futurefibres Industrial

Richard Adams / Business Development Director - Industrial

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1. ABOUT **future** fibres

Future Fibres is a Southern Spars brand, **the world's largest carbon spar maker** and part of the North Sails group, the world's leading sail maker.

Today we are the leading supplier of composite rigging to the yacht industry.

The properties of Future Fibres cables have drawn the attention of many industries outside of yachting, and have seen them used in motorsport, civil engineering, architecture, aerospace or defense among others.

We produce **the most durable, long lasting and strongest composite cables available,** perfectly balancing both safety and performance.

2. NORTH TECHNOLOGY GROUP (NTG)

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North Technology Group originated as a worldwide sail making with North Sails in 1957 and today includes a diverse family of companies serving marine and manufacturing markets worldwide.

Each was founded on the principle of delivering advanced **performance** through **superior technology.**

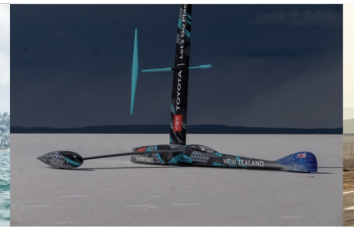
Employing over 3,600 staff and with more than 150 facilities and representation **over 30 countries.**

All divisions of NTG leading their respective markets, we are perfectly poised to deliver world leading products, whatever the application.

NTG

(3,600)

North Sails	Doyle Sails	Quantum Sails	NTG Masts Group	North Actionsports	North Sails Apparel
Sailmakers	*Sailmakers*	*Sailmakers*	*Masts + Rigging*	*Kiteboarding/Foiling*	
1,700	200 (650)	500	800	80	300


3. NTG LOCATIONS

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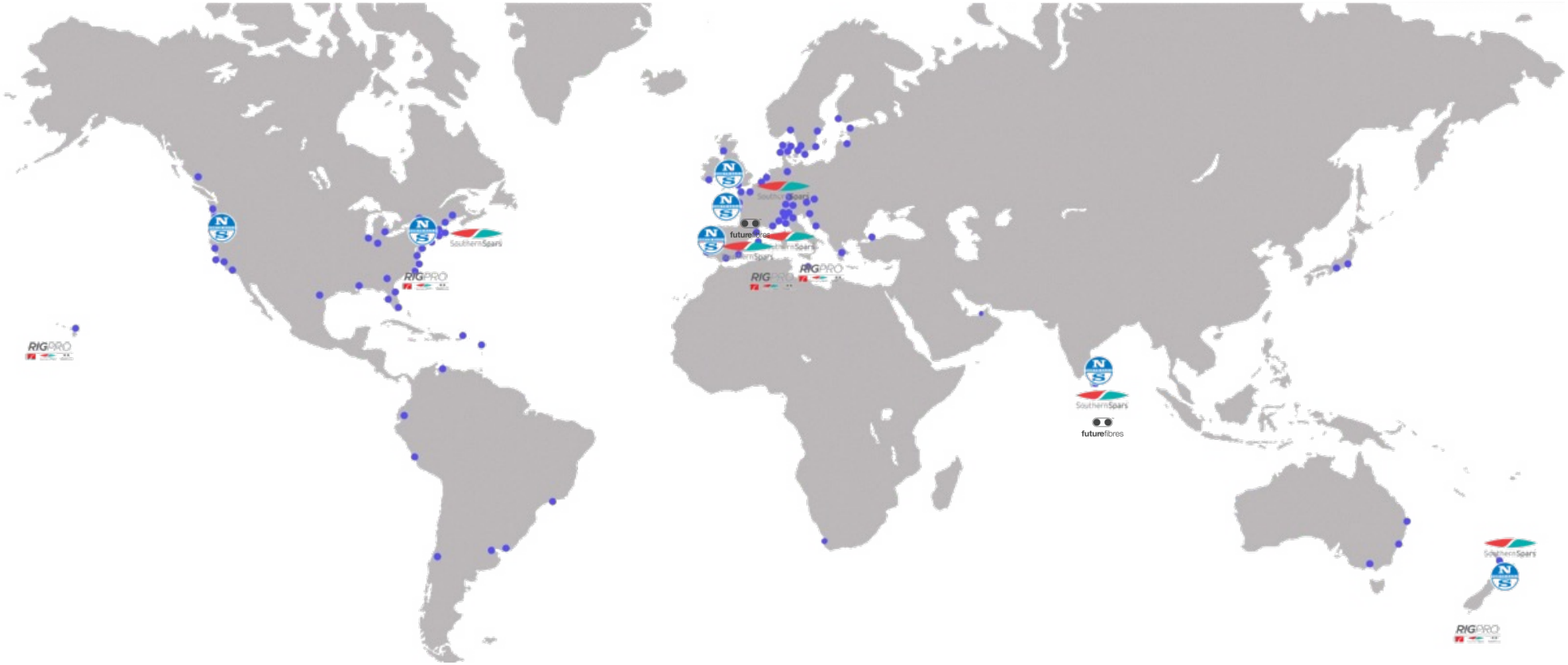


