

# E7000 High-Speed CNC Fuselage Riveting Cell

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## ABSTRACT

Electroimpact has recently produced a high-speed fuselage panel fastening machine which utilizes an all-electric, CNC-controlled squeeze process for rivet upset and bolt insertion. The machine is designed to fasten skin panels to stringers, shear ties, and other internal fuselage components. A high riveting rate of 15 rivets per minute was achieved on the first-generation E7000 machine. This rate includes drilling, insertion, and upset of headed fuselage rivets. The rivets are inserted by a roller screw-driven upper actuator, with rivet upset performed by a lower actuator driven by a high-load-capacity ball screw. The rivet upset process can be controlled using either position- or load-based feedback.

The E7000 machine incorporates a number of systems to increase panel processing speed, improve final product quality, and minimize operator intervention. The upper riveting head includes automatic tool changers for drills and upper anvils, both designed with very fast tool changes as a primary goal. The machine also includes fastener verification laser curtains to ensure the fastener being inserted is the correct type and length, and oriented properly. The system has automatic calibration functionality to calibrate normality and stringer tracing sensors, as well as upper and lower die lengths. Additionally, an automatic machine vision system provides high-speed, high-accuracy part resynchronization across a wide range of surfaces for improved local accuracy.

The E7000 automated fuselage riveter is a fast, robust and flexible system that can be used to fasten a wide range of fuselage panels, while improving reliability and final product quality.

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## INTRODUCTION

In 2012, Electroimpact designed and built the first E7000 series fuselage panel riveting machine for Turkish Aerospace Industries. This is Electroimpact's first automatic riveting for metallic fuselage panels. The system was designed around A320 and A400M fuselage panels, and utilizes unique kinematics to enable automatic fastening accessibility at high angles of curvature. Emphasis has been placed on increasing the "floor-to-floor" rate - not just maximizing fastening speeds - and on ease of maintenance. The machine incorporates many innovative design features to help achieve these goals.

## MACHINE STRUCTURE

The machine gantry carries upper and lower independent heads. The heads traverse the gantry in the Y-direction, while the gantry itself drives in the X-direction. The upper head includes the drill spindle, resynch camera, and fastener

driver, while the lower head provides clamping and rivet upset force.

A set of access platforms mounted to the machine allow easy access to the upper head at any position in the cell, without necessitating a return to the park zone. This is in line with the design goal of minimizing overall panel build time, but these platforms also serve another purpose: they provide an optimum position for the fastener feed rack. The rack is placed as close as possible to the upper head for very fast feed times.

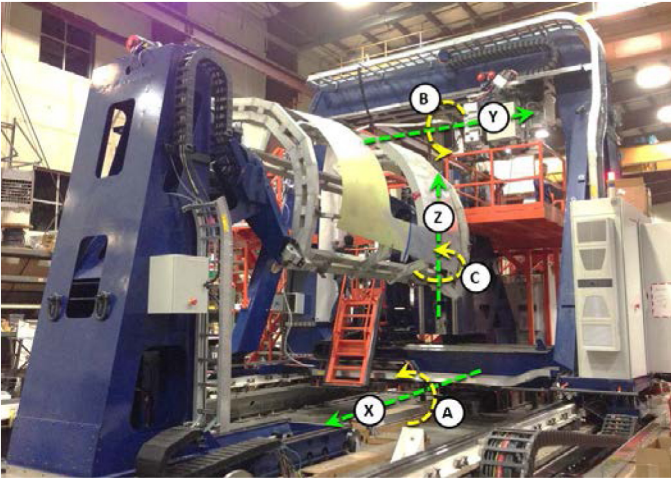


**Figure 1. Overall machine structure and axis orientations**

## UNIQUE FEATURES

The E7000 fuselage riveter incorporates a number of unique features which are designed to reduce overall panel processing time and simplify machine operation and maintenance.

### X-axis Struts



**Figure 2. Struts allow more aggressive acceleration and deceleration in the X-direction, reducing cycle time**

The machine is braced in the X-direction by a pair of struts (see [Figure 2](#)). This permits faster X-axis accelerations during pitch moves, without the need to wait for vibrations to damp out before beginning a cycle. The result is faster pitch moves and thus a higher rate of fastener installation. One-

inch (25 mm) pitch moves of less than 0.5 seconds are typical.

