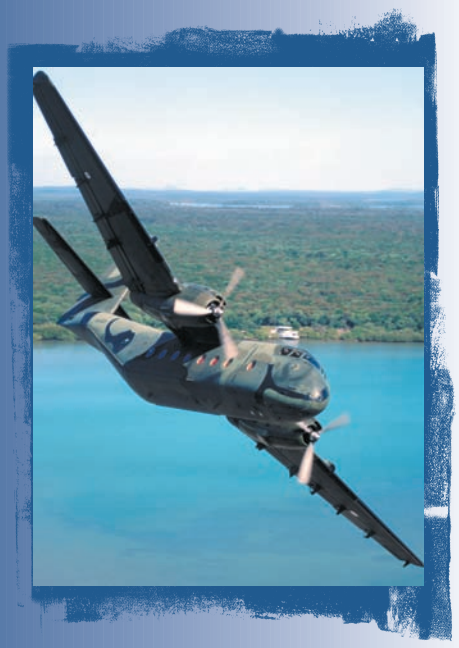


# Replacing the Caribou:

## the Tango Charlie option

John Armstrong

*The previous issue of DefenceToday explored the difficulties in finding a viable replacement for the RAAF's versatile DHC-4 Caribou light tactical airlifter, which served with distinction in the Vietnam War and has proven to be an exceptionally flexible asset ever since: serving in Kashmir, Cambodia, Irian Jaya, Namibia, Bougainville, PNG, East Timor, and most recently in the Solomon Islands. One option that has not received close attention is to re-engine the Caribou with a turboprop type, thereby extending the aircraft's service life considerably. This article addresses that cost-effective option.*

### The unique Caribou

Why then is the Caribou so valuable to the ADF as a tactical airlifter and why is finding and funding a replacement such a dilemma?

What makes the Caribou unique is its short and soft field landing and takeoff (STOL) performance, which has not been matched by any design of a comparable aircraft since the aircraft came into service in the 1960s. The only realistic equivalent today is the vastly more expensive Bell/Boeing MV-22 Osprey tilt rotor, an aircraft that remains bedeviled by immaturity and ongoing political arguments over funding for the US armed forces. All other alternatives, even if exceeding the modest payload/range performance of the Caribou, fall short in that all-important Caribou role – operations from short, unprepared runways.

Losing this capability is not desirable. US forces learned the hard way in Afghanistan and Iraq that using heavy/medium lift helicopters for this niche airlift role is expensive – so expensive that last year a debate emerged in Washington on whether alternatives existed to 'burning out' helicopter fleets. Suffice to say – with the Caribou and its offspring, the Buffalo, both out of production for decades – the US will continue burning hours on its CH-46, CH-47 and CH-53s.

In addition to its tactical military importance, a key role for Caribou continues to be 'support in our region of interest' and national support tasking such as natural disaster relief.

A less obvious but important role for the Caribou is its value as a training platform, used by Army's paratroopers, and air despatch operators – and for RAAF tactical lift qualified commanders, later to progress to the C-130, and for qualified flight instructors (QFIs) and test pilots. The high workload and demand for cockpit coordination inherent in a small airlifter provides valuable experience for developing pilots (Caribou pilots achieve Captain status well before other type operators) and the RAAF experience in these competencies bears this out.

The strategic 'big picture' is sobering. Australia will continue to be engaged in peace enforcement, peace keeping and likely counter-insurgency campaigns globally, with the ongoing turmoil in the Islamic world and 'arc of instability' in the Pacific Rim, all demanding precisely the type of capability the Caribou provides. Yet the RAAF also faces its biggest challenge for decades with the need to recapitalise its fighter, tanker and maritime patrol fleets, and introduce the Wedgetail AEW&C platform over the coming decade.

A low cost option to extend the service life of the Caribou therefore has much to offer, both in terms of retaining a valuable capability and in not adding significantly to budgetary pressures.

# State of the Caribou

The Caribou is a design that predates the era of computer-aided design and modern fabrication techniques. Its structural design and construction compare best to the ubiquitous C-47/R-4D/DC-3 and it is, in the simplest of terms, rugged, simple and durable – maintainable using the same techniques as general aviation types.