10 MANUFACTURING LOCATIONS
120 SERVICE CENTRES

4. COMMITMENT TO INNOVATION

In the late 90's **Future Fibres** pioneered lightweight composite tensile cable technology for high performance yachting and motorsport.

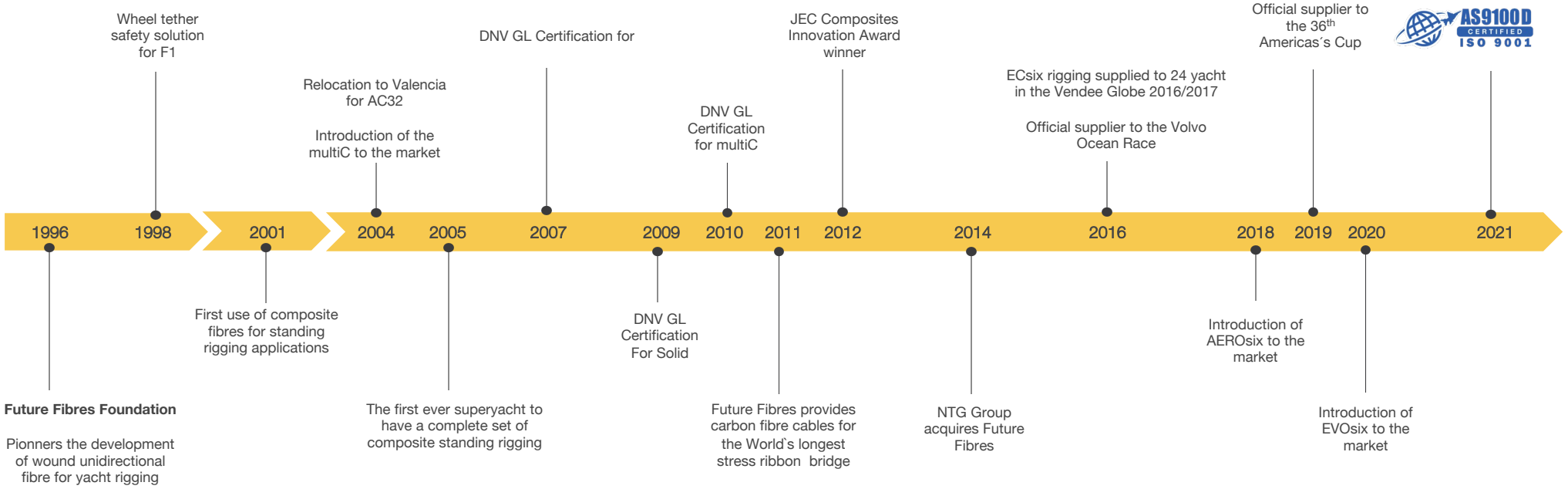
Commitment to innovation and development, quickly established **Future Fibres** as market leaders and the company has remained at the cutting edge to the present day.

