

# The potential use of military tiltrotor aircraft for aeromedical evacuation

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THE AUSTRALIAN DEFENCE FORCE defines three categories of aeromedical evacuation (AME):

1. Forward AME, which is the airlift of casualties between points on the battlefield (to or between treatment facilities in the combat zone or between points in the maritime area of operations).
2. Tactical AME, which is the airlift of patients from the combat zone to points in the communications zone (the theatre of operations behind but continuous with the combat zone, containing lines of communication, establishments for supply and evacuation and other agencies required for immediate support of the field force).
3. Strategic AME, which is the airlift of patients from the communications zone to points outside the communications zone, or between points within the support area.<sup>1</sup>

Additional varieties of AME include peace-time missions as part of Australia's humanitarian military aid to the civilian community and "opportunity" AME, when any suitable available ADF aircraft is used to transport patients for reasons of convenience rather than because of clinical need.

Military AME is popularly but erroneously supposed to predate the aeroplane. The claim that besieged Parisian forces used balloons to transfer 166 casualties beyond the enemy's lines in the Franco-Prussian War can be dismissed as romantic fiction.<sup>2</sup> However, an experimental military air ambulance was developed by two US Army officers at Fort Barancas, Florida, in 1910.<sup>3</sup> France produced the first aircraft designed for AME (the Dorand AR II) in 1917, which was used for evacuation of wounded military personnel from

## Synopsis

- ◆ The ADF's contingency planning anticipates the need to be prepared to move military casualties over great continental or international distances.
- ◆ The RAAF's C-130 Hercules is the only aircraft routinely tasked for aeromedical evacuation, although the Australian Army and Navy both use helicopters as required for this purpose.
- ◆ Tiltrotor aircraft combine advantages of helicopter (vertical takeoff) and fixed-wing aircraft (high cruise speed and large passenger load) that may make them useful for aeromedical evacuation.
- ◆ Current military tiltrotor aircraft are expensive and lack the range required for Australia's strategic aeromedical evacuation purposes, but future developments may make them a desirable alternative to the use of helicopter and fixed-wing aircraft.

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Flanders in the following year.<sup>3</sup> World War II brought major technical developments in AME and saw the US forces transport more than 1 300 000 patients during their involvement in those hostilities, including a record number of 4707 on a single day, while sustaining fewer than 60 in-flight deaths among all the patients so carried.<sup>3</sup>

The RAAF used C-47 aircraft for AME during World War II and the Korean conflict, but its proficiency and expertise in long-range AME may fairly be dated from its introduction of C-130 medevac aircraft and its deployment of specialised Permanent Air Force/Reservist teams of surgeons, anaesthetists and nursing officers during the Vietnam War. RAAF AME teams then flew several hundred missions, recovering more than 3500 casualties from South Vietnam to Australia without any recorded deaths in flight. All these strategic AME missions were staged through Butterworth Air Force Base in Malaysia. Today the RAAF retains principal responsibility for the ADF's strategic AME requirements.

Aeromedical evacuation will not benefit all patients and may involve excessive risks to patients, AME teams and operating aircrews in some circumstances.<sup>4</sup> Nonetheless, AME is generally superior to other means of retrieval of



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battle casualties as it provides rapid transfer to definitive or interim medical care facilities.

Since 1949, air transportation has been the primary method of moving patients over long distances used by the armed services of the United States. For this reason the US Air Force (USAF) maintains a standing, worldwide AME capability based on a dedicated fleet of C-9 Nightingale aircraft. These aircraft undertake virtually all domestic AME missions and some international tasks required by the US military forces. The USAF also undertakes many international AME missions using non-dedicated but specifically tasked C-141 Starlifter aircraft. The USAF designates the Nightingale and Starlifter as its usual and strategic AME carriers because these aircraft can carry large numbers of patients and their required attendants and operate at passenger jet speeds over extremely long distances.

Given this standing, specialised capability, the USAF deems aircraft such as the smaller C-130 Hercules to be suitable only for tactical or opportunity AME missions.

## Aeromedical evacuation in the ADF

The ADF's size and its AME capabilities are more modest than those of the USAF, but the ADF anticipates the need to move battle casualties over great continental or international distances, and this dictates an extensive reliance on AME. Although all ADF aircraft types are formally assessed and technically documented for their potential use in AME, the principal vehicles used for this purpose are the C-130 and Caribou (RAAF fixed wing aircraft) and Black Hawk and Chinook (Australian Army rotary wing aircraft). The RAAF's C-130 is the only aircraft routinely tasked for strategic AME missions.

