text by Bob Grimstead, photos by Paul Sadler

Electric Super Parrot

Flying the CT-4F Akala, Raytheon's surprise Air 5428 ace

> "The CT-4F is part of Raytheon Australia's complete modern, integrated 'Evolutionary Military Aircrew Training System', the like of which I (and I suspect most, if not all, of our readers) have never before seen."

For nearly three decades the CT-4 Airtrainer has provided basic training for budding Australian and New Zealand military pilots.

This dark blue CT-4F Akala (the aboriginal word for parrot) is an updated model of that respected trainer which Raytheon unveiled to a surprised industry at Avalon. Yes, the CT-4F has a much bigger engine and a glass cockpit, but this aeroplane is far more than that.

For a start, it is not merely being marketed as a basic trainer, but in conjunction with the Hawker Beechcraft T-6B, several simulators and some superb computer based tuition, it is part of Raytheon Australia's complete modern, integrated 'Evolutionary Military Aircrew Training System', the like of which I (and I suspect most, if not all, of our readers) have never before seen – for more details, see the sidebar. This effort is directed at the ADF's bid for Project Air 5428 to find a new 'Pilot Training System' to replace the current arrangement of contractor operated CT-4Bs and 2FTS operated PC-9/As.

To concentrate on this, the 'Electric Super Parrot', let us first look at the main changes from earlier models. The RAAF's Airtrainers (refer our Airtest of a civil ex-RAAF CT-4A in the Jan/Feb '06 edition of *AA*) had a 210hp (157kW) Continental engine which, while being rather noisy and moderately economical, gave the aeroplane sufficient grunt on a cool day and just about enough power on a hot one. But the aeroplane was never over-powered. Both the later 'E' model (which is in RNZAF service) and this current 'F' version have almost 50 per cent more thrust, now from a beefy 300hp (225kW) Lycoming AEIO-540 that has both fuel injection and a fully inverted oil system, driving a big, three bladed Hartzell constant speed propeller. This is the same monster powerplant as used in the Extra 300L, those Red Bull air racers and Jim LeRoy's Bulldog Pitts (as seen at Avalon), albeit in a slightly lower state of tune (and with a consequent longer life expectancy). The IO-540 is one of the world's most reliable piston engines, and is known throughout the industry to be 'unburstable', even in aerobatic use.

To compensate for this bigger, heavier motor, Pacific Aerospace Corporation (PAC) moved the CT-4's wing forward rather more than two inches (7 cm), but even with that modification, the RNZAF, and particularly the Thais, have discovered that the aeroplane's centre of gravity (C of G) is still a little further forward than ideal.

Enter Jon Wachman, Raytheon Australia's director – pilot training systems. Jon and his team identified a requirement for a less expensive platform into which to install the T-6B's current electronic instrument and navigation systems, to supplement it with a lower cost, more economical initial step in Raytheon Australia's integrated aircrew training system. They wanted a safe, robust, manoeuvrable, tried and trusted two-seat airframe that could not only train military aircrew of all types, but do so right from the start in an environment they would encounter during their active working life. That is, with multifunction displays (MFD), head-up displays (HUD), night vision goggles (NVG), GPS and INS navigation systems, flight management computers (FMS) and all the other electronic kit to which they would soon have to become accustomed.

Raytheon Australia's 'Aircrew Training Systems' team quite rightly reasoned that there is no point whatever in training aircrew in an old fashioned, round dialled, simple, low performance analogue trainer when they will immediately thereafter be flying (or navigating, or operating the weapons of) a combat mission system equipped high performance aircraft, be it fighter, bomber, transport, reconnaissance, helicopter or whatever. This is an opinion shared by the ADF, which talks of training 'Warrior Aviators'.

Today's military aircraft are all electronic, with fully integrated systems. How much better it would be to train students right from the start in a fully electronic cockpit, not only to get them familiar with their future working environments, but also to take advantage of all the additional benefits that come with these systems. And what better mission system installation to use, than the CMC Electronics system currently fitted to Raytheon's preferred advanced turboprop trainer, the Hawker Beechcraft T-6B? (See Drew Searle's April 2007 *AA* article to understand why Raytheon selected the T-6B.)