The product development journey over the years has led to three main cable manufacturing techniques; **Pultruded Multistrand Carbon, Solid Carbon and Unidirectional Wound Fibre.**

These three product lines are the platform from which **Future Fibres** offers solutions to an ever increasing number of new and diverse market places.

Products are only one component of a solution. At **Future Fibres** solid engineering support is a key part of the service.

5. future fibres Timeline



6. TRUE INDUSTRY LEADER

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COMMITMENT TO TECHNICAL EXCELLENCE
Future Fibres welcomes collaboration with client R&D teams, technical institutes and independent experts in their respective fields.

INTEGRATED DESIGN & ENGINEERING
Utilising the latest composite design software (Abaqus, Solidworks and CAD).

QUALITY MANUFACTURING
Certified production processes, documentation, testing and measurement ensures full traceability and repeatability.

TESTING
In our rigging facility, every cable is tested thoroughly during the production process to ensure the finished cable will perform to its design specification.

R&D
A full time onsite R&D team works in conjunction with leading technology institutions, research labs and external test houses.

25 YEARS

- **More than 25 years of experience**

- **More than 800 projects per year Worldwide**


syntheticS

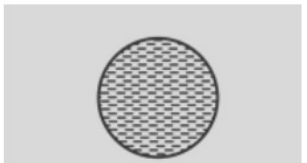
syntheticS

futurefibres

WOUND CABLES

Future Fibres pioneered this low weight standing rigging solution in 2001. Utilising unidirectional wound fibre core, syntheticS rigging is the next step in the evolution of metallic rigging.

The continuous winding used for syntheticS allows the creation of a wide range of cables and strops, which makes this technology fit for a variety of applications.



Utilizes a unidirectional wound fibre core

High performance fibres

Robust, flexible, light and easy to handle

syntheticS

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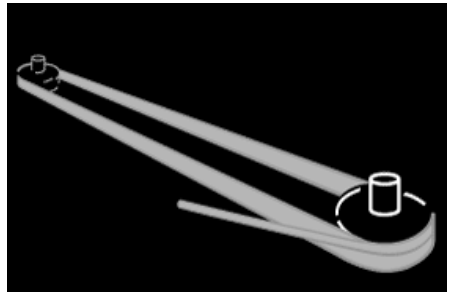
PRODUCT FEATURES

- **UNIDIRECTIONAL WOUND LOOP**, made of various core fibre options depending on requirements: PBO (Zylon®), UHMWPE (Dyneema®), Aramid (Kevlar®, Twaron®, Nomex®, Technora®), etc …
- **COMPACT TERMINATIONS**, metallic ends encapsulated in 2-part Polyurethane resin. Threaded ends, locked in, ball or pin/lash solutions.
- **ANTI-CREEP,** Using the modern range of fibres available, Fibrelite cables exhibit the best combination of strength, stretch and creep.
- **QUALITY ASSURED,** On-site and In-house fatigue test proven.
- **FLEXIBLE,** Easy manipulation and transport.
- **ULTRA LIGHT,** fibre only, no matrix.
- **SAFE,** Continuous technology, ends are inside the cable structure.
- **COST-EFFECTIVE,** automated single step manufacturing process.
- **SCALABLE,** Small soft loops to 85Lm cables at diameters to suit required strength.



syntheticS cables are finished with spools or forks that are integral to the winding process.

The spool can be prepared to accept either pins or soft lashing terminations.