While the Royal Australian Navy (RAN) also uses several varieties of rotary wing aircraft for AME work, these are not further considered in this article. For practical purposes, the Army's Black Hawk may be considered as a reasonable proxy for the capabilities of the RAN's helicopters.

Lacking dedicated AME aircraft, the ADF relies on the appropriate configurability of operational cargo/troop transport aircraft that can be tasked for AME missions. For military planning purposes, an important consideration in AME capability is the possession and ready deployment of sufficient aircraft to airlift anticipated casualties in any foreseen conflict.

The ADF's health service planners accept the need for trade-offs between the treatment of casualties close to the scene of wounding and the ability to provide immediate airlift for large numbers of casualties to definitive care facilities in the communications zone. Pragmatically, this is necessary because of the ADF's small numbers of suitable AME aircraft and specialised AME teams.

In future when the ADF acquires aircraft that are

expected to be used in AME, all aircraft under consideration should be comprehensively assessed for their suitability in that role, even though this is unlikely to be the principal selection criterion. Fortunately, designers of modern military transport aircraft invariably incorporate some readiness for AME fit-out in their designs. In consequence, any military transport aircraft acquired by the ADF in future may confidently be expected to surpass the performance of our present aircraft in AME, both in comfort and safety for patients and workplace convenience for their medical and nursing attendants.

## Tiltrotor aircraft

A "tiltrotor" is a unique type of aircraft which can fly fast and efficiently in forward flight like a turboprop [aeroplane] and also takeoff, hover, and land vertically like a conventional helicopter.

A tiltrotor has a wing with lift/propulsive proprotors at each wing tip. These proprotors are designed with a high degree of twist and careful aerodynamic design to function effectively both as propellers and as rotors. The proprotors, along with their engines and reduction gearboxes, are typically mounted in wingtip nacelles which rotate from a horizontal position ([aeroplane] or cruise mode) to the vertical (helicopter or hover mode).

In helicopter mode, the proprotors provide all lift and attitude control. Required engine power is highest when hovering. As the aircraft converts to [aeroplane] mode, power and thrust are reduced as the wing takes on more of the lift. As a result, the tiltrotor can achieve very efficient cruise performance.<sup>7</sup>

Australia has no present plans to augment its military air fleet with tiltrotor aircraft. The technology and capabilities of these aircraft are little known to most members of the ADF, except perhaps to fans of novelist Dale Brown.<sup>6</sup>

Tiltrotor aircraft have the potential to provide high-speed, long-distance AME without requiring a landing runway, raising the possibility of transporting patients from the combat zone to distant medical facilities without changing transport platforms. Although several European consortia are exploring development of commercial tiltrotor aircraft, none of these is likely to produce even a prototype for at least another five years, with any possible military derivatives still further delayed.<sup>8</sup> At present, and for the next decade, the Bell Boeing V-22 Osprey will be the only in-service military tiltrotor aircraft which is of suitable size for AME use (Box 1).

Deliveries of the aircraft to operational squadrons of the US military forces are scheduled from 2001, with 425 MV-22s ordered by the US Marine Corps (USMC), 50 CV-22s ordered by the USAF and 48 HV-22s required by the US Navy (USN). While the primary specified missions of the several models are combat assault and assault support (MV-

## I The V-22 Osprey



### Characteristics

Fuselage length	17.47 m		
Maximum width (rotors turning)	25.78 m		
Height (to spinner, helicopter mode)	6.73 m		
Folded length	19.2 m		
Folded width	5.61 m		
Folded height	5.51 m		
Rotor diameter	11.61 m		
Power	4586 kW		
Empty weight	15 032 kg		
Maximum vertical takeoff weight	23 982 kg		
Maximum short takeoff weight	25 855 kg		
Self-deployment weight	27 443 kg		
		Maximum fuel capacity (with wing and sponson tanks)	7710 L/6286 kg
		Cabin length x width x height	7.37x1.83x1.83 m
		Cabin provisions	24 troop or 12 litters, 4 attendants
		Rescue hoist capacity	272 kg
		Cargo floor limit	1465 kg/m <sup>2</sup>
		Cruise speed	510 km/h
		Maximum speed	565 km/h

22), long range special operations (CV-22) and special warfare / fleet logistic support (HV-22), generic AME configurability has been designed into the MV-22 and CV-22 versions. Although the final configuration of the HV-22 has not yet been determined, it appears likely that all variants will be capable of AME as a secondary mission.

Since the Osprey aircraft is the only AME-capable military tiltrotor aircraft now flying, and since its AME capabilities have been established and documented, the remainder of this article concentrates on the potential use of the V-22 for use in military AME.

