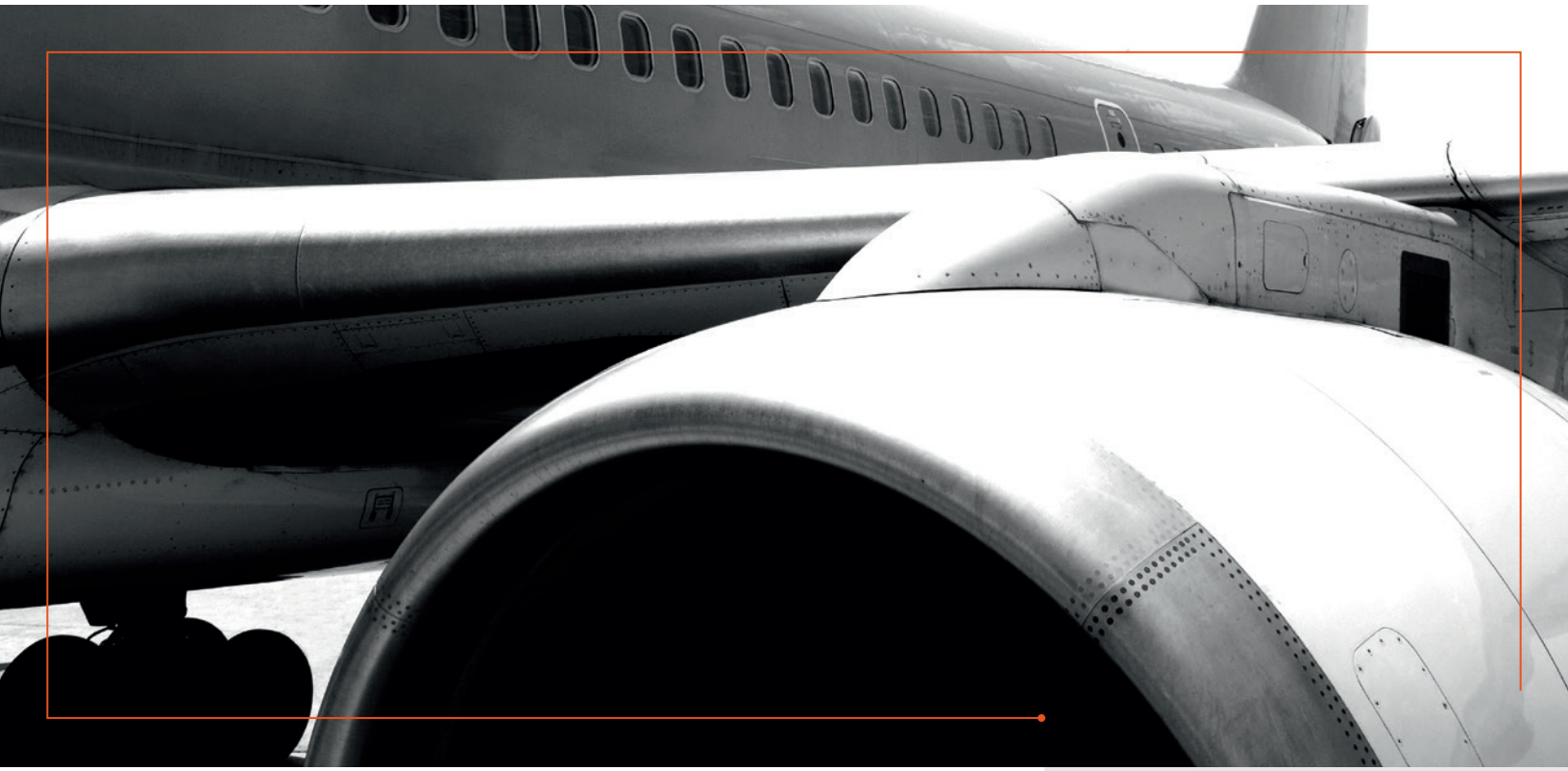


AXIAL JOINING TECHNOLOGY

COMPOSITE STRUTS, RODS & ACTUATORS

High performance, low weight

Collins Aerospace composite axial product offerings use our multi-patented tooth joining technology. This technology is inherently scalable delivering unrivaled performance in static and fatigue. The technology is also fully customizable – with the design of the metallic end tailored to suit any application from a rod eye to an actuator end.

