CARBON FIBER RODS & TUBES FOR DRONE & AEROSPACE APPLICATIONS

ISO 9001:2015

CONTENTS

Carbon fiber composites deliver the strength-to-weight performance drone structures require, without the limitations of metal. For OEM engineers designing drone systems (or, Unmanned Aerial Vehicle (UAV)), Goodwinds Composites offers precision-engineered small-diameter carbon fiber rods and tubes built to spec, made in the USA.

In this guide to **Carbon Fiber Rods & Tubes for Drone & Aerospace Applications**, you'll find:

What are the advantages of

CARBON FIBER IN DRONE APPLICATIONS?

Carbon fiber is nearly 5x stronger than steel and roughly one-third of the weight. For aerospace applications, that means structural components that carry loads without limiting flight time, payload, and range. Carbon fiber rods & tubes also provide corrosion resistance, high fatigue life, and dimensional stability across temperature extremes, making them ideal for drone applications.

CARBON FIBER RODS & TUBES: KEY PERFORMANCE FACTORS

- **Strength-to-weight ratio** is nearly 5x higher than steel
- **High axial stiffness** with minimal flex under load
- **Fatigue resistance** over repeated stress cycles
- **Thermal stability** across wide operating temperature ranges
- **Corrosion resistance** eliminates secondary coatings or surface treatments
- **Electrically conductive (carbon fiber) or insulating (fiberglass)** provide options based on application

ENGINEERING CHALLENGES IN AEROSPACE DRONE DESIGN

What are the main design challenges in

DRONE STRUCTURAL SYSTEMS?

Drone engineers are often faced with competing constraints: structures must be light enough to fly efficiently, stiff enough to stay stable, and durable enough to survive repeated use in demanding environments. Consistently meeting these requirements requires focused design and material profiles that can be difficult to match.

6 DESIGN & ENGINEERING CONSIDERATIONS FOR DRONES

1. Weight:

Every gram of structural mass competes with and directly affects payload, battery capacity, and flight range. Carbon fiber's low density (roughly 1.6 g/cm^3 vs. 2.7 g/cm^3 for aluminum) enables significant mass reduction and maximum performance.

2. Stiffness & Vibration:

Arm and boom flex degrades motor alignment, sensor accuracy, and flight control response. Likewise, resonance shortens fatigue life. High-modulus carbon fiber rods & tubes with proper fiber orientation provide the rigidity needed to keep drone structures stable under dynamic loads.

3. Dimensional Tolerances:

Drone assembly requires part consistency. OD/ID tolerances, straightness, and cut-length accuracy all matter in production and performance. Off-spec components create integration problems and slow manufacturing.

4. Environmental Exposure:

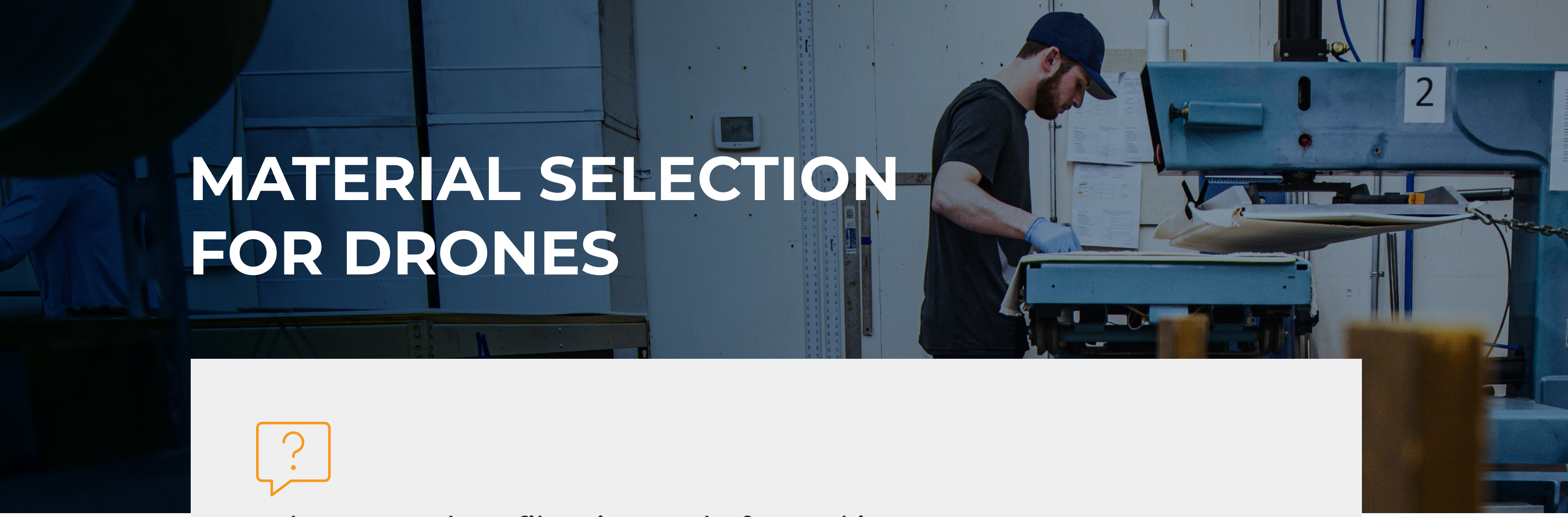
UV, moisture, salinity, and temperature swings are standard in drone field operations. Carbon fiber handles all of them without the corrosion or coating maintenance that metal requires.