### Part Positioning System

Traditional riveting machine part positioners use a large, welded steel “picture frame” to carry the work piece and its associated tooling. In the typical axis layout, part rotation in the B-direction (around the Y-axis) is achieved passively through differential Z-axis positioning at the two towers. This results in a change in the X-directional component of the structure length, which is taken up by a passive linear bearing arrangement. However, the presence of the picture frame obstructs access to edges of panels at high angles of rotation due to collision between the frame and the lower fastening head structure (see [Figure 3](#)). Therefore, a concept was developed to enable part-holding without the use of such a large supporting structure.

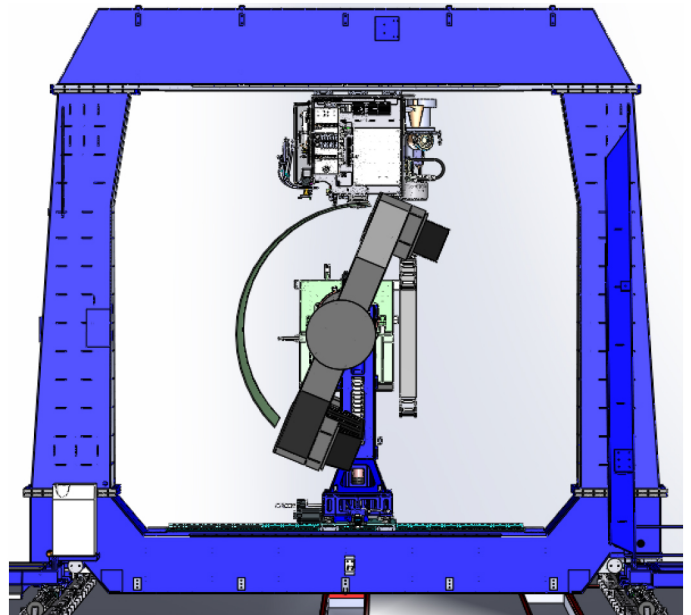


**Figure 3. Collision of the picture frame with the lower head would obstruct machine access near panel edges**

The E7000 part positioner concept eliminates the need for a picture frame. A very light and low-profile dedicated part frame is used, which prevents collisions of the frame with the lower machine head at high A-axis rotations. Consequently, interferences between the part-holding structure and the machine are minimized. The E7000 is able to easily access and fasten all parts of A320 fuselage panels that span 120°, and in fact is theoretically capable of accessing the edge of a panel that spans over 150°. This advantage does come at a cost: because the low-profile dedicated part-holding frame is not as stiff as a conventional picture frame, it is necessary for the positioner to provide moment support in the B-direction to prevent the frame and part from sagging excessively under

gravity load. Thus, all of the positioner axes must be servo-driven on the E7000 - no passive axes are used.