Forks are designed to suit the purpose. The geometry of the fork is designed to load the the fibre evenly and transmit the load to the pin safely.

multiC

multiC™

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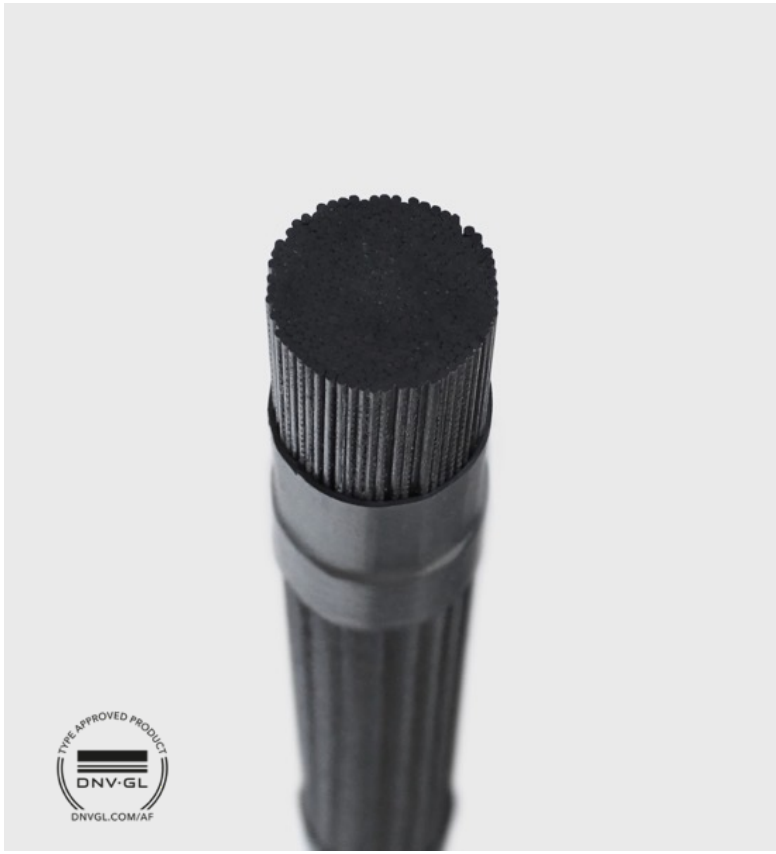
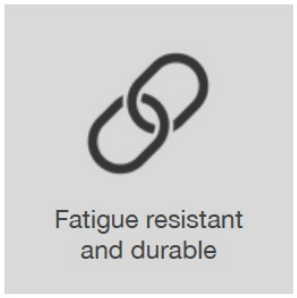
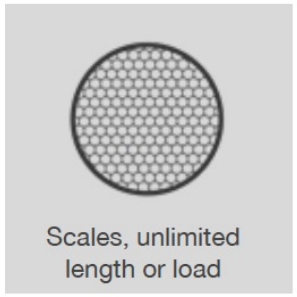
multiC is a multistrand carbon rigging system manufactured out of bundles of separate pultruded carbon rods. It can be terminated in a metallic cone or a metallic spool.

multiC system features a braided jacket which is added to further protect the cable. Standard or intermediate modulus carbon fibre can be used to optimize the cable for mass, diameter, tensile strength or EA or price.







PRODUCT FEATURES

- **NO LENGTH RESTRAINT,** Unlike conventional rod systems composite solutions can be made longer than 6m between joins.
- **EASE OF INSTALLATION,** Lighter cable systems means faster and more efficient construction.
- **LIGHTER, STRONGER,** 80% lighter and 50% stronger than stainless steel rods for similar stiffness. See, Testing 812,000kg break load test, 90mm dia. multiC cable.
- **RELIABILITY,** Inert to environmental elements, excellent corrosion fatigue resistance
- **ZERO FAILURES,** Millions of load off load cycles without failure
- **RESILIENCE,** Rods are independent of one another, so if some rods are damaged, it does not affect the others in the stay. See multiC Axe test.
- Sizes ranging from 50 to >800,000kg UTS.
- Terminated with a conical/friction style fitting using strengthened Epoxy bonding system or a loop around 2 load bearing spools, called Carbon Eye.
- Easily coiled and transported.