But all this kit meant extra weight (about 30kg), so Jon needed an airframe that could take all these screens, plus their many associated control panels and electronic boxes *and* the necessary cooling equipment, but without encroaching on its payload or endurance, or adversely affecting its C of G. Jon took on this challenge and looked far and wide, but could find no more perfect vehicle than the venerable and venerated CT-4. Having been originally based on a four-seat airframe (the Victa Aircruiser), and having stood the test of time (during which it has repeatedly proved its manoeuvrability, strength and ruggedness, not to mention its surprisingly good safety record), and even with its bigger, heavier engine, this aeroplane still had excess carrying capacity.

Raytheon's Jon Wachman at the controls of CT-4F VH-XFR.

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A 300hp (225kW) Lycoming AEIO-540 turning a three bladed Hartzell constant speed propeller powers the CT-4F.

(left) The CT-4F's cockpit resembles that of the T-6B Texan II (right) with its three multifunction display screens, a five-in-one backup flight instrument, and the up front control panel making the transition for a student between the two types very easy.

Raytheon Australia's technicians installed the T-6B's three big MFD screens, the smaller standby five-in-one backup flight instrument (BFI), the up front control panel (UFCP), and intercom controls pretty much as they are in the bigger aeroplane, and still had instrument panel space to spare. And the electronic boxes all went into the back of the cockpit, again with space to spare, but better still, with weight left over. Best of all, this equipment pulled the loaded C of G squarely into the centre of its approved envelope.

The current demonstrator airframe was Pacific Aerospace's CT-4E prototype, and has a number of heavy modifications, including under wing hard points, and yet it will carry all this equipment, plus full fuel and two 90kg pilots and still have the capacity left for 15 kilos of baggage, extra charts, ground handling kit or whatever.

With the expected weight reductions of a new build airframe plus the anticipated weight savings of the updated production electronics, and even though there will be more equipment, Raytheon Australia expects to be able to carry this payload plus air conditioning, and still have capacity to spare. That air conditioning is already an option on the CT-4E, and will counter the old Airtrainer's biggest criticism from instructors of an unnecessarily hot cockpit on the ground, while making its already spacious cockpit a truly comfortable working environment. They also intend to refine the aeroplane's seats, ideally by making them adjustable, but certainly through improving the comfort of its upholstery by utilising more modern materials, like conformal foam.

What is more, if extra military equipment needs to be carried, or the optional tip tanks are fitted, the CT-4 airframe has still more capacity if operated in the Utility Category. (It is currently certified in the Aerobatic Category). It seems that the original structural analysis of this airframe (presumably carried out in the old days of slide rules and logarithms) was unduly conservative. With modern computer aided calculations, it has already comfortably absorbed a weight increase from 1112 to 1179kg with no reduction in its +6/-3g strength. Utility Category acceleration limits of +4/-1.7g would allow a significant overload, and still with more than adequate performance.

The always generous fuel tanks give the Akala a maximum range of 520nm.

Jon proved this when he flew this demonstrator across the Tasman Sea at 1300kg, with a ferry tank, life raft, immersion suit, life jacket and all the other safety paraphernalia, plus his own luggage and personal effects. "It went like a dream," he says, "climbing to 10,000ft in less than 15 minutes, and cruising happily at 150kt all day."

The Akala's exterior will be familiar to any Parrot pilot; its wing relocation and longer cowlings being virtually unnoticeable – so that big, three-bladed Hartzell is the main clue to its redesign. The always generous fuel tanks remain the same, so the aeroplane's maximum range drops a little from 700 to a still useful 520nm. Its endurance at 75 per cent power is still more than three and a half hours – long enough, I would suggest, for any training detail.

However, once inside the cockpit, everything except the controls has changed. At the back, under a neat grey cover, are all the electronic boxes. On this civilian demonstrator, the avionics have been limited to a single VHF transceiver, a VOR/ILS, a transponder and an intercom, all of which are integrated. There is also an iPod socket in the centre console, although this might not be fitted in production aircraft. More military specific equipment includes a single mission computer (MC) utilising a 1553 databus, an embedded GPS/INS incorporating a solid state ring laser gyro, and one dual channel air data computer.

