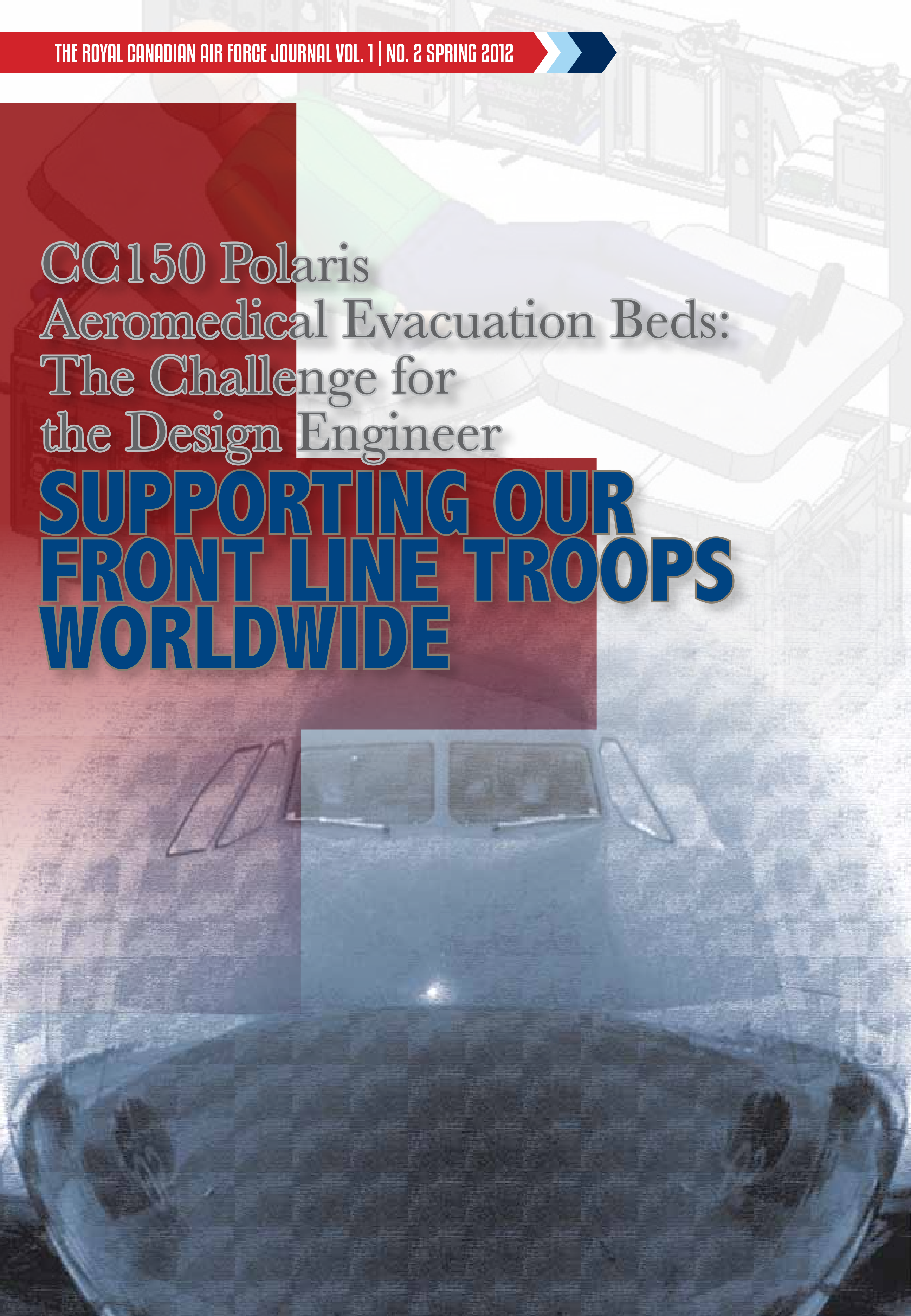

CC150 Polaris Aeromedical Evacuation Beds: The Challenge for the Design Engineer

SUPPORTING OUR FRONT LINE TROOPS WORLDWIDE

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INTRODUCTION

One of the most important of the many roles of the CC150 Polaris aircraft of the Royal Canadian Air Force (RCAF) is that of aeromedical evacuation (AE). This task involves the safe transport of injured and ill personnel from foreign or domestic locations to Canadian or other westernized medical treatment facilities for continued care. To accomplish these AE missions, the RCAF has historically used patient transport units (PTUs), also known as AE or MEDEVAC beds.