multiC

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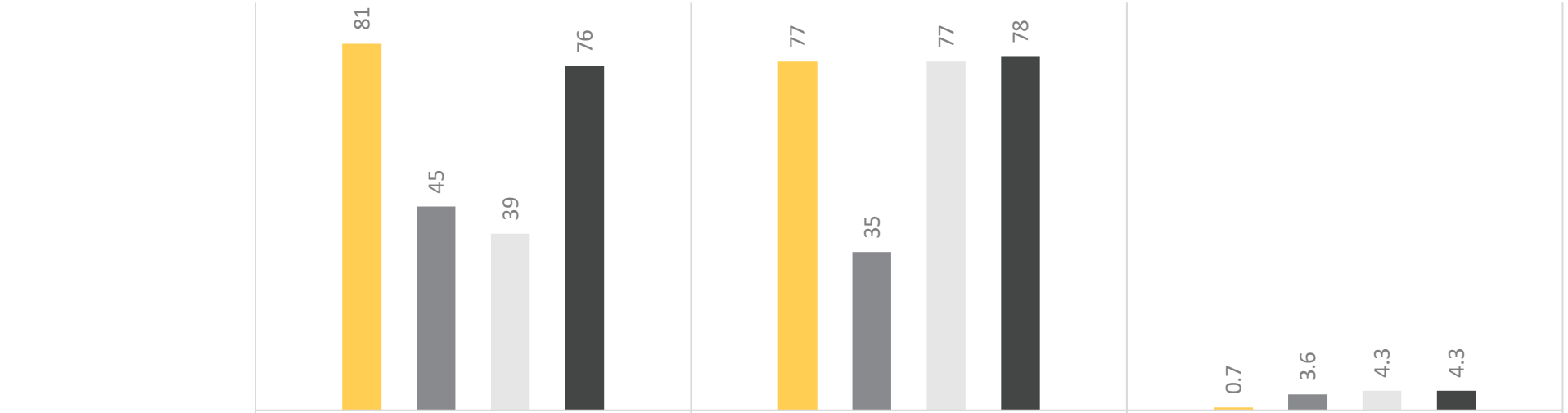
Comparison 26mm Diameter Cable



	Strenght (Tons)	Stiffness EA (MN)	Weight/m (Kg)
multiC	81	77	0.7
1/19 Wire	45	35	3.6
316 Rod	39	77	4.3
Nitronic 50	76	78	4.3

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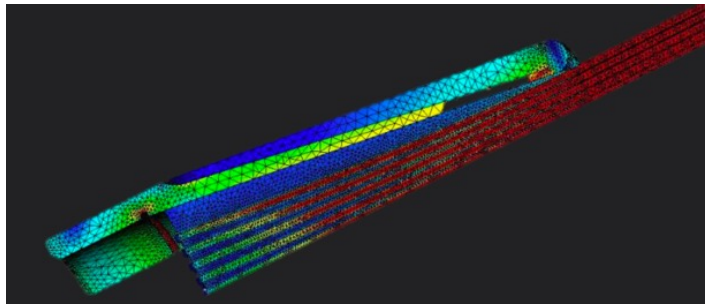
TWO PATENTED PROCESSES

CARBON EYE - CONTINUOUSLY WOUND

The pultruded rod is wound around two fixed points - at a prescribed distance apart, creating a continuous loop of pultruded fibre (Limited length).

NANOLITE CONE - POTTED METALLIC END

Pultruded rods are bundled and cut to length, then passed through the narrow end of a conical metallic fitting (Unlimited Length).