A dual channel engine data unit (EDU) feeds the engine display screen.

Production aircraft will have a second communications radio, a radio altimeter, a Tacan with DME, and a traffic advisory system (TAS). This is like an airliner's TCAS, but without the conflict resolution component, since TCAS calls for 'climb' or 'descent' conflict avoidance manoeuvres, and for much of its life this aeroplane might be upside down.

A helmet mounted HUD will be a standard option, since the MC already produces the HUD data. The production aircraft will also have a full IRS, rather than the MC's current embedded GPS/INS, while the GPS and FMS will move into the MC. It will also feature a Mode-S/ADS-B transponder and a forward facing video camera, probably mounted in the vertical stabiliser. In other words, the production version CT-4F will be certified with the all same equipment as the T-6B except the weapons release capability, its fixed HUD, the second MC and the angle of attack indicator.

RAYTHEON AUSTRALIA'S EVOLUTIONARY MILITARY AIRCREW TRAINING SYSTEM

The important thing to understand about the CT-4F is that this is far from being merely a re-engined, higher powered, glass cockpit CT-4 with air conditioning. This new trainer is in fact simply one component of an incredibly well thought out and developed training package offered by Raytheon Australia for the ADF's Air 5428 program (among others).

Raytheon Australia's EMATS (Evolutionary Military Aircrew Training System) includes computer based flight training modelled on a modified version of the USA's T-6 program, a series of simulators and computer based trainers, from the simple laptop compatible level, through procedures trainers to the advanced fixed base full flight kind (provided by Flight Safety). Unlike the propositions of some other tenderers, and as could be seen at Avalon, all this equipment, both hardware and software, already exists.

It was realised that all warplanes have simulators, but there were none for training, so that this would be a more economical way of imparting many techniques and procedures. The idea is to use effective and efficient training so that students will be trained in directly relevant competencies. This should not necessarily reduce airborne time or costs (although of course this is possible) but ought to increase the students' final skill levels.

This ground learning is to be complemented by flying instruction in two aircraft types, this featured Pacific Aerospace CT-4F and the Hawker Beechcraft T-6B Texan II.

The planned high level of commonality in cockpit displays and system controls allows considerable flexibility in the training syllabus and significant cost benefits, since much of the flying training (and, more importantly, most of the systems training) could now be completed on either type. Since practically a whole squadron of CT-4Fs can be purchased for the cost of just three Texans, while CT-4F fuel and maintenance costs are inevitably lower, considerable savings can be achieved without any significant reduction in the quality of training.

Having myself reviewed (and enjoyed) some of Raytheon's computer based training, I can attest to its detail, quality and relevance. Succinct text is combined with simple but high quality graphics, and supplemented by animated video clips utilising both in-cockpit and external views to give a comprehensive overview of each learning step, plus detailed instruction on the successful completion of each task, backed up with brief questionnaires to confirm and reinforce the student's understanding.

Although this course material is currently aligned to the T-6, I can see that some fairly straightforward re-writing and graphics revision would immediately enable it all to be used with the CT-4F, incorporating the ADF's curriculum, standards and instructional techniques. The presentation is so straightforward and yet so comprehensive that I can imagine it would almost be a pleasure, rather than a chore, to learn this way. Because the training syllabus is both modular and flexible, it is clearly possible to fine tune it to the requirements of any particular group of students, and to allow each trainee to take away a disc to study in depth, review completed flight sorties and rehearse a controlled number of future lessons in their own spare time.

To use Raytheon's words, they have developed a system that allows aircrew to "Train like they fight".

The mid grey instrument panel has a simple, quickly understood layout, with an air of military efficiency, heavy with acronyms. It is dominated by the three big 13 by 18cm back-lit liquid crystal (LCD) MFD screens, all of which are compatible with night vision goggles.

Through each screen the pilot can access all and any MC data, but can select two 'active' pages that can be toggled from one to the other, giving six instantly available displays from a total of 10 primary pages, each with multiple sub-pages. Additionally, two newly developed sub-pages are being added, these will have a couple of simple but functional system schematics (probably of the 28 volt electrical and fuel systems) to accustom students to the mass of information that will be available to them on the larger, more complex aircraft for which they are destined.

