' in each seat compartment, restricting volume.

The two main rotor blades are of all-metal construction, utilising a stainless steel leading edge spar, aluminum skins with a honeycomb core (yes, RHC have fitted aluminum-skinned main rotor blades – the R44 now has them and the R22 will have them). The chord of the R66 is wider than that of the R44, and it has a further one-inch wider chord at the outboard trailing edge, as does the R44 Raven II.

The rotor hub is the same as the R44 – tri-hinge, where the coning and teeter hinge use self lubricating Teflon bearings. The tail rotor has two aluminum all-metal blades attached to a teetering hub with a fixed coning angle, incorporating elastomeric teeter bearings.

A single Rolls-Royce model 250-C300/A1 (commercial designation RR300) free turbine turboshaft engine powers the R66. The engine is mounted at a 37 degree nose-up attitude aft of the baggage compartment. A sprag type overrunning clutch or freewheel unit is splined



Richard Mornington-Sanford completes the conversion course on Robinson's new turbine-powered R66*

directly into the engine power take off shaft. The freewheel unit is connected directly to the main rotor gearbox via a shaft with flexible couplings at each end. A ring and pinion spiral bevel gear set at the main gearbox input reduces engine output speed to tail rotor driveline RPM. A second ring and pinion stage reduces speed from driveline to main rotor RPM.

The main rotor gearbox is pressure-lubricated with several internal oil jets. The oil

Top: heading into the circuit it's clear the R66 has huge power margins
Left: RR300 free turbine turboshaft engine mounted at 37 degrees leaves ample space for luggage beneath
Above: the centre rear seat is cosy
Above right: Richard Mornington Sanford with Frank Robinson and his new turbine helicopter
Top right: Richard lifts off on his first R66 flight from Torrance Airport in California

is pumped via a pump fitted to the main rotor gearbox through an airframe-mounted filter and cooled by an oil cooler, which receives its airflow from the engine cooling fan.

Drive is transmitted directly to the main rotor gearbox. Engine oil cooling is via a 'squirrel cage' cooling fan mounted to the shaft forward of the tail rotor drive shaft, supplying cooling air through the engine oil cooler mounted on the left side of the engine bay.

The R66 has an Engine Monitoring Unit

(EMU) which is a digital recording device. The EMU continuously monitors N1, N2, engine torque and measured gas temperature (MGT). The EMU will record any exceedence of MGT during start, MGT with engine running, N1, N2, torque and start cycles.

When the pilot switches on the battery as part of the pre-flight or pre-start checks, the EMU needs approximately ten seconds to initialise. Once initialisation is complete a continuous light on the annunciator panel indicates normal operation. A slow flashing light, once every two seconds, indicates a fault in the system. A fast flashing light, four times a second, indicates an exceedence. Any exceedence indication should be reviewed by a qualified mechanic prior to flight.

A single starter-generator is used for engine start and electrical power generation with a generator control unit (GCU) controlling the starter/generator functions. During start, the GCU latches the starter on until the N1 reaches 58% RPM, therefore the pilot is not required to hold the starter button down during the start sequence. At 58% N1 the GCU will automatically switch out of the start mode.

The engine igniter is selected via an igniter key switch; when the igniter key is switched to the 'enabled' position, depressing the starter button causes a normal start sequence, with the starter latched on and the igniter active. Above 58% N1 RPM the igniter will become active any time the starter button is pressed but will not latch the starter, thus giving the pilot in-flight starting possibilities. With the igniter key in the off position, the engine can be motored by the starter without the starter latching or the igniter operating.

The R66 pilot is cautioned that the starter button is active when the battery master switch is on, even if the igniter key is in the off position. To disable the starter switch, the pilot needs to apply the rotor brake.