A RAAF sponsored study of the structural life of the Caribou assessed that the airframe is capable of being operated to 2020 and beyond, or more, providing some investment is made in corrosion control and structural refitting of key but simple components.

The principal obstacle to extending the service life of the Caribou is the age and sustainability of the Pratt & Whitney R2000 powerplant, a technological artifact of the 1940s. While the R2000 was a robust design, it has been out of production for decades and is now maintained using mostly refurbished components. An Avgas-burning radial piston, the R2000 is the only piston engine remaining in ADF service and requires retention of a unique and costly fuel distribution and replenishment infrastructure. The Caribou was not deployed in support of the Aceh Tsunami relief effort (Operation Sumatra Assist) because Avgas was not available on site.

Much of the downtime and most of the maintenance bill on the Caribou fleet is a result of problems with the R2000 and related power plant system. These include failures in the antiquated electrical system, engine components, oil leaks, overboosts, over heating, damage from thermal shock – with many resulting in in-flight loss of power and shut downs (the aggregate being known as the IFSD rate) and power plant shutdowns on the ground during maintenance and ground handling. In the civil aviation community, the number of engine problems on the ground are also considered when determining the IFSD rate.

Remedial measures to deal with the obsolescence of the R2000 have been quite expensive and not particularly successful. In 2001, Air Project 5190 Phase 1A, termed “the recovery program for the Caribou” had a stated budget of between $100m to $150m “in addition to the existing operating budget to help arrest declining aircraft availability levels”. Surprisingly, this phase (and funding level) did “not include any provisions for revised engine solutions”. This year, the Caribou fleet will fall well short of its planned flying rate of 5,080. Independent analyses in 2001/02 predicted a shortfall of some 15% to 20% but the achieved flying rate could be lower (around the 3,600 hour mark, or only 70% of ROE).

Operating cost, aircraft availability and reliability problems aside, flight safety is now emerging as a major issue. With the unreliable condition of the R2000s, full payload and fuel, there is the potential for an engine-out scenario arising where the remaining R2000 cannot sustain the required power rating, resulting in the potential for loss of the aircraft. An independent analysis last year predicted an IFSD rate generally considered to be above the maximum acceptable for civil aviation operations.

The only realistic remedy to the R2000 problems is replacement with a modern turboprop engine. This would lead to a five to ten-fold increase in the Time Between Overhauls (TBO) along with a number of other important benefits, not least being the removal of Avgas and its support infrastructure from the ADF. The savings in logistics costs would be significant.

# The Tango Charlie Upgrade

To re-engine the Caribou is not a new idea, and follows the rationale of the S-2T and other successful piston-to-turboprop conversions. Several proposals were put to the Department, with the most detailed and credible submitted by Hawker de Havilland (circa 1988). None of these materialised mainly because there was no existing design or flying prototype.

In 1999, Australian Flight Test Services, an Adelaide based flight test and design contractor, proposed a recovery program, jointly with Pen Turbo Aviation in New Jersey,and an Australian Industry team, under an unsolicited industry proposal called ‘Project Tango Charlie’. Tango Charlie is an adaptation of Pen Turbo’s DHC-4T 'Turbo Caribou' upgrade with the Pratt & Whitney, Canada, PT6A-67T turboprop, first flown in 1996. Since then the prototype N600NC has accrued more than 500 flight hours.

The Tango Charlie proposal is unique as it was based on an existing, proven, flight-tested and certificated conversion design, and would not incur risks associated with a new design. It also included other improvements resulting in the Caribou’s utility and value increasing markedly.

Pen Turbo's design focused on reliability, maintainability, affordability and mitigation of risk. Unlike many re-engine programs, the Turbo Caribou maintained the power rating of the R2000 engines, with the PT6A-67T an exact fit to the existing nominal power ratings. In practice, however, the operational R2000s no longer deliver the ratings of new engines, so the Turbo Caribou would deliver slightly better performance than newly manufactured R2000s.

The PT6A is a mature engine, with more than 215 million operational hours on 34,000 units produced since 1963.