Each screen has 16 'soft' keys around its perimeter. Soft keys are rectangular buttons which have no set function, but can have a variety of uses depending upon the 'page' selected on the screen, or upon previous button pushes. The 'normal' inflight mode would probably be with the left screen acting as primary flight display (PFD), the one to its right showing the engine indication and crew alerting system display (EICAS) and that on the cockpit's far right selected to the tactical situation display (TSD). In the production fit, this screen is likely to be canted five degrees or so to the left, not to prevent parallax errors, which are never a problem with LCDs, but simply so that it can more easily be viewed and operated by the left seat's occupant (this is usually the seat allocated to the student). However, due to its flexible design, the PFD display may be replaced with a moving map, for example when the pilots are using a helmet mounted HUD.

Rather than confining its artificial horizon to a finite circular panel, this PFD's attitude instrument background fills the upper screen's full breadth, making the aeroplane's attitude instantly apparent. Again mimicking the original layout of the T-6B, the Akala's ASI, altimeter, VSI and G-meter have circular dials – a format I believe to be much better than the more compact (and consequently more common) tape read-outs.

In my experience, when glancing at an EFIS tape airspeed or altitude reading, a pilot has to process the number he (or she) sees and compare it mentally with the required figure before comprehending that they are fast or slow, high or low.

All of the Akala's electronics (left) and the big Lycoming, coupled with the wing being eight centimetres further forward than earlier CT-4 variants, makes for heavier nose wheel steering (right).

The pointer's position around a dial's circumference immediately alerts any pilot to their deviation from the required reading. Nevertheless, either the dial or tape format is already available, should that be more compatible with a student's next operational type. This would allow students on several courses, destined for a variety of different aircraft, to use the same trainers with a quick re-boot before each flight.

The slaved compass (DG) can be displayed as a whole or partial compass rose, with overlaid direction pointers for ADF, VOR, ILS Tacan and GPS. Like the ASI and altimeter bugs and altimeter setting, the heading and course bugs can quickly be changed in several ways, including typing in the required number using the screen's peripheral soft keys.

The EICAS also uses this round dial format, only the fuel quantity being presented in a columnar display that is probably more appropriate for this parameter. One of the many benefits of EICAS is that the 'bingo' fuel figure can be set by the pilot, the fuel remaining columns changing to amber as this figure is reached. The other dials work similarly, the read-out changing to amber or red when an important parameter is exceeded. In the screen's lower portion a number of warnings can be displayed, and these are tied in with the small square warning and caution lights above the central screen, which also trigger audio warning tones.

The TSD equates to a civilian navigation display (ND), with the programmed route, waypoints, target and threats encircled by a compass rose, again optionally overlaid with navigation beacons, and displayed in either heading-up or north-up format. Once more, inputs can be made alternatively through the peripheral soft keys or via the UFCP. This is the primary data entry panel, and has similar functions to a civil FMS mode control panel (MCP) but also doubles as the nav-com selector and MC controller.

The totally independent BFI is a single, smaller screen incorporating an artificial horizon that can be overlaid with ILS or VOR pointers. This is flanked by tape ASI and altimeter readouts and a digital VSI, while below it is a transverse directional gyro heading display. Even a digital VOR course can be displayed on this one versatile instrument.

Production CT-4Fs will feature simulated electronic warfare and self protection training equipment, so that students can become used to operating this kit at an early stage in their training.

Production versions of the CT-4F will also have simulated electronic warfare and self protection training equipment, so that students can become used to operating this kit at an early stage in their training. The electronics' open architecture allows quick modification or updating, to make Raytheon Australia's flexible and integrated mission system 'future proof'.

Flight planning can be completed on the ground using an 'everyday' computer, then uploaded into the aircraft's MC. All in flight data is then recorded, and can subsequently be replayed for post flight review and lesson reinforcement and, being electronic, the whole sortie does not need to be watched – instructors can immediately go to any point in the detail.