Hybridisation of fixed and rotary wing aircraft characteristics in the V-22 has produced an aircraft with a number of notable advantages over either of its progenitors. Its supe-

riority to rotary-wing aircraft in terms of ferry speed, range and patient carrying capacity arises principally from its similarities to fixed-wing aeroplanes. Its helicopter-like characteristics of short or vertical takeoff provide advantages not shared by fixed-wing aircraft, and eliminate the requirement for most surface transfers of patients.

Box 2 presents a comparison of some of the V-22's capabilities with those of existing ADF aircraft regularly employed on AME tasks. Only the RAAF's pressurised C-130 aircraft, with the ability to carry passengers above most adverse weather conditions and out of range of small arms fire at a slightly higher cruising speed and over a vastly greater unrefuelled ferry range, appear to be obviously superior platforms for strategic AME. Considered on the bases

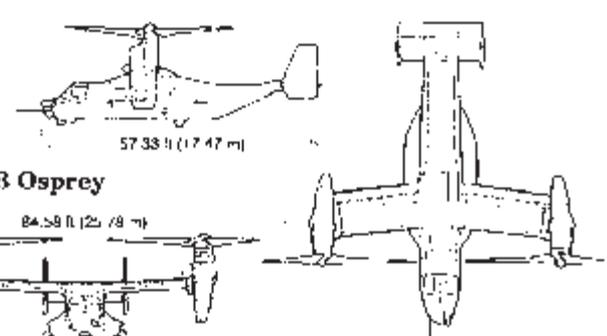
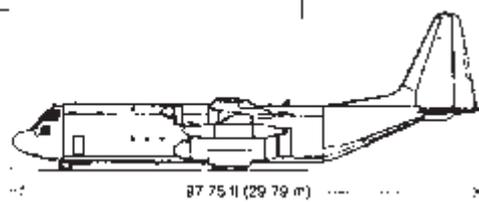
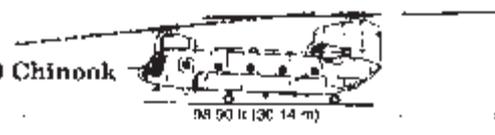
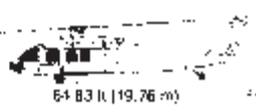
of its cruising airspeed, extended flight duration capability and patient-carrying capacity, the V-22 impresses as very capable when compared with the ADF's Caribou, Black Hawk and Chinook aircraft, particularly for strategic AME missions. This reflects the age-related limitations of the older aircraft as much as the inherently greater abilities of the tiltrotor.

Bell Boeing has constructed several hypothetical scenarios, in which the V-22 replaced the aircraft actually deployed in rescue missions, as a dramatic means of illustrating its multiple capabilities. While specific AME missions are not included, these scenarios demonstrate the potential appropriateness of tiltrotor aircraft for specific and specialised tasks. For example, in considering the failed 1980 US Iranian hostage rescue mission, Operation Desert One, which was aborted after 33 hours, Bell Boeing calculated that V-22 aircraft might have accomplished the entire mission within an elapsed period of only eight hours (ie, during a single period of darkness). Closer to home, in considering the RAAF/RAN Vendee Globe Race rescue mission in the Southern Ocean three years ago, Bell Boeing calculated that a combination of a V-22 plus land-based C-130 tanker(s)

might have successfully undertaken the mission within 24 hours and at a total cost of \$200 000. The actual operation occupied almost 200 hours, involved the FFG HMAS Adelaide and RAAF P-3C and RAN S-70B aircraft, and cost between \$4 and \$8 million.<sup>9</sup>

The V-22 is a robust aircraft with advanced design features which fit it well for military operations (including AME) within hostile environments. It is self-deployable worldwide, being capable of mid-air refuelling and of hover inflight refuelling from the deck of a surface (naval) vessel, as well as having an unrefuelled ferry range (with auxiliary tanks installed in the cabin) of 2800 km. It has an operational ceiling of 26 000 feet and an onboard oxygen generating system with generating capacity sufficient to supply medical grade oxygen to meet the breathing requirements of the aircraft's three standard crew members plus four passengers. It needs less runway than any fixed-wing AME-capable aircraft when operating in short rather than vertical takeoff mode, but is quieter than a helicopter, has a much higher cruising speed and is more stable and less affected by vibration than any existing military rotary wing craft. The V-22 has an efficient heating and ventilation system serving cockpit and cabin,

