Des Barker flies the

DIAMOND GUARDIAN DA42 MULTI-PURPOSE PLATFORM

There is no doubt that the technology gap that has traditionally existed between the classic military/civil purpose-built platforms and the generic, smaller commercial airframes, is rapidly diminishing. A "first" in South Africa as a surveillance platform for CK Aerial Surveys, the Diamond DA42 MPP was presented for evaluation in the LIDAR surveillance mission.

WALKING OUT to pre-flight the Diamond DA42 Multi-Purpose Platform (MPP) for a flight test from Lanseria International Airport, near Johannesburg, recently, made for some intriguing viewing and even more interesting comments.

It was clear that this was not your average light general aviation aircraft; a number of unique design features have been included to optimise the performance of the aircraft in the surveillance role.

Hunched over the under-slung LIDAR Pod and letting his imagination run for a while, an observer's comment was heard: "With the bubble canopy and the proboscis nose, it reminds me of a mosquito, no possibly a dragon fly."

Irrespective of the comments, it certainly looked "operational".

LIDAR, a combination of the words "light" and "radar", is essentially remote sensing technology measuring distance by illuminating a target with laser energy and then analysing the reflected energy returns, much the same as radar; basically using laser energy instead of electromagnetic waves as is the case in radar; laser, of course, being more accurate than radio waves.

Raising further interest, a label on the top of the wing adjacent to the refuelling point posted the following: "WARNING: APPROVED FUEL JET A-1", this while staring at the propeller and engines of a non-turboprop?

The two Thielert 2,0-litre Centurion 135 hp engines are gas turbine engines that can be fuelled with either JET A-1 or diesel. Considering the ever decreasing availability of Avgas, this design attribute was an enhancing feature essential for remote operations in which either of the two fuels would, in all likelihood, be available.

Getting into and out of the DA42MPP poses no problems as can be seen above. The systems operator sits behind the pilot with his computer nicely positioned for easy access.

THE AIRCRAFT

At a maximum takeoff weight of 1 785 kgs, the Diamond DA42 MPP is categorised as a light twin-engine aircraft designed as a multi-purpose platform to carry a range of sensors, thereby providing a multi-role surveillance capability.

It is clear that the designers strove to improve performance through the use of composites, in which the fuselage "wetted surface area" was visibly decreased to reduce drag, winglets on the wingtips and the tailplane to improve the aerodynamics and stability and control, a sharpened, multi-purpose "universal nose" and a bubble canopy to provide improved field of view for the surveillance mission.

From a design philosophy of cost effective sensor capability, the team of Diamond Airborne Sensing (subsidiary of Diamond Aircraft) has integrated several different sensor types on the DA42 MPP including RIEGL's state-of-the-art airborne laser scanner LMS-Q680i.

The semi-monocoque fuselage is made of →

ultra-light, high-strength composite materials while the low wing cantilever design integrates outboard aerofoils, an inboard split flap and an outboard plain flap, while the tail section incorporates a T-tail, elevators and rudder.

In an effort to provide docile handling qualities, the Wortmann FX 63-137/20 - W4 aerofoil, the first aerofoil designed to operate at low Reynolds numbers of <1 000 000, was used since it has become the benchmark for this category of aircraft. With a large pitching moment and a relatively thin trailing edge and a maximum thickness of 13,7 % at 29,7 % chord, it generates high lift-to-drag ratios.

The composite wing structure is smooth and seamless in which the structural engineers have used a reliable aerofoil section to generate the lift efficiencies evident in the performance and also the handling of the Diamond. Washout towards the wingtips terminates in a winglet to reduce lift dependent drag and provide symmetrical and relatively docile stall characteristics.

Another enhancing feature is the bubble canopy providing a very wide field of view of approximately 290° – 145° each side in the horizontal and 125° in the vertical which provides for a relatively wide field of view that is ideal for the visual surveillance role and provides a feel of head space and unrestricted view.

To enable operations from remote strips often associated with the surveillance mission, the DA42 aircraft is equipped with a robust hydraulically retractable, single bogey undercarriage.

The DA42 MPP is fitted with a duplicated anti-icing system which protects wings, tail and windshield using anti-icing liquid TKS.