Being a turbine engine, the RPM is controlled by a pneumatic-mechanical governor when the throttle is in the open position. The governor will attempt to maintain 100% engine out-put shaft RPM. The pilot has a bleep switch on the end of the collective lever, giving a bleep range of 5%. Now, for all those people who have asked me the same question for the past 30 years – "Why does Robinson have 104% or 102% indications on the R22 and R44 and not a 100% indication?" Well, thank god there is no need for that question to be asked of the R66. Yes, Robinson has given you 100% – well, 99% to 101% N2 and NR power-on, to be precise, but the pilots bleeps 100% for flight.

Engine anti-ice system is provided, operated by the pilot from a switch in the cockpit. The annunciator panel has a green segment that comes on when the anti-ice system is selected on. As with other turbines, there is a reduction in engine performance as hot air is taken from the compressor discharge area.

The R66 has fundamentally the same flight controls as the well-proven R44 system, hydraulic pressure being supplied by a pump mounted on the main gearbox. The normal operating pressure is the same as the R44, 450 to 500 psi. As per the R44, the hydraulic system requires electrical power to turn the hydraulics off. The system is controlled by a switch on the pilot's cyclic.

Tail rotor controls are also fundamentally the same as the R44, but the pilot will notice that the tail rotor pedals have a full left pedal force applied when in a static situation. This balances the tail rotor control forces in flight.

The engine fuel system is via a single bladder type, crash-resistant fuel cell and supplies fuel flow to the engine under gravity. There is a single fuel contents gauge which derives its signal from a float-type sender, and a low fuel warning segment in the annunciator panel is activated by a low fuel switch in the fuel tank when approximately five gallons of usable fuel remains – approximately ten minutes flight time at MCP. The fuel filler cap is reached via a cowl door on the left side of the airframe, and just aft and below is the single fuel tank drain valve, also reached via a cowl door.

Top: binnacle looks like an R44 but differnces soon become apparent
Top right: Richard Mornington Sanford at the business end of the Robinson R66
Above right: open inspection panels will trigger warning lights on the annunciator panel
Rght: two prototype R66s on the ramp at Torrance airport

Pre-flight

The R66 pre-flight inspection is just a little more comprehensive that the R44 pre-flight. For example, the first area is the 'pilot's station' where among other things you will need to check the annunciator panel lights via a test button. These lights cover: (amber) main rotor chip, tail rotor chip, engine chip, generator, low fuel, fuel filter, low RPM, cowl door, air filter, engine monitoring unit; and (red) main rotor temperature/pressure, engine fire, engine oil; and (Green) anti-ice. On the right side of the R66 fuselage we now have a baggage compartment, therefore we need to check the baggage loading and security and verify that the door is latched – an annunciator panel amber light segment will caution the pilot if the baggage compartment door is not latched correctly.

We have to check the engine air intake filter condition, and there is an engine oil filter bypass indicator to check in the engine bay area. The right side engine bay area is the location of the external power receptor. The tail cone, empennage and tail rotor are similar to the R44.

The left side of the R66 fuselage is a bit more comprehensive than the right side as we have the single fuel cap and fuel tank drain point, a further inspection of the engine air intake, engine, hydraulic and main rotor gearbox oil levels (sight glass visibility is enhanced by the clever use of LED lights which automatically come on when you open the cowl door and are directed to the relevant sight glasses) and the engine and main rotor gearbox oil coolers to inspect.

The main rotor hub and blade assembly are a long way up (approximately eight inches higher than the R44). However, Robinson have given you footsteps in the fuselage to climb up the left side to the point where you can stand on top of the upper step adjacent to the fuel tank filler cap to check this area. The annunciator panel has an amber light segment marked 'cowl door' that will tell you if the baggage compartment, engine oil filter/external power, or fuel filler cowl doors are not correctly latched.

A new caution when you pre-flight the internal cabin area relates to the unique energy absorbing seats of the R66. Robinson has placed a 'water mark' or 'fill line' in the area under the seats and you must not exceed this line if the seat is occupied. The other point to be aware of is that when the seat is doing its job, the air inside the seat must be able to vent as the seat collapses, therefore the seat structure has large vent holes. Don't place items under the seats that could interfere with this process.