Choosing an engine with an identical power rating and thrust line would significantly reduce risks and design effort required in development and the flight test effort. There would be no need to update the structural design, or expand the aerodynamic envelope.

The core of the upgrade is a new forward engine nacelle design with the PT6A-67T powerplant, a five-bladed Hartzell HC-B5MA-3M/M11691NK all-metal propeller, and new set of engine instruments and controls. The nacelle internal structure supports the engine, mounts the inlet and inlet duct, and provides supports for the dual exhaust ducts from the engine routed to an overwing position at the aft of the nacelle. Flush auxiliary inlets and exhaust vents for nacelle cooling airflow are located at the bottom of the nacelle. The stainless steel nacelle structure is built around a robust tubular steel engine mount with two additional hard points on to the aircraft firewall and composites are used for the cowling and main gear fairings.

The new engine ball bearing cable system controls the engine power, propeller and condition with prop sync and torque limiter functions included. A modular instrument display is used, with analogue and digital readouts.

The PT6A-67T has a takeoff rating of 1420 SHP with an emergency rating of 1560 SHP and a max cruise rating of 1200 SHP, with an achievable TBO of around 6000 hours. The Hartzell prop is a more modern design, with a higher disk loading than the legacy prop. It is rated for a 1600 SHP engine, providing a robust margin in deliverable thrust over the service life of the prop. The five-bladed (as opposed to three) smaller diameter propeller is better suited to operations on unprepared runways, and the smaller thrust cone means less prop wash impingement and, therefore, lesser stresses on the tailplane.

*R2000 engine installation on RAAF Caribou showing the large, 13-foot diameter, 3-bladed propeller and enormous bulk of the R2000 radial piston engine.*

*Pen Turbo modified "Turbo Caribou", N600NC, flying off Cape May, New Jersey in the USA. The aircraft has accumulated over 500 flying hours. Completed a function and reliability trip in June 2000 - over 7,000 nm flown in 51.4 hours; average fuel consumption - 910 lbs/hr; total oil consumption - 1.5 qts per engine; no discrepancies; only tooling used - "a screwdriver to service fuel and oil". (Pen Turbo)*

In terms of performance capabilities, the Turbo Caribou upgrade results in a 30% increase in maximum payload capability as a result of the new prop and sustained engine power rating, and a greater than 60% improvement in payload/range against the R2000-powered Caribou.

The additional thrust margin provided by the PT6A/Hartzell prop, coupled with the long standing demonstration of very high reliability by the PT6A engine, results in a significant safety improvement in Short Take Off & Landing (STOL) operations and increased aircrew confidence in engine performance in this role.

The new powerplants also produce a 10% increase in cruise speed and 30% reduction in time to climb to cruising altitude, while permitting a higher cruise altitude. While these gains clearly add to airlift productivity, they also produce an important survivability benefit. When operating in global hotspots the higher cruise altitude reduces the engagement envelope and exposure time to shoulder-launched SAMs (MANPADS) and RPGs, both of which contributed to helicopter and aircraft losses in Afghanistan and Iraq. The design of the Turbo Caribou exhaust system would also accommodate an exhaust infrared suppressor.

Other benefits also accrue from the Turbo Caribou retrofit. The first is significantly increased availability for operations, as the PT6A is more reliable than the R2000 and requires less scheduled maintenance. With finite resources in maintenance personnel, this allows higher availability without the cost penalty of increasing maintenance personnel numbers. As the PT6A series also powers the Pilatus PC9/A flown by 2FTS and CFS, the pool of RAAF maintenance personnel qualified on the engine is significantly greater. This commonality in support extends further, as the PT6A is widely flown by commercial operators, and, thus, far easier to support in Australia and globally. Deployability is therefore improved, further enhanced by fuel commonality with other turbine powered types. Not only is the Turbo Caribou more survivable in theatre, it is also easier to deploy and operate in such conditions.