A weeping wing system, also known as a TKS (Tecalemit-Kilfrost-Sheepbridge Stokes) system uses a liquid based on ethylene glycol to coat the wing surface and prevent ice from accumulating. The leading edges of the wings, horizontal and vertical stabiliser are made of porous, laser-drilled titanium panels, through which the fluid is pumped during flight in icing conditions. A “slinger ring” is used to distribute fluid on the propellers, and a spray bar is used to apply fluid to the windshield.

ENGINE

An enhancing feature is the engine power management controls. The two Thielert 2.0 ltr Centurion 135 hp turbocharged, common-rail injected diesel engines drive two MT three-blade constant speed propellers, generating a relatively low 270 hp.

Engine management is essentially via the engine control electronic unit (ECU) which facilitates automatic engine control so that pilots no longer have to manage six levers to control and feather an engine manually and synchronise rpm; in fact, the two engines of DA42 MPP are controlled fully by a single lever for each engine.

Pitch and mixture are automatically controlled allowing the pilot to focus on flying the aircraft. Engine feathering is equally easy. To restart after a simulated engine failure, it is enough to turn the switch on and restart it.

The engines are capable of operating at maximum power without time limit, which, with the ability to climb on single engine at maximum weight, provides a degree of resilience and reassurance for the mission, both during day and night time.

It must be emphasized that this is a light twin, yet single engine performance was demonstrated at 1 700 kgs/7 500 ft pressure altitude/ISA +18°C at Vyse = 82 KIAS which resulted in an absolute ceiling density altitude of 9 530 ft. The manufacturer’s single engine operational flight ceiling for a DA42 without the Lidar Pod is reported to be 10 000 feet.

The DA42 is claimed by Diamond to be environmentally friendly, burning far less fuel than any other aircraft while using jet fuel in a turbo-charged diesel engine which results in low carbon emissions. Most other conventional general aviation aircraft using petrol-based engines burn high leaded fuels at approximately three times the rate that a DA42 burns fuel!

Diamond claims that passenger carbon tax measured in a passenger mile context is the lowest of any aircraft.

AVIONICS, FLIGHT SYSTEMS

The DA42 MPP is provided with the Garmin G1000 integrated avionics system, a fully integrated flight, engine, communication, navigation and surveillance instrumentation system.

The system consists of a primary flight display (PFD), multi-function display (MFD), audio panel, engine sensors and processing unit, and integrated avionics containing VHF communications, VHF navigation, and GPS.

The aircraft is also equipped with Garmin GDC74 integrated digital air data computer, Garmin integrated Mode S transponder, solid-state attitude and heading reference system (AHRS), and dual flight controls to provide the pilot with the capability required to accurately fly the surveillance mission.

The primary function of the PFD is to provide attitude, heading, air data, navigation, and alerting information to the pilot. The primary function of the MFD is to provide engine information, mapping and terrain information and, in conjunction with autopilot GFC700 and Garmin ChartView system, displaying aero navigation maps on a flight data indicator provides the pilot automated navigation capability.

The system is also installed with Garmin SVT (synthetic view technology) incorporated as standard equipment. Throw in TCAS, GPWS, GPS, VOR and DME, the multitude of flight, engine and navigation information available to the pilot is equal to that possessed by the most sophisticated aircraft crossing world airways.

Remembering that the aircraft is designed for single pilot operation, the danger of pilot cognitive saturation exists, but this has been cleverly negated by displaying all required flight and navigation data such as TAS, density altitude, OAT, fuel flow, etc, via digital tapelines and digital displays making it possible for the pilot, in a single glance, to determine aircraft status, thus reducing pilot workload and thereby enhancing safety.

The synthetic vision overlay of the primary flight instruments provides the pilot with a "bird's eye view" for spatial orientation which with a coupled autopilot, TCAS and ground proximity warning, additionally makes available a protective bubble to allow the pilot the luxury of being the system's manager.

AIRBORNE LASER SCANNING

Airborne laser scanning is a rapid, highly accurate and efficient method of capturing 3D 1 Pilotdata of large areas for various applications, for example: city modelling, power line monitoring, large area and flood-plain mapping and even precise digital terrain modelling.