## 2 Comparison of V-22 tiltrotor aircraft with ADF aircraft used for aeromedical evacuation

Aircraft	Maximum no. of litter patients (no. of attendants)	Maximum ferry range (km)	Cruising speed (km/h)	
V-22 Osprey	12 (4)	1560 (extendable by mid-air refuelling)	510	 <p><b>MV-22B Osprey</b> 57.38 ft (17.47 m)</p>
Hercules	74 (1)	7685	590	 <p><b>C-130H Hercules</b> 87.75 ft (29.79 m)</p>
Caribou	20 (2)	2220	265	
Chinook	24 (1)	555	250	 <p><b>CH-47D Chinook</b> 98.50 ft (30.14 m)</p>
Black Hawk	6 (1)	450 (extendable with external fuel tanks to 750)	220	 <p><b>UH-60L Black Hawk</b> 64.83 ft (19.76 m)</p>

although the existing and planned military versions have air conditioning available only for the cockpit. Failsafe engine power for its proprotors is assured, as these are linked by an interconnected drive shaft, with either engine capable of driving both proprotors. In the event of catastrophic engine failure, the aircraft is recoverable either by gliding or by autorotation, and it is designed to survive ditching in sea states up to level 5 on the Beaufort scale, with moderate waves to 2.5 m and winds from 29–38 km/h.

When directly in harm's way, the V-22 has further beneficial characteristics which are not shared by other AME aircraft. Its low infrared signature and its high ballistic tolerance are supplemented by designed-in crashworthiness. All fuel tanks are burst resistant and their contained fuel vapour can be rendered inert by means of an onboard inert gas generating system. Large mass items such as the transmissions and engines are located away from occupied areas of the aircraft and the wing is designed to fail outboard of the wing/fuselage attachment in the event of a crash landing. The landing gear and all seats are energy-absorbing, with the cabin seats designed to attenuate vertical crash loads of up to +13.5 G for the 50th percentile occupant. Cargo restraint devices, including the litter support system, are similarly robust, designed to tolerances of 10G static downward force, 8G upward, 10G longitudinal and 5G lateral acting separately and in combination along all three aircraft axes. The aircraft's air intake and circulation system embodies nuclear, biological and chemical (NBC) agent filters and maintains both cockpit and cabin overpressures (0.06 kg/cm<sup>2</sup> and 0.05 kg/cm<sup>2</sup>, respectively), sufficient to exclude NBC contamination of air within the V-22. The aircraft's other militarily useful features are not listed here, as its specific AME capabilities are now detailed.

The V-22's cabin can accommodate up to 12 standard NATO litters, arranged in two tiers of three on each side of a central aisle (minimum available aisle width is 42.6 cm at the inboard support fittings when litters are installed). With the 12 litters installed, crashworthy seating for up to four attendants or walking patients remains (Box 3). As in other AME aircraft, the V-22's litter support system is composed of stanchions, struts and straps. The litter handle restraint arrangement has been designed to afford easy removal of all litters individually when required. The kit weight for supports and fittings for 12 litters is only 89 kg.

Despite its considerable sophistication and capabilities, the V-22 Osprey represents only an early stage of military tiltrotor aircraft development. As with seemingly all emerging technology aircraft designs, the Osprey aircraft now entering (US) service is the result of innumerable necessary compromises required by sponsors' budgets, their demands for timeliness of deliveries and the physical characteristics of sponsors' capital equipment with which the aircraft must interface during operations. Because the USMC and USN are

its principal customers, the V-22's gross dimensions have been dictated by the size and layout of flight decks on USN amphibious assault vessels from which it will be required to operate. The Osprey's "footprint" (rotor/wing span) is four feet wider than that of the USMC's heavy-lift CH-53 E helicopter that it is scheduled to replace, but the tiltrotor craft can lift externally or carry internally less than half the weight that can be transported by the older helicopters. The development and deployment of a larger and more capable "Super V-22" must await or parallel the availability of future, larger or redesigned USN ships able to accommodate larger tiltrotor craft. Eventually, such a "Super V-22" might replace the medium- and heavy-lift helicopter requirements for all of the US armed forces, although this is regarded as impracticable until the second quarter of the next century.<sup>10</sup>

### **Tiltrotor aircraft for the ADF?**

While the V-22 has much to offer as a military AME aircraft, its high initial cost appears certain to rule it out of consideration for present-day ADF purchase. Even if it were available in numbers, its lack of cabin pressurisation makes it unsuitable, *prima facie*, for use in strategic AME on anything but an opportunity basis, and its (unrefuelled) limited ferry range also restricts its usefulness. As an AME platform, the current V-22 is better suited to tactical than to strategic missions (as defined by the ADF).