The budgetary benefits that would flow from the adoption of the Turbo Caribou upgrade for the RAAF's Caribou fleet are considerable, and in many areas. According to industry sources, savings against current operating costs for the R2000 powered Caribou are expected to be in the order of $A1M per month on the current cost of operating the RAAF Caribou, with the potential for whole of economy savings of $A2.5M per month (or AUD$300M over 10 years). Deferring the replacement of the Caribou with a new type would also push the current $A1 billion of replacement costs in the DCP outside the critical 2010-2020 budgetary window, allowing these funds to be used for other critical purposes.

Analysis performed by AFTS back in 2000 indicates that a retrofit of the full RAAF fleet would be revenue neutral against current operating costs within a 5 to 8 year timeframe, subject to annual R2000 and fuel infrastructure operating and maintenance costs.

## Implementing the Turbo Caribou Conversion

The Turbo Caribou is a mature project, with hundreds of hours of accrued time on the prototype, and impressive reliability and availability statistics to date. This success is due to merging a mature and robust airframe with a mature and modern engine and propeller.

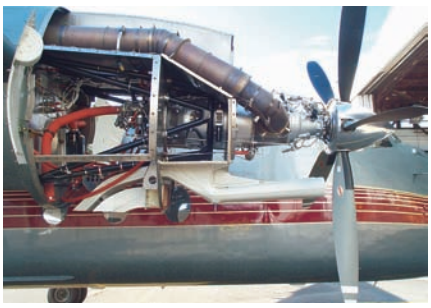
With nine years elapsed since the prototype first flew, and Transport Canada and FAA Supplemental Type Certifications achieved on the design since then, implementing the Turbo Caribou upgrade would be a very low risk proposition.

The implementation model originally proposed is still applicable today: an Integrated Product Team, comprising a group of Australian contractors and Pen Turbo in the United States along with an IV&V/T&E capability assuring the Commonwealth's needs. A Private Finance Initiative (PFI) or 'power by the hour' is still an attractive option, but not the sole funding strategy available.

Much of the conversion kits would, subject to agreement with Pen Turbo, be manufactured in Australia, with engines, propellers and some other major items more economically produced and sourced from the US. The Caribou fleet would then be progressively cycled through a nominated depot where the retrofit and associated engineering tasks would be performed. The expected time in depot for each aircraft would be three months, subject to production economics. The fleet of 14 aircraft could be retrofitted over a 30-month period.

With a fleet of Turbo Caribous the effective strength of No 38 Squadron would be increased by over 25% as the achievable 96% availability would permit a significantly higher flying rate and rate of sortie completion against that currently being achieved by the legacy R2000-powered fleet. Should more Caribous be sought, refurbished aircraft modified to the Turbo Caribou configuration would be a credible option. With several refurbished Caribous used for the initial in-country conversions, there would be no loss of aircraft availability at the outset of any conversion program.

*Top view of turbine installation showing nacelle details, relative reduction in size compared with R2000 radial piston engine and ease of access for maintenance of installation.*

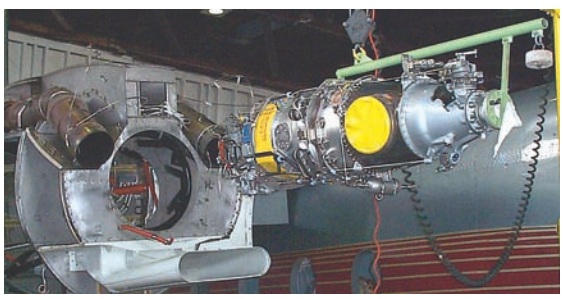


*Side on view of turbine installation showing air intake, plenum and exhaust details as well as the engine mount and spaciousness of the engine bay.*

## Summary

The reality for Defence over the next decade seems destined to be constrained budgets resulting from large scale recapitalisation of much of the RAAF fleet along with sustained pressures to provide airlift support of Coalition operations, regional stabilisation and relief operations. These are unavoidable facts of life Australia must confront.

The Turbo Caribou proposal offers an opportunity to retain and enhance a vital existing capability through this difficult period, with revenue-neutral expenditures, taking into account existing Caribou fleet operating costs.



*Close up of engine change in progress taking less than one third of the time, tooling and manpower required to change an R2000 radial piston engine. (Photos: Pen Turbo)*