

Processing CSeries Aircraft Panels

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ABSTRACT

Bombardier faced new manufacturing process challenges drilling and fastening CSeries* aircraft panels with multi-material stacks of composite (CFRP), titanium and aluminum in which Gemcor responded with a unique, flexible CNC Drivmatic® automatic fastening system, now in production at Bombardier. This joint technical paper is presented by Bombardier, expounding on manufacturing process challenges with the C Series aircraft design requirements and Gemcor presenting a unique solution to automatically fasten CFRP aft fuselage panels and aluminum lithium (Al Li) cockpit panels with the same CNC Drivmatic® system. After installation and preliminary acceptance at Bombardier, the CNC system was further enhanced to automatically fasten the carbon fiber pressure bulkhead dome assembly.

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INTRODUCTION

When the CSeries aircraft program launched in 2008, Bombardier recognized a need to increase its capacity and internal manufacturing process capability with more automatic fastening. The CSeries design continued to evolve throughout procurement, adding a higher level of complexity to project engineering and requiring a fast response time, which Gemcor accommodated in their E-frame machine design. Bombardier's original specification requirements requested a solution capable of drilling and fastening multi-material stacks of CFRP, titanium and aluminum lithium for manufacturing a 360-degree cockpit assembly and 360-degree aft fuselage assembly, which included tight areas with minimal clearance. Additional challenges also included an evolving aircraft design, CSeries aircraft panel assembly weight considerations, safely controlling and removing CFRP dust, flexibility to install both rivets and two piece fasteners, upstanding structure 130 mm (5.12 inch) tall and fitting the system footprint within a smaller factory floor space. Soon after becoming familiar with the CSeries requirements, a new E-Frame CNC positioning system with a traversing lower horn assembly was introduced by Gemcor for drilling and

fastening a 360-degree cockpit assembly and 360-degree aft assembly in a single fixture sequence.

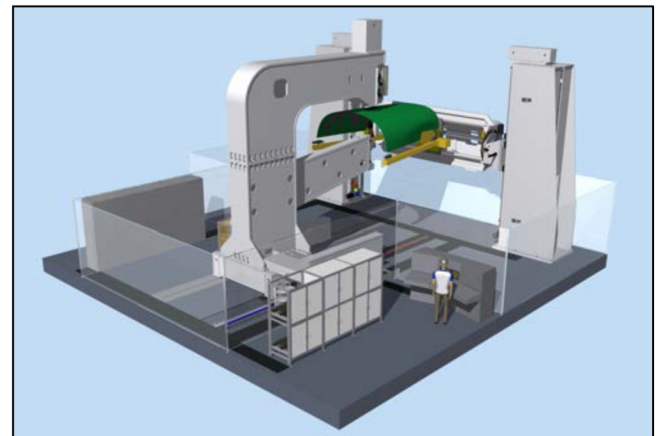


Figure 1.0. Conceptual CNC Composite Fastening System

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Figure 2.0. Installed CNC Composite Fastening System

The unique E-Frame CNC system met Bombardier's technical requirements and has proven to be a flexible solution with superior reliability and quality for processing high contoured panel assemblies fixtured from a single pick point, whereby minimizing part handling while maximizing accessibility for automatic fastening.

E-FRAME CNC COMPOSITE FASTENING SYSTEM OVERVIEW

This new CNC Drivmatic® system with E-frame and CNC positioner automatically installs solid rivets, stump type lockbolts, flanged collars, straight collars and will also drill-insert threaded pins. A next-generation rotary upper head with innate automatic tool change function instantaneously switches between three resident tool groups. Gemcor's patented roller screw upset process, multi stack drilling function and new patent pending pressure foot monitoring technology proved to create additional control for efficiently drilling and fastening composite panels. The CNC Drivmatic® system also incorporates two distinct operation work line heights for a standard pocket and deep pocket, providing clearance for tall upstanding structures.

The unique positioning capability of the E-Frame 5-axis CNC Drivmatic® fastening system was primarily dictated by the configuration of high contoured CSeries cockpit panel assemblies with compound curvature, which are currently being manufactured and assembled at Bombardier's Montreal plant.

The original system concept accommodated a pre-tacked 360-degree panel assembly fastened in a single sequence as shown in [figure 3.0](#). During the engineering phase, Bombardier's requirements were modified, requiring the cockpit and aft fuselage section to be fastened in multiple setups due to handling challenges in maintaining shape during transport. The final CSeries aircraft design for the cockpit and aft fuselage have different panel breaks and different upstanding structure, therefore the final configuration of the E-Frame CNC positioner also evolved,

into a static lower horn assembly whereby removing an axis from the system.