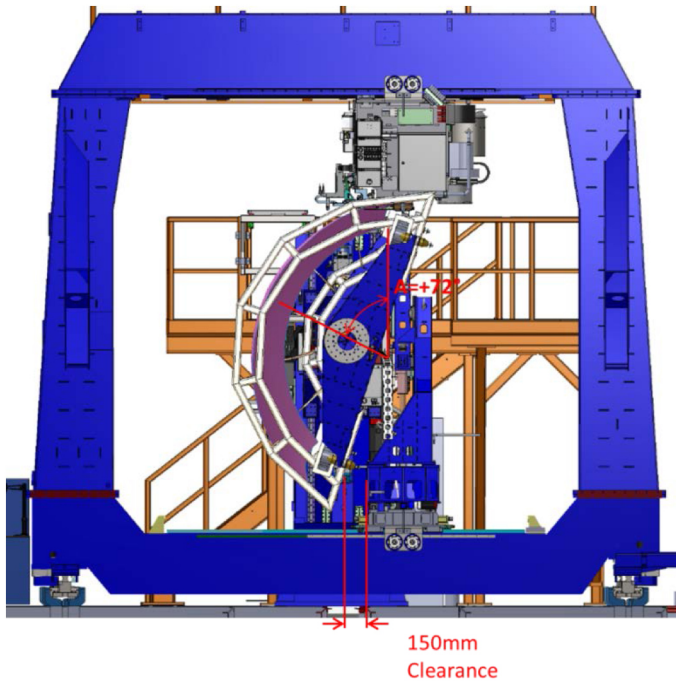


**Figure 4. E7000 machine accessing the edge of a panel that spans 144° of curvature**

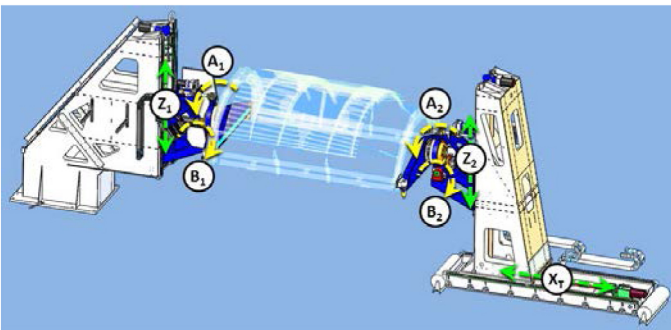


**Figure 5. Positioner axis layout**

As an added benefit, by removing the picture frame, the moving mass is greatly reduced. The total weight supported by the positioner is in the hundreds of kilograms for most parts, as opposed to several tons for a traditional part positioner. The low supported mass eliminates the need for counterbalance mechanisms and allows for smaller gear reductions, faster axis accelerations, and improved accuracy.

As with the traditional design, there is a change in the X-directional component of length during B-axis rotation. In the E7000 system, this is controlled through a servo X-axis on one of the positioner towers, rather than a passive axis. The lightweight part holding frames are not designed to transmit load associated with moving a passive axis, so this movement must be commanded. B-axis rotation is therefore

accomplished by coordinated movement of five servo axes - the two Z axes on each tower, the two B axes, and the tower X axis.

The presence of an X-axis under one positioner tower also serves another purpose - it allows the positioning system to accommodate a range of different panel lengths, while keeping the towers only as far apart as is required for the particular panel being processed (see Figure 6). This is especially useful when both short, high curvature panels and longer, more cylindrical panels are to be processed by the same machine, because large B-axis angles can be achieved for the shorter panels without requiring very tall positioner towers.

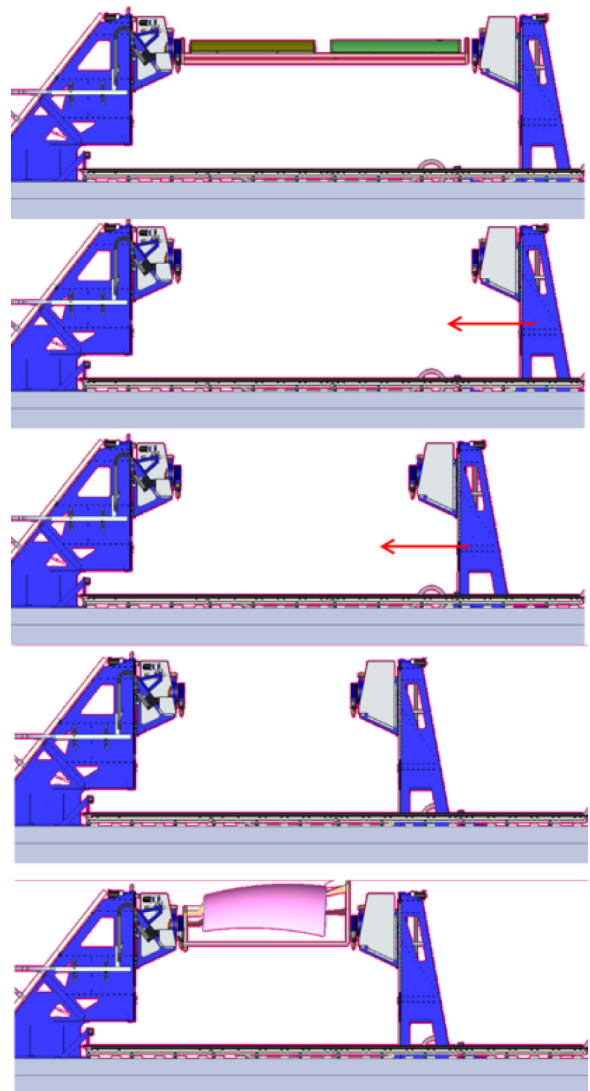


**Figure 6. Part positioner tower moves to accommodate different panel lengths**

In order to accommodate part loading, conventional CNC riveting machines either require extra Y-axis travel so that the