The fidelity and capabilities of airborne sensors has increased exponentially over the last ten years and the ability to generate 3D products is now within easy reach of even the smaller airborne surveillance companies.

The REIGL airborne laser scanning system provides a rapid, highly accurate and efficient method of capturing 3-D data of large areas for various applications.

Up to now airborne service providers had to put a lot of time and work into system integration and data acquisition; a major cost factor of the whole surveying mission – today, it has become "plug and play".

A laser-scanner captures the terrain topography by firing a laser and measuring the time it takes for the laser to be reflected back from a point. The result of the collected measurements is a digital terrain model in the form what is known as a "point cloud".

By merging an ortho-photo with the "point cloud", a precise, realistic 3D model of the object is generated. So what is the principle of operation?

SURVEILLANCE MISSION PROFILE

Critical mission requirements for surveillance aircraft have, and will continue to be, cost effective operations with maximum endurance utilising high technology sensors.

In this specific LIDAR mission, the pilot is usually "hands-on", following the instructions of the backseat operator, monitoring and controlling the aircraft flight path along a designated route, manually making changes to keep the platform level; so, no banked turns, only "flat turns".

This obviously requires harmonised control inputs from aileron and rudder, the amount being a direct function of the directional stability of the aircraft.

A typical surveillance mission using airborne LIDAR could require the aircraft to operate at 100 KIAS and normally at a height between 1 000 to 5 000 ft agl. Under such conditions, the DA42 MPP is flown at relatively low power settings of 45% to 65% which provides endurance from six hours to nine hours.

Once the aircraft is trimmed out, the positive stability enables the precision required to maintain tracks hours on end, that is until, according to the mission pilot, you are forced to land due to a "weak bladder or a sore butt".

FLIGHT TEST PROGRAMME

A "snapshot" of aircraft performance and handling testing was conducted specifically with reference to the surveillance mission and which included takeoff performance, specific excess power tests at 5 500 ft pressure altitude and climb performance testing from 5 500 ft pressure altitude to 7 500 ft pressure altitude.

Stability and control testing included stall testing in cruise, approach and landing configurations;. longitudinal and lateral directional static and dynamic stability testing including Phugoid damping, short period damping, steady heading sideslips, spiral stability and Dutch Roll damping was evaluated. In addition, single engine climb performance was evaluated.

IN-FLIGHT HANDLING

With brake release against full power on Lanseria's runway 07 (26°C/density altitude = 6730 ft/ISA +20°C) and a seven knot crosswind, rotation at 72 KIAS occurred after 24 seconds, lift off at 76 KIAS at 26 seconds which resulted in a ground roll of 540 metres and a total distance of 600 m to cross the 50 ft agl screen height.

To assess the effect of the under-slung pod on the specific excess power of the DA42 MPP, a level acceleration at full power was conducted at 5 500 ft (ISA+20°C) density altitude 7 100ft from 80 KIAS (90 KTAS) to 140 KIAS (156 KTAS). Despite the increased drag from the LIDAR Pod and a relatively low power-to-weight ratio of only 0,15 hp/kg, the aircraft accelerated at an average rate of approximately one knot per second demonstrating adequate excess power at the higher density altitudes typically found in African conditions.

Level cruise performance tests were conducted in an effort to determine typical range performance. An economy of 29,1 nm/gallon at 65%/2 050 rpm/135 KTAS was measured at 7 500 ft pressure altitude (ISA +18°C) which would enable a range of approximately 1 300 nm plus 45 minutes reserve or 10 hours of flight. Pilot fatigue would be the singly most constraining factor to maximising this specific capability.

At 75% power, the performance was equally impressive; a 142 KTAS at fuel flow of 5,3 gph provided a SAR of 26,7 nm/gal. To give substance to this platform/sensor combination performance, the DA42 MPP is able to

BASIC CHARACTERISTICS
Diamond DA42 MPP

Capacity:	1 Pilot + 3 Pax
Length:	8,56 m
Wingspan:	13,42 m
Height:	2,49 m
Wing area:	16,29 m^2
Empty weight:	1 520 kg
Gross weight:	1 785 kg
Maximum speed:	192 kt
Range:	914 nm
Service ceiling:	18 000 ft
Rate of climb:	1 280 (ft/min)

complete an impressive 10-hour survey flight with a range of up to 1 042 nm at an altitude of 10 000 feet and can collect data from areas of 3 400 km² during a single flight.