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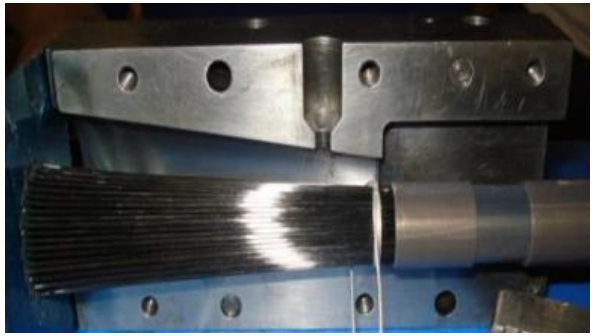
MANUFACTURING

- Carbon eye or Cone end
- Constructed with equal tension on all rods
- Potted one bonded to each rod
- Complex bridle-arrangements possible
- Angle optimized for bending stress
- S. Steel or Titanium body carries tensile load.
- Robust chafe-resistant jackets.
- Proof loading to 125% of max working load.



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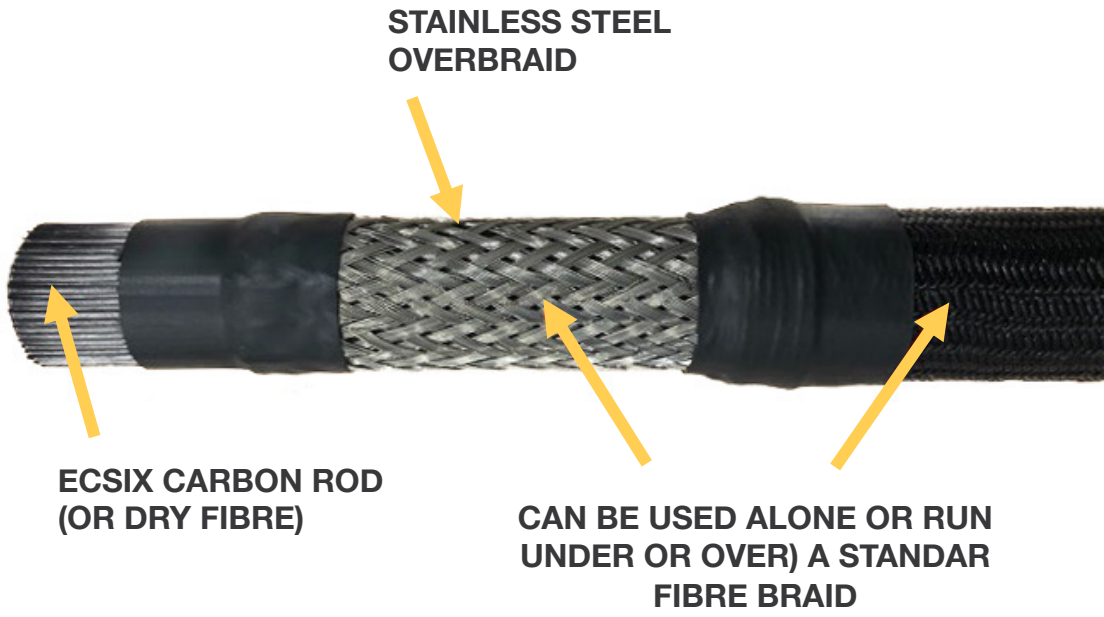
CORE PROTECTION

multiC cables can be jacketed in braided fibres to suit anticipated aggression towards a cable. Differing fibre types can be used to compliment each other against different forms of abuse. All braiding helps further with the already very good impact resistant of multiC cables.
Typical fibres and their uses are,

- Technora- high chafe resistance
- TexTen- high temperature resistance, highly UV stable, very low friction surface preventing climbing, sawing, dirt accumulation and chafe. Surface shows a degree of “self-cleaning”.
- Aramid- high temperature and chafe resistance, fibre “fluffs” and clogs saw blades to prevent sawing.
- Metal fibre braiding is the heaviest solution but can be used to prevent sawing and puncture, additionally it can be used for aesthetic purposes.

Naturally, it is possible to add additional jacketing in vulnerable areas and/or compliment the braided jacket with outer piping in close proximity to the ground.