5. Fatigue & Cyclic Load:

Fatigue & Cyclic Load: Every flight cycle causes drone structures to flex and load repeatedly. Carbon fiber maintains its mechanical properties through far more stress cycles than aluminum.

6. Impact & Rough Handling:

Landing loads, transport, and field handling stress drones’ structural components. Accurate geometries and material selection determine impact performance.



MATERIAL SELECTION FOR DRONES

Why use carbon fiber instead of metal in

DRONE STRUCTURES?

Carbon fiber outperforms aluminum and steel on vital drone design metrics: stiffness per gram, fatigue resistance, and corrosion immunity. The tradeoff is cost and fastener interface complexity. Metal typically still makes sense at attachment points and high-load joints.

MATCHING MATERIALS TO DRONE APPLICATIONS

Carbon Fiber

Provides the best stiffness-to-weight ratio available in structural rods & tubes. Axially pultruded carbon fiber rods & tubes deliver high tensile and compressive strength in the fiber direction, making them ideal for arms, booms, longerons, and push-pull rods. Roll-wrapped tubes add hoop strength and multi-axial stiffness for applications with off-axis loads or torque.

Best for: airframes, arms, booms, spars, push rods, tail assemblies, internal structural members

Fiber orientation: Axial (0°) fibers maximize stiffness along the length, which is right for most structural members. Off-axis or helical wraps add torsional and hoop strength. Specify fiber orientation based on primary load direction.