Prior to starting the engine there are a few extra actions required compared to the R44, for example; cabin heat (engine bleed air), anti-ice, pitot heat etc. As we now have an external power receptor as standard, it is recommended that the pilot use an external ground power unit to start the engine.

Some of the actions of starting the R66 engine should be very familiar for the pilot who has Robinson time. For example there is an ignition key, now called an 'igniter key' which is selected to the 'enable' position and there is the familiar mixture control, now called a 'fuel cut-off'. The engineers at RHC are famous for coming up with simple and effective ways to resolve pilot-induced problems. So if you happen to be one of the pilots who has never fully understood the meaning of "throttle closed" in the pre-start check list and have started the engine with the throttle somewhere other than the fully closed position, RHC have come to your aid. The R66 has an over-centered spring in the throttle system which imparts a force that will close the throttle for you up to approximately 50% of throttle travel. There is then an area of natural force before the spring imparts a full throttle force. Talk about "keep it simple, keep it light, keep it economical".

Starting the engine is simple. With the fuel cut-off in the off position and the throttle in the closed position, the pilot presses the starter button located on the end of the pilot's collective lever. Having done so, you release it – it is now latched into the starting mode. At between 12% and 15% N1 and with the MGT below 150 deg C, you push the fuel cut-off to the 'on' position. The engine should light off within three seconds. The pilot monitors MGT and engine oil pressure as the engine accelerates and stabilises at 65 to 67% N1. The generator control unit (GCU) will automatically switch out of the start mode and unlatch the starter button at 58% N1. RHC still use the fuel cut-off guard, so this is fitted, ground power is removed if used.

There are a few cautions given that should be observed during the start cycle. Do not push the fuel cut-off to the on position unless you have 12% to 15% N1. If light-off does not occur within three seconds immediately pull the fuel cut-off to the off position. If the MGT reaches the maximum limit, immediately pull the fuel cut-off to the off position as excessive MGT will cause severe engine damage.

The engine start is very much a non-event, very cool (780 deg C MGT during this start), and the starter latching system reduces the pilots workload. There is no sprag clutch check prior to take off as the engine spool-down is too slow to allow for the needle split. The low rotor RPM light is on, so all you have to do is just slightly raise the collective lever to get the low rotor RPM horn to sound. There is a small amount of lag in the throttle system as you accelerate the engine to 100%. There's no bleep range check – just adjust N2/Nr to 100% if required.

In the air

When lifted into the hover the R66 came off the ground front right skid first, giving a nose-up, left skid low hover attitude. There was a slight N2/Nr droop during take-off, but otherwise everything was very stable. As we were light, torque and MGT indications were very low.

The R66 flies very smoothly and just like the R44; the flight controls are very well balanced. It is noticeably quieter in the cabin (I had elected to wear a non-noise cancelling headset to check noise levels).

After a few take-offs and landings we departed. You very quickly come to realise that there is so much power available to the pilot, and that the R66 accelerates remarkably quickly. Due to our reasonably low take-off weight it was just not possible to use MCP, let alone my take-off limit, as it would have resulted in us busting the circuit height.

We flew out over Long Beach harbour to conduct the upper air work. Throughout the manoeuvres one cannot help but be impressed with the R66 power, speed and well balanced flight controls. Up towards Vne there was a small amount of one-per-rev vertical vibration but nothing that could not be removed. The R66 at our weight cruised at 120kts very happily well below MCP.