Details of the AER configurations and major components of the E-frame CNC Drivmatic® fastening system supplied to Bombardier, including a next generation rotary upper head, lower head, new electronically actuated Huck collar swage tools, HMI operator interface with multi-stack drilling function, Fanuc CNC positioner, Delta Tau high speed motion control for riveter function and Cenit OLP, are included in this technical paper

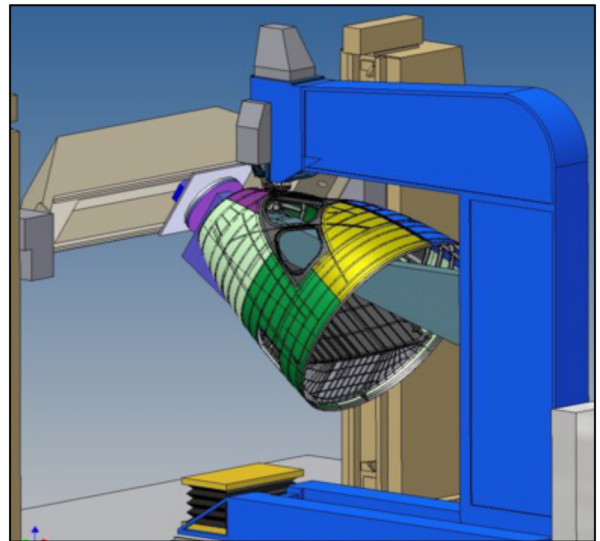


Figure 3.0. Original System Concept



Figure 4.0. Installed CNC Composite Fastening System

Bombardier's competitive advantage from this unique system is flexibility to quickly change from fastening composite panel assemblies to fastening aluminum lithium panel assemblies with the same CNC Drivmatic® system.

The significant cost savings provided by this new CNC Drivmatic® system is a proven and consistent fastener installation quality and Gemcor's new pressure foot monitoring technology with enhanced panel protection, which prevents expensive rework. Additional benefits from this new machine design include:

- Ease of maintenance
- High uptimes with consistent reliability
- Positive operator acceptance
- Enhanced ergonomics with health and safety

CNC POSITIONER

The final design of the CNC positioner incorporated 5 axes of motion control and an additional E axis for automatic rotation of the lower tooling on the riveter. A planocentric gearbox was utilized for rotation of the A axis and the B axis rotation was achieved through a dual pinion drive ring gear system. The final positioner configuration and axes designations are shown below in [figure 5.0](#).

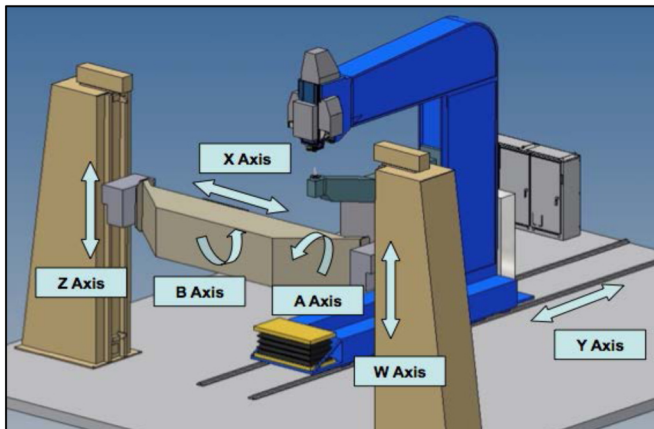


Figure 5.0. Axes Designations

X axis	Positioning B axis perpendicular to the Y axis
Z1 & Z2 axis	Positioner motion up and down
A axis	+/- 90-degree rotation around the X axis
B axis	+/- 180-degree rotation around the Y axis
Y axis	Positioning of riveter perpendicular to X axis
E axis	+/- 360-degree rotation of lower tooling

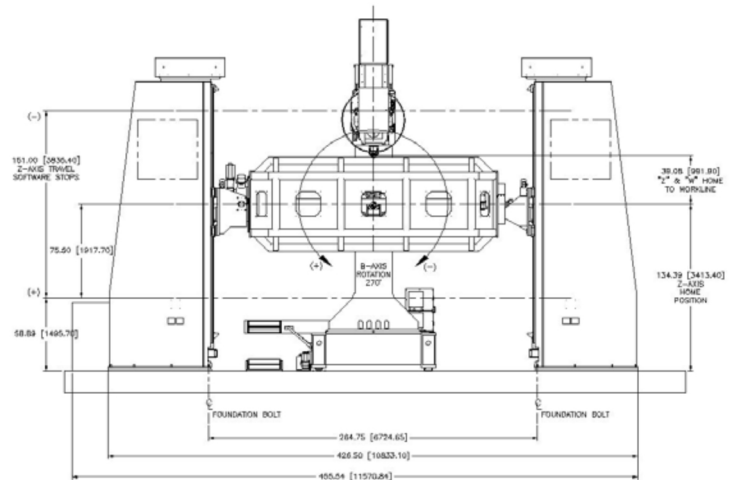


Figure 6.0. E-Frame CNC Positioner

After the CNC system was installed in Bombardier's factory, more changes were requested to automatically fasten the CFRP bulkhead with the same system. Gemcor then provided a pneumatic rotating bulkhead fixture assembly shown below in [figure 7.0](#).



Figure 7.0. Rotating Pneumatic Bulkhead Fixture

The rotating bulkhead fixture assembly was designed with pneumatics to unlock and manually index as required during fastening operations to access all fastener locations on the pressure bulkhead. Pneumatic clamps and locators shown below in [figure 8.0](#) were utilized to secure the pre-tacked pressure bulkhead to the fixture.

The CFRP pressure bulkhead dome includes round cutouts, so aluminum tape was temporarily placed around the perimeter of each cutout for the normality sensors to reference when normalizing the pressure bulkhead to the machine. This idea evolved into using an aluminum plate, which is now Bombardier's method to ensure the pressure bulkhead is normal when installing two rows of stump type lockbolts and swaging collars around the perimeter of each cutout. One hundred percent of the pressure bulkhead