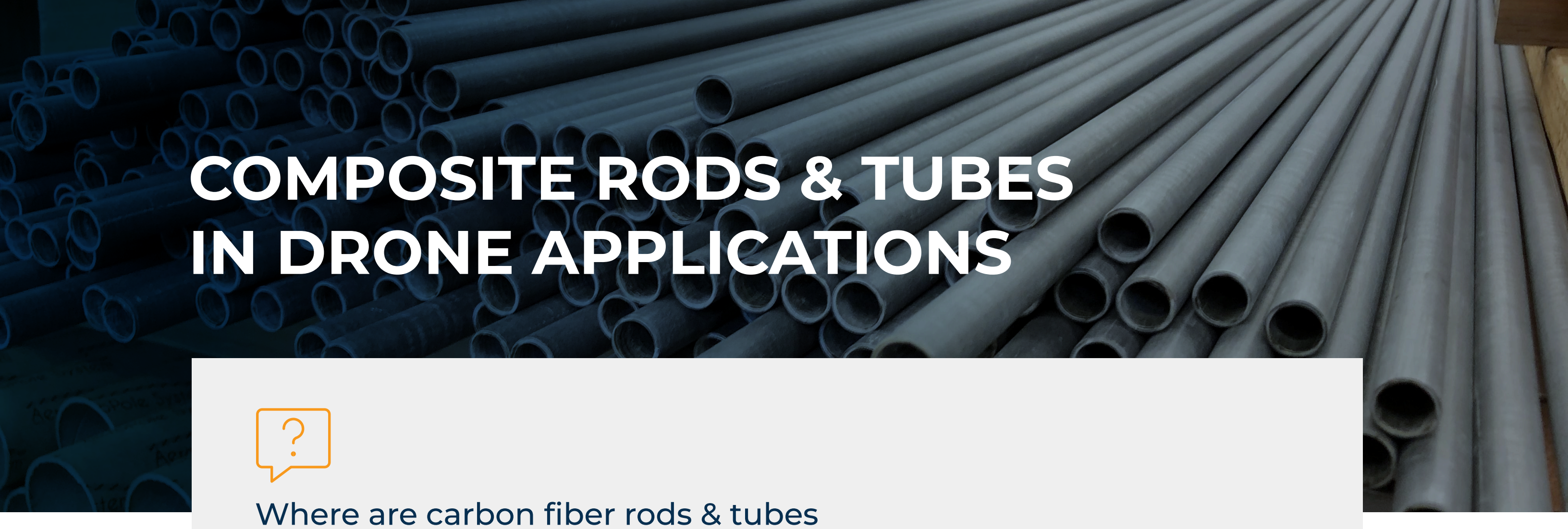
Fiberglass

Affordable, electrically non-conductive, and RF-transparent for use near antennas or where carbon fiber's conductivity creates interference risk. Less stiff than carbon fiber but absorbs impact better.

Best for: antenna housings, non-structural enclosures, electrical isolation applications, cost-sensitive secondary structures

Carbon Fiber vs. Fiberglass at a Glance

Property	Carbon Fiber	Fiberglass
Stiffness	High	Moderate
Weight	Very Low	Low
Tensile strength	Very High	High
Cost	Higher	Lower
Electrical conductivity	Conductive	Non-Conductive
RF transparency	No	Yes
Best for	Primary Structure	Secondary Structure/RF Zones



COMPOSITE RODS & TUBES IN DRONE APPLICATIONS

Where are carbon fiber rods & tubes

USED IN DRONES?

Carbon fiber rods & tubes are used in drone structures anywhere load must be carried, stiffness must be maintained, or weight must be minimized.

Airframes & Fuselage Frames

Roll-wrapped carbon fiber tubes provide the hoop and axial strength needed for primary airframe structure. Custom OD/ID and wall thickness allow precise tuning of stiffness and weight for the specific platform.

Arms & Booms

Pultruded carbon fiber tubes carry bending and shear loads across drone arms and booms. High axial stiffness and excellent straightness tolerances are critical — arm flex directly degrades flight stability and motor alignment.

Wing Spars

For fixed-wing UAVs, pultruded carbon fiber rods and tubes carry bending loads across the wingspan. Consistent wall thickness and straightness are essential for repeatable aerodynamic performance.

Tail Assemblies (Booms)

Lightweight carbon fiber tube assemblies in tail sections minimize moment arm weight penalties while providing the stiffness required for precise control surface response.

Landing Gear Supports

Carbon fiber tubes provide lightweight, fatigue-resistant landing support structures. They handle repeated landing loads without the corrosion risk of metal in outdoor or marine environments.

Internal Structural Supports

Carbon fiber rods and tubes serve as internal bracing, push-pull control rods, and structural ties — replacing heavier metal equivalents without compromising strength.

Cable Management

Carbon fiber tubes provide lightweight, rigid conduit for routing wiring and control lines through the airframe, protecting critical systems while minimizing weight.

DESIGN PRIORITIES BY APPLICATION

- Legs, arms & booms → axial stiffness, straightness tolerance
- Airframes → hoop strength, wall thickness consistency
- Landing gear → impact resistance, fatigue life
- Internal supports → weight, dimensional stability

PULTRUSION VS. ROLL WRAPPING:
How Manufacturing Affects Performance

Which manufacturing method results in a stronger part,

PULTRUSION OR ROLL WRAPPING?