The strategy to develop this adhesive-free metal to composite joining technologies comes from understanding how to correctly exploit materials and their specific properties. When the load path and geometry are complex, metal is advantageous due to its superior isotropic properties and established manufacturing processes. Composites conversely are superior where load paths can be aligned with the main fiber direction. Our designs utilize this to deliver the highest performance at the lowest weight.

Implementing the axial joint enables significant weight savings rather than the metallic equivalents, while the mature automatable manufacturing process enables a comparable price that is normally unachievable with composite parts.

KEY FEATURES AND BENEFITS

- Cost neutral to metal equivalents with 30-70% weight reduction
- Lighter than many composite equivalents with significant cost down
- Manufacturing simplicity and high level of automation
- In-depth understanding
  - Low risk technology
  - Predictable NPI

Criteria	Typical Performance Range
Load range	5kN – 2,500kN
Fatigue strength	Unlimited up to 50% of ultimate
Diameter	Up to 150mm
Length	Up to 4.0m
Service temperature	-55°C to +120°C
Compatibility	Fully adjustable in length to match customer requirements

Collins Aerospace

Adhesive-free axial joint

Our axial joints are mechanical joints that require:

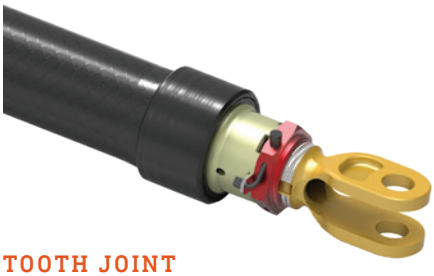
- No adhesive, which aids in qualification, removing inherent manufacturing difficulties and NDT requirements of bonded joints that increase cost and complexity
- No additional mechanical fasteners, such as rivets, that weaken the laminate as a result of high stress concentrations

The fully customizable metallic end fittings feature a serrated tooth form machined as a bespoke thread into the outer conical surface. The end fitting is screwed into the CFRP tube and, subsequently, the hoop ring is then pushed onto the tube, overcoming a large interference fit with the tube's outer diameter.

Load is transmitted from the end fitting into the composite tube, predominantly via a reaction force at the flank of the teeth along the length of the interface. As a result, friction is not required to transfer ultimate loads. The interference fit generates a pressure along the interface and the preload this creates in the joint prevents any relative movement under fatigue loads, hence failures due to fretting fatigue are avoided.

The tapered interface allows the load to be transmitted directly into all of the composite load carrying axial layers, reducing the design's reliance on interlaminar shear strength. This results in the design being tolerant to interlaminar defects. Additionally, a cylindrical interface would result in a less even distribution of load across the interface, however the taper enables the joint to be designed with a load uniformity of up to 98% across all teeth.

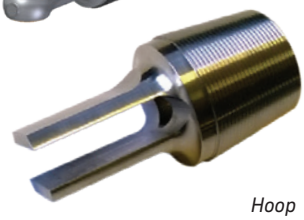
Collins has also developed a novel process to integrate the benefits of both pre-impregnated fibre and dry fibre processing. The process enables prepreg performance material to be created from any combination of fiber and resin that is optimal for the individual component requirements. Using fiber and resin as the inputs, rather than traditional pre-impregnated materials enables greater optimisation and flexibility whilst reducing raw material costs.



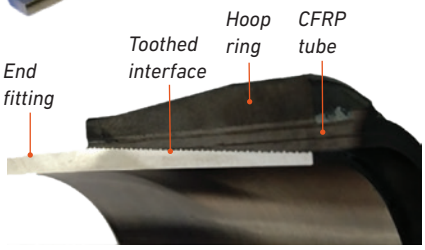
TOOTH JOINT

- Patent published and multiple pending
- Over 6 times stronger than equivalent adhesively bonded joint in hot wet conditions
- Unlimited fully reversed fatigue life up to 50% of ultimate strength
- Highly automatable

Brake rod



End fitting



Tooth joint cross section

Some potential applications

NACELLE

- Hold open rods
- Power door operating system actuations

INTERIOR

- Interior tie rods

FUSELAGE

- Floor beam struts

LANDING GEAR

- Brake rods
- Side stays and braces

CENTRE WING BOX

- Centre wing box struts

Specifications subject to change without notice.

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