Based on over a decade of AE missions throughout the world, the RCAF's Aeromedical Evacuation Crew Members (AECMs) have noted deficiencies in the current PTUs used within the Polaris fleet. While these AE beds have served their purpose with distinction and great effect over the last 14 years, the significant increase in the medical acuity of our personnel being airlifted meant these beds were no longer suited for long transfers. This led the AE community to request a revisit to the design of the MEDEVAC beds to meet the needs of both Canadian personnel and the AE community.

The purpose of this article is to describe the design process adopted for the new AE beds, taking into account not only the needs of the AE community, but also the considerations given to maintaining technical and operational airworthiness of the CC150 fleet. The article also discusses some of the practicalities of accessing the aircraft, including loading and unloading the beds and patients in the wide and diverse conditions the Canadian Forces (CF) encounter.

FLEET OVERVIEW

The RCAF operates a total of five CC150 aircraft, maintained by Aveos under a Public Works and Government Services Canada (PWGSC) contract. Aveos is responsible for all aspects of maintenance, airworthiness, and configuration control of the aircraft through Director Aerospace Equipment Programme Management (Transport and Helicopter) DAEPMTH and is co-located with 437 Squadron at 8 Wing Trenton.

Aveos was tasked by DAEPMTH to select a contractor to design and manufacture a suite of new AE beds for use on the CC150 Polaris aircraft. LifePort Inc, a Sikorsky Aerospace Services company, has been assigned this contract.

The Airbus A310 aircraft (see this page) is a wide-body, twin-engine, low-wing monoplane with a pressurized fuselage and normal configuration tail. All five aircraft were manufactured by Airbus Industries in approximately 1986 and hold a Transport Canada (TC) Approved Type Design Certificate. The aircraft were bought by the Department of National Defence (DND) around 1992, and brought into service with 437 Squadron over the following three years. Two of the aircraft—tail numbers 15002 and 15003—are designated for aeromedical evacuation use, although other aircraft from the fleet could be configured with AE beds if required.


CF Photo

A CC150 Polaris aircraft, bought from Canadian Airlines

The PTUs are permanently stored at 8 Wing to ensure quick reconfiguration of the aircraft and subsequent deployment on AE missions. Storage is always an ongoing challenge at Canadian Forces Base (CFB) Trenton, partly because the entire 8 Wing is currently undergoing a revamp of their base facilities to accommodate the growing and changing space needs of several fleets. Provision of an appropriate location is important for long-term storage of the beds to ensure they are safe from damage and environmental degradation. Designers must be mindful of these challenges.

> Wide-body? A wide-body aircraft is also known as a twin-aisle aircraft. The typical fuselage diameter of a wide-body aircraft is from five to six metres. In the typical wide-body economy cabin, passengers are seated 7 to10 abreast, allowing a total capacity of 200 to 850 passengers.

DESIGN REQUIREMENTS

Overview

The high-level specification requirements for the AE bed can be summarized as follows:

- provide increased patient comfort for the duration of AE missions by establishing a more ergonomically friendly design;
- increase the ability of the AE team to deliver care to various type of patients, including critical care patients, for flight durations of up to several hours;
- take into consideration the needs of various stakeholders involved with AE missions, including medical staff, Aveos maintainers, CFB Trenton personnel, and 437 Squadron flight crew; and
- design for various loading and unloading scenarios to ensure aircraft can be quickly and efficiently evacuated as required.

It is essential for the designer to develop an AE bed solution that will ensure the best possible delivery of care while in flight. The designer must customize every aspect of the AE beds to ensure maximum efficiency—from the dimensions of the bed mattress to the type and locations of medical mounts, storage provisions and overall envelope. Simple, right?

Size and comfort

High on the list of areas for improvement for the new AE bed is the requirement to improve its size and comfort. Space on aircraft is always at a premium, and so one of the challenges for the design engineer is to make efficient use of every single inch. The initial design of the AE bed provided a width of approximately 18 inches (0.46 metres). Considering anthropometric measurements—the 99th percentile male model—and the space requirements to properly support injured limbs and external bracing for fractures, it was evident that the width and length of the proposed design were not suitable. In addition, the thickness of the mattress on the current PTU was insufficient to provide adequate comfort to the patients. The mattress must be designed to provide optimal protection from pressure-ulcer-formation risk inherent to lengthy missions.

One more challenge for the designer was the height of the AE bed. The currently used PTUs force the medical staff to stoop for extended periods of time, thus increasing the chance for injury and workplace discomfort.