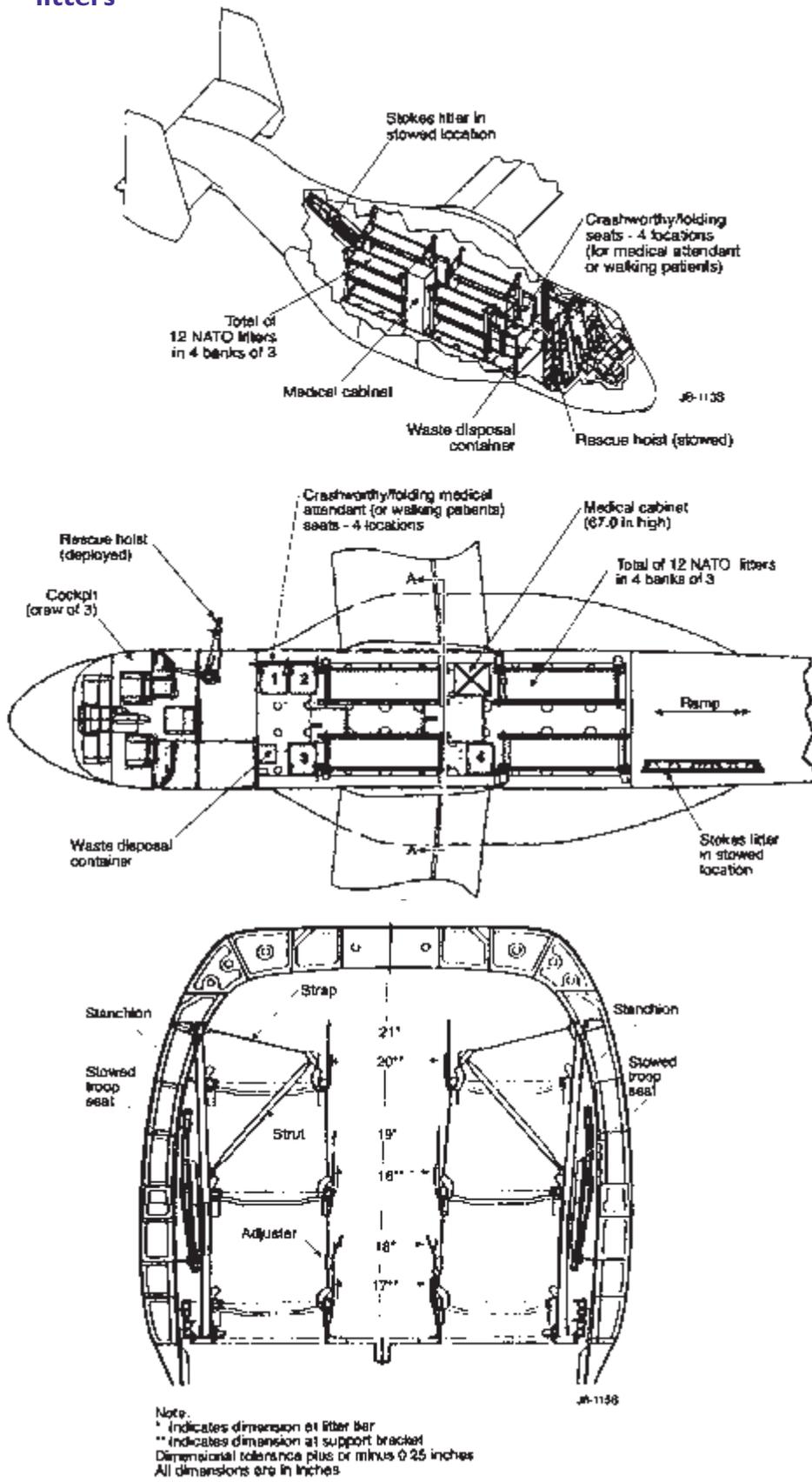
At this stage, military tiltrotor aircraft are properly regarded as a "sunrise" technology. Later development of larger aircraft of this type, capable of full cabin pressurisation and of considerably enhanced load carrying capacity, such as the proposed "Super V-22" or its competitors, could alter the balance of factors which determine the most appropriate aircraft types for the ADF's future AME and other transport needs. Such is the developmental potential of the type that, by the time the RAAF's C-130 H and J models are retired from service, military tiltrotor aircraft may have become the international benchmark for non-jet AME platforms.

A future AME system for the ADF may then rely on tiltrotor aircraft as its principal AME vehicle. However, for the present, Australia's needs for AME (particularly strategic AME) will continue to be served better by deployment of conventional fixed-wing aircraft types such as the C-130.

### **Acknowledgements**

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### 3 V-22 tiltrotor aircraft configured for maximal carriage of litters



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