CLIMB, STALL PERFORMANCE

Climb performance was evaluated at a constant 85 KIAS as per manufacturer's promulgated airspeed at a mid-weight of 1 750 kgs. At an average ISA +20°C for the climb slice through 2 000 ft, the time to climb was 3,40 seconds, providing an average rate of climb of 550 ft/min which was considered acceptable for the surveillance mission.

The stall characteristics were evaluated in the cruise, approach and landing configuration at a mass of approximately 1 740 kg, 40 kg below MAUW. The aircraft was decelerated at approximately one knot/second with stall warning typically six knots higher than the stall speed, buffet onset approximately two knots later and then the uneventful stall.

There was no significant wing roll off, or uncommanded pitch; roll or yaw motion at the stall which was characterised by a wings level "parachute descent" at approximately 400 ft/min. In the cruise configuration a stall speed of 67 KIAS was recorded; in the approach configuration, stall speed was 60 KIAS and in landing configuration, 55 KIAS.

The average height required for recovery was 300 ft. The POH figures for the 1 785 kg mass were: Cruise: 65 KIAS; Approach: 61 KIAS, and landing: 57 KIAS, which was within two knots of the figures recorded on the flight.

STABILITY AND CONTROL

A sample of stability and control tests was conducted in the cruise configuration at a typical mission cruise power setting of 72% at 7 500 ft pressure altitude/115 KIAS (135 KTAS).

In terms of longitudinal stability, the Phugoid period was measured at 35 seconds and the motion damped within three cycles.

As in most conventional statically and dynamically stable aircraft, the short period was essentially deadbeat. This implied satisfactory control and "pointing" ability in pitch, so important in accurate height and pitch attitude control.

As could be expected from this class of aircraft certificated to Part 23 requirements, the Phugoid period of 35 seconds was positively damped while short period damping was nearly aperiodic, that is: approaching 'deadbeat'.

The implications of this in terms of handling and flying qualities was that the aircraft, under those conditions, would be easily controllable in pitch due to predictable response to pilot or atmospheric turbulence input.

The lateral/directional stability was evaluated by means of steady heading sideslips and Dutch Roll damping. To the left, a roll/yaw ratio of 1:1 was measured, and to the right, 1,5:1 was measured.

Dutch roll damping was measured at 2,5 seconds with two cycles to damp. The roll/yaw ratio generated was approximately 1:1 while spiral stability was neutral.

An enhancing feature of the handling characteristics was the tactile feedback from well balanced controls, the control harmony and the predictability of control inputs thereby allowing for predictable response to pilot input.

Assessing the low speed handling qualities in the flapped configurations during approach and landing, the approach was flown at Vref+10 with Vref = 71 KIAS.

The stability and control about all axes was satisfactory and coupled to well harmonised controls and positive speed stability, the landing configuration was stable enabling precise and smooth landings.

MILITARY UTILITY

The military utility of the DA42 has not gone unnoticed by several air forces worldwide. The air forces of Ghana, Niger, Thailand, Swiss Army, Ukraine and the United Kingdom operate DA-42MPPs in the training and surveillance roles.

At least two of those operated by the Royal Air Force were assigned to intelligence, surveillance, target acquisition and reconnaissance (ISTAR) missions by the British MoD. Civil operators operate the DA42 in flight training schools, aerial surveillance and mapping.

CONCLUSIONS

The integration of modern sensor systems on smaller, cost effective general aviation aircraft has changed the surveillance workplace forever, allowing smaller players to enter this challenging environment in which surveillance, monitoring, modelling and simulation are playing a more significant role in modern society than ever before.

With over 500 delivered aircraft operating worldwide, the DA42 is the best selling light twin engine piston aircraft, popular with private pilots and commercial flight training organisations. With its all carbon airframe, ice certification, Garmin G1000 and single lever jet fuel powered turbo-diesel engines, the DA42 is a technology leader in general aviation.

The message is there: the Diamond Austria order book is full until at least 2015. ✈