> *MIL-STD-1472 Design Criteria Standard: Human Engineering* is used as a reference guide by engineers to establish design criteria for key dimensions of the AE beds. This standard contains extensive tabulations of the height and weight of 95 per cent of all male and female troops … hence the commonly used term "95th percentile" (see https://assist.daps.dla.mil).

Equipment placement

A modern AE bed is a lot more than just a place for a patient to lie down. It is a site for a host of highly technological medical equipment, such as cardiac monitor/defibrillator, vital signs monitor, ventilator, intravenous solution administration pump, oxygen source delivery system, and suction pumps. All of the equipment needs to be safely mounted and readily accessible during flight.

The currently used PTUs have embedded oxygen and suction capabilities; however, there is limited space to secure the medical equipment accompanying the patient. Therefore, the designer must consider equipment placement with regard to accessibility and visualization of the various display screens.

The new AE bed will provide an increased source of medical graded oxygen (the previous bed provided 6,274 litres; the new bed will provide 10,500 litres).

Aircraft access

As the CC150 Polaris aircraft is a wide-body aircraft, the forward cabin area has been modified to accommodate up to five new AE beds. Loading and unloading the aircraft at departure time can be quite congested (see photo this page); therefore, loading these new beds on-board the aircraft presents considerable design challenges. For example, as per the proposed AE bed design, the base unit weighs over 200 pounds (91 kilograms) and must be lifted to the height of the passenger door by means of a scissor-lift table and then manually two-person manoeuvred into position in its cabin location. Care must be taken to avoid damage to the AE beds or to the aircraft. The lighter and smaller the base unit the better, which is another factor for the design engineer to consider.

How is emergency evacuation affected? The installation of the LifePort AE beds requires modification to the configuration of the forward cabin, which in turn presents challenges due to reduced access to the forward passenger doors. This reduction in access affects the emergency evacuation, as patients on the AE beds may require additional time and assistance to evacuate the aircraft, due to their medical condition. There also exists the possibility that the patient and attending AECMs will not be able to exit the aircraft within the 90-second time frame. As such, the designer has to give careful consideration to the ease with which the patient can be removed off the bed, with minimal restrictions resulting from restraint harnesses and securing straps.


CF Photo

Access to the Polaris aircraft can be a hectic and busy place as seen on this cargo load

DESIGN IN PROGRESS

Now that we have identified many of the factors the design engineer must take into account, how have these factors been addressed in the new design?

Canadian Aviation Regulation (CAR) Airworthiness Manual (AWM) 525.803 (c) Emergency Evacuation states: "For aeroplanes having a seating capacity of more than 44 passengers, it must be shown that the maximum seating capacity, including the number of crew members required by the operating rules for which certification is requested, can be evacuated from the aeroplane to the ground under simulated emergency conditions within 90 seconds" (see http://www.tc.gc.ca).

After considerable early evaluations and assessments, it was decided to design the AE beds based on up to five being installed on the aircraft at any one time. Each AE bed is significantly larger than the previous PTU, and as a result of the larger size, five new beds will use the space previously occupied by six older models. The beds are designed for quick removal and easy re-installation between missions.

The LifePort conceptual design of the AE bed consists of three separate yet fully integrated components—the equipment arch, the PLUS base, and the MedBed (see Figure 1). When installed on the aircraft, the AE bed must be a fully integrated system certified for use during all aspects of flight.

capacity has been increased from 6,274 litres from the currently used PTU to 10,500 litres. Oxygen is stored in cylinder bottles easily accessible for removal to be serviced outside the aircraft. The base contains a frequency converter and an AC to DC (alternating current to direct current) power converter for all DC appliances. The frequency conversion is from 115VAC (voltage alternating current), 3-Phase, 400Hz (hertz) to 115VAC, single phase, 60Hz. Air and suction pumps, a lockable drug storage drawer, and a sharp container drawer are also included. The PLUS base is designed to install directly to the existing aircraft seat track without the need for special tools, using an interface mounting system.