It depends on the loading. Pultrusion is superior for tension and compression. Roll wrapping is superior for complex, multi-directional loads, including bending, torsion, and high hoop strength.

Pultrusion

Pultrusion pulls continuous dry fibers through a resin bath and a heated die, curing them into a constant cross-section profile. Fiber orientation is primarily axial, which maximizes tensile and compressive stiffness along the length.

Use pultrusion when:

- Primary loads are axial (tension, compression, bending)
- You need consistent cross-section over long lengths
- Dimensional consistency and tight tolerances are required
- Cost efficiency matters for higher-volume runs

Specs: What Engineers Need to Define

Parameter	Notes
OD/ID	Determines wall thickness, and drives stiffness and weight
Wall thickness	Thicker walls provide more strength, but also more weight
Length	Off-the-shelf or custom-cut
Primary load type	Based on axial, bending, torsion, or combined needs
Fiber orientation	0° axial for most structures; off-axis for torsion/hoop
Secondary operations	Machining, drilling, end fitting, custom attach points

Roll Wrapping

Roll wrapping applies pre-impregnated fiber sheets (prepreg) around a mandrel at controlled fiber angles, then cures them under heat and pressure. Applying prepreg in various orientations builds multi-axial strength for torsion, hoop loads, and off-axis forces.

Use roll wrapping when:

- Loads are multi-directional (torsion, combined bending + shear)
- Custom wall layups are required for specific stiffness tuning
- Cosmetic surface finish matters
- Application demands tailored resin systems

NASA

CASE STUDY:
NASA INGENUITY HELICOPTER

NASA partnered with Goodwinds Composites to develop carbon fiber landing leg tubes for the Ingenuity robotic helicopter, designed to operate in the extreme conditions of Mars.

Overview

The Mars 2020 Ingenuity Helicopter required ultra-lightweight structural tubes capable of surviving launch loads, deep-space transit, Mars atmospheric entry, and repeated powered flight in near-vacuum conditions at temperatures ranging from -80°C to +20°C.

Challenge

Standard composite tubes weren't sufficient. The application demanded custom roll-wrapped tubes with tailored resin formulations for low outgassing in vacuum, thermal cycling stability across extreme temperature swings, and precise dimensional control for integration into a vehicle with almost no margin for error.

Approach

Goodwinds Composites produced custom roll-wrapped carbon fiber tubes engineered specifically for the mission's thermal, structural, and outgassing requirements — collaborating directly with the NASA engineering team on material specifications and tolerances.

Outcome

Ingenuity completed its first flight on April 19, 2021, and continued operating well beyond its original mission scope. The structural tubes performed without issue across dozens of flights in one of the most demanding environments ever faced by a composite component.

Key Takeaway

Custom roll-wrapped carbon fiber tubes from Goodwinds Composites have been validated under conditions that exceed virtually any commercial drone application.

FREQUENTLY ASKED QUESTIONS

How does material choice impact drone performance?

Material selection directly affects weight, stiffness, durability, and environmental resistance. These are key factors that influence flight efficiency, stability, and lifespan.

What are the biggest structural challenges in drone design?

Designers must balance lightweight construction with the need for stiffness, durability, and resistance to vibration, fatigue, and environmental exposure.

Why is stiffness critical in drone structures?

Stiffness maintains alignment and geometry under load, which is essential for stable flight, accurate sensors, and reliable control response.

What is fatigue, and why does it matter for drones?