Back in the circuit I switched off the hydraulic and completed the first landing with a slight run on. The R66 manual flight loads

Robinson R66 specification:

Number of seats	5
Approximate basic weight	1280lbs
Maximum gross weight	2700lbs
Usable fuel capacity	73.6 us/gal (493lbs)
Powerplant:	
Rolls-Royce 250-C300/A1 Type Certificate No E4CE	
Engine ratings:	
Rolls-Royce 5 minute takeoff –	300shp @ 6016rpm
Rolls-Royce continuous –	240shp @ 6016rpm
Robinson 5 minute takeoff rating –	270shp @ 6016rpm
Robinson max continuous rating –	224shp @ 6016rpm
Airspeed Limits:	
Vne up to 3000ft density altitude:	
2200lbs TOGW & above –	130 KIAS
Below 2200lbs TOGW –	140 KIAS
Up to 9000ft density altitude:	
Autorotation –	100 KIAS
For higher altitudes refer to to relevant placard	
Additional airspeed limits:	
65 KIAS maximum above 83% torque (MCP)	
100 KIAS Maximum with any door(s) removed	

This photo: turbine-powered R66 could be mistaken for an R44 from a distance, as long as you didn't hear it
Lower right: Richard Mornington Sanford (wearing tie) with Doug Tompkins and R66 at Torrance

are very similar to those of the R44, so no great problem. The second hydraulic off exercise was to a hover and then a landing. Again, no problems.

Autos next. From the base of the downwind leg I try my first autorotation, Doug has informed me that the entry should be initiated by closing the throttle to prevent an overspeed. Up to this point the R66 has been impressive, but now its shows another area of excellence. When you close the throttle everything happens so slowly… the engine spool-down time is so slow that you can delay putting the lever down for several seconds before the low rotor RPM warning horn and light activate at 95%. The R66 is very benign in auto and it was easy to maintain 100% Nr and 65 to 70 KIAS during the 180 degree turn onto the runway heading. Having experienced the slow engine spool-down time, I informed Doug that I would open the throttle just prior to the flare to give the engine sufficient time to spool back up again. "No, open it prior to the end of the flare," he said. We end up in a power recovery, very nice. This is just another area where the engineering team have come up trumps. They have adjusted the engine fuel scheduling to effect a slow engine spool-down and a fast spool-up time, resulting in the most benign helicopter in autorotation you could wish for. The autos to a touchdown were just as uneventful as you have plenty of main rotor blade inertia, coupled with the small amount of engine torque produced at idle. As the R66 engine was so slow to spool down when the throttle was closed, the FAA made Doug shut the engine down in-flight to check the 'real' intervention time. Same as the R44, Doug said.

Hovering auto next. "A piece of advice, Dick, do not touch the right pedal when you close the throttle."

Now I am suspicious! In all the years I have flown with Doug he usually finds a way to increase my heart rate. Throttle closed, you hear the engine spool down but there is no left yaw and you just have to gently settle the aircraft onto the ground. Even from a greater height a hovering auto proves to be a non-event.

Out of wind take-offs and landings prove to be very similar to the R44. However, there seems to be less of a ground cushion, which makes the landings somewhat easier.

The R66 shut-down procedure includes the standard two-minute engine cool-down and cover the sprag clutch check, otherwise they're very straightforward.

The R44 carried forward the reliability and cost effectiveness of the R22 but was a step change in flight safety due to its docile handling qualities. The R66, in my view, is a

further step change in the same direction. It will undoubtedly find its place in such areas as police, ENG etc, and it will make a superb training platform. I would not be surprised to see it adopted for that purpose by many military and police forces worldwide.

Please note that some things might change slightly prior to the R66 being delivered to the impatient owner.

**Richard Mornington-Sanford is an engineer and helicopter flight instructor, who runs the European Robinson Pilots' Safety Courses in the UK and worldwide. He also conducts the factory approved R22/R44 maintenance courses worldwide. Richard is RHC's UK Accident/Technical investigator. He also runs an EASA Part 147 approved Training Facility, conducting type training on the R22/R44, with Lycoming engine and shortly the R66, with the RR300 engine. You can contact him at richard@flightsafety.co.uk, or see www.morningtonsanfordaviation.com* ■