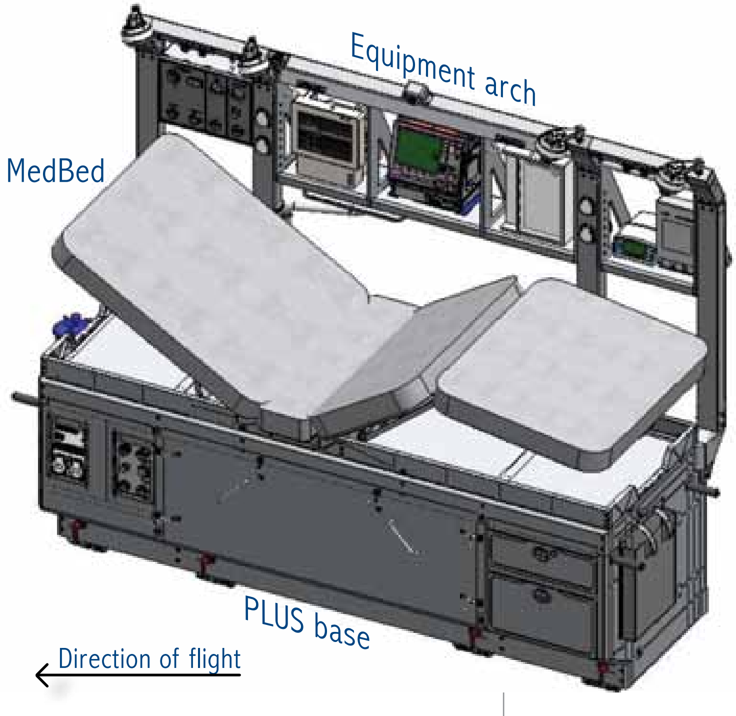

Figure 1. Three major components of the new MEDEVAC bed: PLUS base, equipment arch, and MedBed

Equipment arch

The equipment arch is designed to support all required ancillary medical equipment and payloads, and to improve visualization of the various screen displays. It also includes a track light system of adjustable intensity, oxygen, air, suction, and electrical outlets. The equipment arch is supplied services from the PLUS base, and can be accessed at the height of the patient.

PLUS base

The PLUS base provides oxygen, air, suction, electrical outlets, and storage compartments. The medical graded oxygen storage

MedBed

The MedBed is removable from the PLUS base for installation and cleaning. The MedBed is articulated to enhance patient comfort, and includes adjustable upper body and knee lifts, as well as a 3-inch (8-centimetre) thick foam mattress (see Figure 2). The MedBed is structurally substantiated for carrying a 300-pound (136-kilogram) occupant flying in two configurations: head forward or feet forward. Patients will be secured via a five-point restraint harness and a thigh strap.

Figure 2. Conceptual MEDEVAC bed design showing patient

CONCLUSION

Design of a fully functional and effective AE bed for modern-day military deployments is a considerable challenge for the design engineer. Consideration must be given to a wide range of factors: the needs of the AE community as it fulfill its obligation to deliver high-quality care; the design challenges to provide an efficient AE bed solution in a weight- and size-constrained aircraft where all available space must be used effectively; and the needs of the modern partnership of aircraft operators and maintainers. The current plan is to bring the AE beds into service in fall 2012. All in all, the challenges are considerable, but DND feels confident that these challenges are being met with careful and diligent attention to detail.

Major Dominique Laplante is the Senior Staff Officer (SSO) Aeromedical Evacuation to the Chief of the Air Force Staff (C Air Force) Medical Advisor. An experienced flight nurse on CF rotary- and fixed-wing aircraft, she obtained her Nursing Degree from the University of Montreal, and her Masters in Advanced Nursing Practice from the University of Victoria, British Columbia.

Captain Sophie Lavoie joined the CF in 2004 and completed her Bachelor of Science in Nursing through Regular Officer Training Plan (ROTP) at Lakehead University. She has been a flight nurse with the Canadian Forces Aeromedical Evacuation Flight since September 2009. She is proud and honoured to be able to care for and assist in the return of injured troops from wherever they may be.

David Smith joined DND as Deputy Aircraft Engineering Officer, DGAEPM(TH), in early 2011. David brings to DND over 30 years' experience in a wide and diverse range of industries, including nuclear, steel, high-tech, and military in England, New Zealand, and Canada. His experience is augmented by formal qualifications in both electrical and mechanical engineering (Leeds University) as well as an MBA from Ottawa University.

ABBREVIATIONS

AC	alternating current
AE	aeromedical evacuation
AECM	Aeromedical Evacuation Crew Member
CF	Canadian Forces
CFB	Canadian Forces Base
DAEPMTH	Director Aerospace Equipment Programme (Transport and Helicopter)
DC	direct current
DND	Department of National Defence
Hz	hertz
PTU	patient transport unit
RCAF	Royal Canadian Air Force
VAC	voltage alternating current