All those electronics may be the Akala's brain, but its heart is that big, husky Lycoming, which started promptly, however warm. Unfortunately this heavier engine, coupled with moving the wing's structure nearly eight centimetres further forward, makes its nose noticeably heavier than the original Airtrainer's (because the main gear legs are attached to the fuselage and have not moved) so the nosewheel steering is significantly heavier. A change in nose leg or steering linkage geometry might help, and the pressures are not intolerable, but the Akala's steering seemed unusually heavy.

Jon since told me that this is a 5500 hour airframe that had been used as a prototype for many years, and its steering seems stiffer one way than the other (something I had not noticed).

Thanks to its short wing and that big motor the Akala's top speed at sea level in ISA is actually a little over 160kt.

Apparently, other CT-4Es do not suffer this problem, so either it is airframe specific, or production examples have had the problem solved.

Whatever the reason, any complaints about ground handling are immediately forgotten when you open the throttle for takeoff. That Lycoming roars, giving the aeroplane a sure, steady, inexorable pull forward. Directional control is easy, the all-round visibility is excellent, and we sprinted off the ground in near calm conditions after no more than 200m. PAC's figures say the sea level takeoff run only drops from 224 m to 187m, but the performance difference seems greater than that. Remember, this is at a higher weight, and I don't think any standard CT-4A/B ever truly lifted off in this distance!

Heard from the outside, on takeoff the CT-4F has a more purposeful, but lower pitched growl than its predecessors, with a much less noisy propeller rasp, thanks to its engine's lower maximum rpm and the three blade propeller's reduced diameter.

As briefed by Jon, at 60kt I raised the nose to precisely 12.5 degrees of attitude and it flew off cleanly at 65. Retracting flap at 300ft produced a very slight sink, but no pitch change, so that 12.5 degree attitude remained valid to 3000ft, during which the VSI indicated a steady 1700ft/min. Here we pitched down a little, to nine degrees nose up, before throttling back to a climb power of 25 inches and 2500rpm until the 5500ft full throttle height. Continuing the climb at 90kt to 10,000ft, all at nine degrees nose up, got us there in less than 10 minutes. Instructors will love this, for that gives them ample opportunity for a comprehensive briefing, but with very little wasted time.

The power loading drop (from 11.43 lb/hp to 8.67 lb/hp) produces a very noticeable performance improvement – more than those numbers might suggest at a glance, since any aeroplane's climb rate is relative to the *excess* power available over that required to maintain level flight at the same airspeed. To me, it felt much greater than the 1350 to 1830ft/min book figure increase. The A model Airtrainer I flew last year climbed at only 800ft/min, which I would suspect to be closer to a true service example's performance. Since this CT-4F prototype's engine already has several hundreds of hours on its clock, I feel a direct comparison of its timed 1750ft/min climb would be appropriate. In other words, it performs *twice as well* as its forerunner.

The Akala's large EFIS horizon allows it to be flown by attitude like its big brother the T-6B, so to level off I merely lowered the nose to half a degree above the horizon line and reduced the power to 2300rpm. Our airspeed crept up to 130kt indicated, which equated to nearly 150kt TAS. Thanks to its short wing and that big motor the zippy Akala's top speed at sea level in ISA is actually a little over 160kt, and these comparatively high speeds (for a piston trainer) will ideally suit students going on to helicopters, while giving the fixed-wing types good preparation for the T-6B's 250 to 270kt cruise speed.

The wing loading increase (from 18.6 lb/sq ft to 20.15 lb/sq ft) also puts the Akala's closer to the T-6B's (37 lb/sq ft), and gives it a noticeably smoother ride through turbulence than the old Parrot, and makes it closer in feel to military turbine machines. The tail's increased moment arm (due to the wing's move forward) combined with the heavier engine gives the CT-4F slightly more pitch and yaw stability than its forebears.

Because of this big Lycoming's increased power and torque, the rudder has to be used rather more than on older CT-4s, making that low geared electric rudder trim button atop the control column even more useful than before. Again, this coolie-hat trim button will help prepare helo pilots for their next mount.