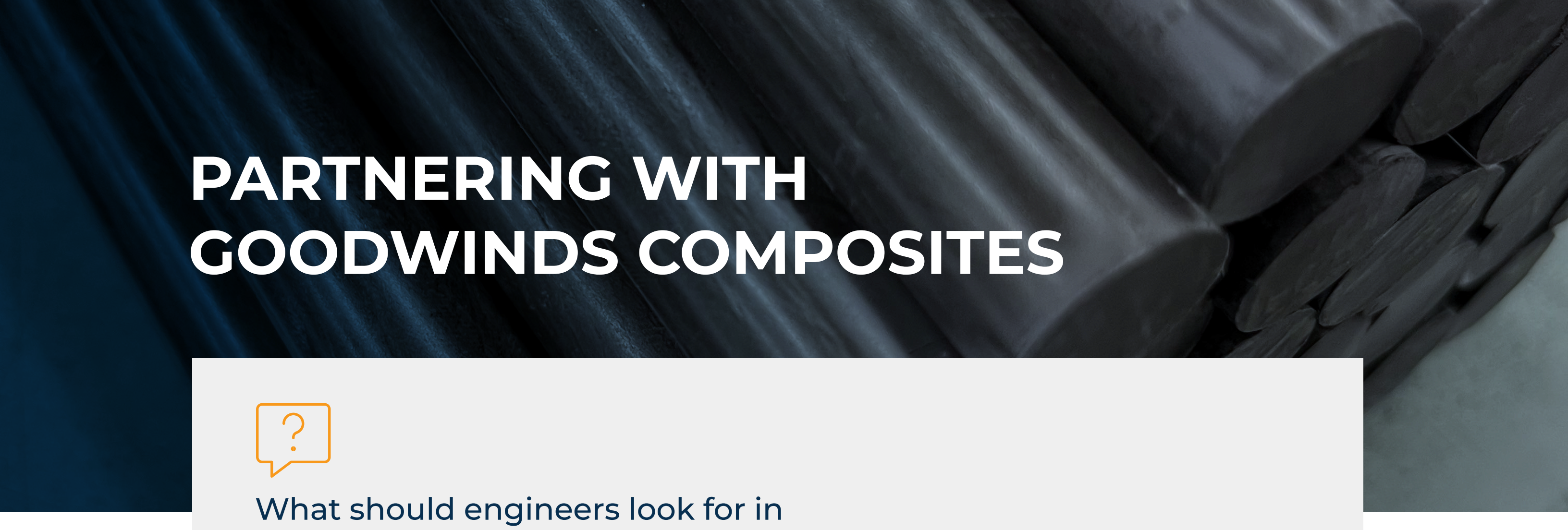
Fatigue is the gradual weakening of a material under repeated stress cycles, which can lead to failure if not properly accounted for in design.

What are common failure points in drone structures?

Failures typically occur at joints, connection points, and areas with concentrated stress rather than along uniform structural members.

How do environmental conditions affect drone materials?

Exposure to UV, moisture, temperature extremes, and corrosive environments can degrade materials over time, impacting performance and reliability.



PARTNERING WITH GOODWINDS COMPOSITES

What should engineers look for in

A COMPOSITE SUPPLIER?

Technical knowledge, responsive communication, and the flexibility to support both development and production — without forcing large minimum orders or routing every question through a sales team.

What Differentiates Goodwinds Composites

- **Direct engineer access:** Talk to someone with composites knowledge, not a sales rep reading a spec sheet. Technical questions get technical answers, fast.
- **Low or no minimums:** Development quantities and production runs both welcome. No forcing large MOQs on programs still in iteration.
- **U.S.-based supply chain:** Domestic sourcing and manufacturing. No tariff exposure, no overseas lead time risk, no supply chain surprises.
- **Custom capability:** Cut-to-length, custom wall layups, precision machining, custom resin formulations, and tailored configurations for specific performance requirements.
- **Consistent quality:** ISO 9001:2015 certified. Tight tolerances, documented processes, and products undergo quality assurance checks before they ship.
- **Responsive:** Fast quotes, clear communication, and a team that respects your timeline.

GOODWINDS COMPOSITES CAPABILITIES

- Pultruded carbon fiber rods & tubes (round, square, flat)
- Roll-wrapped carbon fiber tubes (custom layups, resin systems)
- Fiberglass rods & tubes
- Custom cut-to-length
- Precision machining: drilling, end prep, attach points, custom fittings
- Large-scale pultrusion

READY TO SPEC YOUR DRONE PROJECT?

Contact our team of experts to discuss composite rod & tube OD, ID, length, and load requirements. We'll ask questions, make material recommendations and provide a quote. No runaround. No minimum order pressure.

GOODWINDS COMPOSITES

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