Despite its greater weight, the Akala remains very manoeuvrable, and its big engine gives it an aerobatic capability significantly better than its A and B model Airtrainer predecessors, as anybody watching Jon's performance at Avalon could see. It is now quite possible to fly a comprehensive sportsman level routine at 5000ft without any loss

PAC CT-4F AKALA
Technical specs

Powerplant
One normally-aspirated, fuel-injected, six-cylinder, horizontally-opposed Lycoming AEIO-540-L1B5, producing 300 hp at 2700rpm. TBO 2000hrs. Propeller: Three bladed, 193cm diameter, all metal, constant speed Hartzell HC-C3YF-4BF.

Performance
(Manufacturer's quoted)
SL Vne 207kt
Max speed (MSL) 163kt
75% cruise (8500ft) 152kt
Economy cruise 118kt
Stall, full flap 44kt
SL takeoff run 187m
SL landing dist 335m
SL landing run 169m
SL climb rate 1830ft/min
Service ceiling 18,200ft
75% power, empty tanks range 520nm

Weights
Equipped empty 862kg
Max takeoff 1179kg
Max baggage 77kg
Standard fuel 204 lit
Load factors +6.0/-3.0 g

Dimensions
Wing span 7.92m
Wing area 11.98m^2
Length 7.16m
Height 2.59m
Cabin length 274cm
width 103cm
height 134cm

Manufacturer
Pacific Aerospace, www.aerospace.co.nz.
Raytheon Integrated Military Training System, email: jwachman@raytheon.com.au

The Akala's light and nimble airframe, great control authority, completely unhindered visibility and good stability make formation flying in the type a breeze.

of height. Most manoeuvres are started from between 150 and 170kt (although Jon's vertical roll starts at 190), and its high Vne of 207 knots with a 150kt Va give the aeroplane good margins. I have to admit that, at these speeds, I found its controls a mite heavy for my taste, but not unduly so.

As a formation mount, I do not think I have ever encountered its superior. With a light and nimble airframe, great control authority (except perhaps in yaw, which is a tiny bit lacking), brilliant, completely unhindered visibility, and good stability, coupled with the immediate acceleration and instant deceleration from that powerful engine and broad, three bladed propeller, it is possible to place the aeroplane within an inch of its required position and hold it there easily and with great precision, both in straight and level flight and throughout prolonged turns. Paul Sadler's accompanying photos are testimony to the ease of formating with the Akala, since it was my first acquaintance with this very capable machine.

I think it would also be a good mount for military low level work. Law abiding civvie pilots like myself don't get much exposure to this stuff, but I have enough experience to know that these crisp controls, the great forward visibility and the precision of the Akala's electronic navigation equipment will combine to make it a perfect first introduction to this arena. For future rotary pilots it will be all they need, since its 150kt plus top speed is as fast as they will likely fly nap of the earth ops.

The machine's broad speed range enables it to fly a comfortable ILS at 120kt, a speed at which Jon told me it was good and stable, and fast enough not to get in the way of the big boys.

According to PAC's figures, the CT-4F's sea level landing distance over a 50ft obstacle drops from 335 m to 244m, although the actual ground run increases from 155m to 169m, which is understandable, since this is a heavier airframe. I had little chance to validate these figures, since my first landing was in formation and my second had to be continued to a runway intersection. I can say though that, providing the approach speed of 75kt is maintained, slowing to seventy at the threshold, and being careful not to reduce power until the flare has been completed, it is an easy aeroplane to land gently after a brief float, with light control forces if trimmed properly, and precise control right the way to touchdown.

The Akala is something of a Tardis. A two-seat basic trainer on the outside, its wide cockpit and big, bubble canopy give it bags of room inside, even if the occupants' helmets are burdened with HUDs and NVGs. Its cockpit is crisply modern, and capable of continuous updating. Future instructors will love its spaciousness, the cool cockpit and its ample power. No longer will a posting to CT-4s feel like a two year sentence. For many future instructors, this tour will seem more like a long holiday!

Jon is proud that not only could his daughter learn military flying with Raytheon Australia's revolutionary integrated training system, and using this capable trans-Tasman aeroplane, but that thanks to the facility for both the CT-4F and the T-6B's avionics to be continuously updated and improved, his grandchildren could benefit from it too. ❏