ROBUSTNESS, IMPACT & FATIGUE

Continuous, aligned, carbon fibre-reinforced laminates are known to have excellent tensile fatigue resistance under constant amplitude tension-tension loading conditions. Results from cyclic fatigue tests conducted on unidirectional carbon/epoxy laminates indicate that the stress-life (applied stress over the number of cycles to failure) response for these materials is almost flat. Unlike metallics, composites do not have a yield point and can be engineered to be loaded closer to their Nominal break load, with a constant and predictable Factor of Safety over an extensive lifespan. Deterioration of mechanical properties occurs very slowly and in predicable fashion in constant tensile condition, allowing for high engineering confidence. This is a significant statement compared to both wire and the perception that composites are fragile.

With statistical modelling we can apply this to new applications.

With a test regime tailored to the application, we can show the percentage to ultimate strength vs no. of cycles at nominal working load at different numbers of cycling (say 25K, 50k, 100K, 250K etc), the resulting fatigue graph is essentially a flat (S-N curve) which allows confidence to engineer to extended year life span.

Our fatigue testing undertaken to qualify the product for DNV-GL certification and has been subsequently repeated as part of analysis for further product developments.
multiC cables have been tested in the laboratory and in real world applications since the first set of prototype cables in 2003 Alongside testing in the laboratory, multiC cables have countless miles at sea and have circumnavigated the globe countless times without failure.
It is important to consider that the end cones are metallic and suitable metal to suit the fatigue properties of the cable and application should be considered.

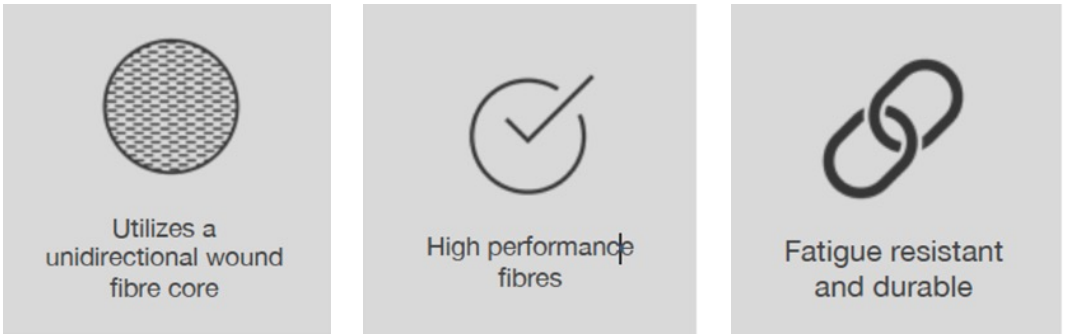

monolithiC

monolithiC™

futurefibres

monolithiC solid carbon is a carbon rigging system manufactured from uni-directional continuously would carbon fibre towpreg.

Solid carbon offers the lowest possible cross-sectional area and the manufacturing method allows for the cable to be shaped in elliptical or aerodynamic profiles with tooling, if required.



monolithiC

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PRODUCT FEATURES

- **UNIDIRECTIONAL WOUND LOOP,** ends are integral to the fibre winding process.
- **COMPACT TERMINATIONS,** metallic end spools or nanolite cones
- **HIGH TENSILE PROPERTIES,** various grades of carbon fibre cable used to create solid carbon rigging. Modulus, strength or other properties can be targeted.
- **MECHANICAL PROPERTIES,** commercially available high toughness epoxies can be utilised in the manufacturing process.
- **ENVIROMENTAL PROPERTIES,** epoxies with high Tg, flame resistance, low outgassing, etc can be used for high temperature, aerospace and space applications.
- **LOW DRAG,** smallest possible cross section area. Option to shape the CSA into elliptical or aerodynamic profiles with tooling.
- **COST-EFFECTIVE,** automated single step manufacturing process.

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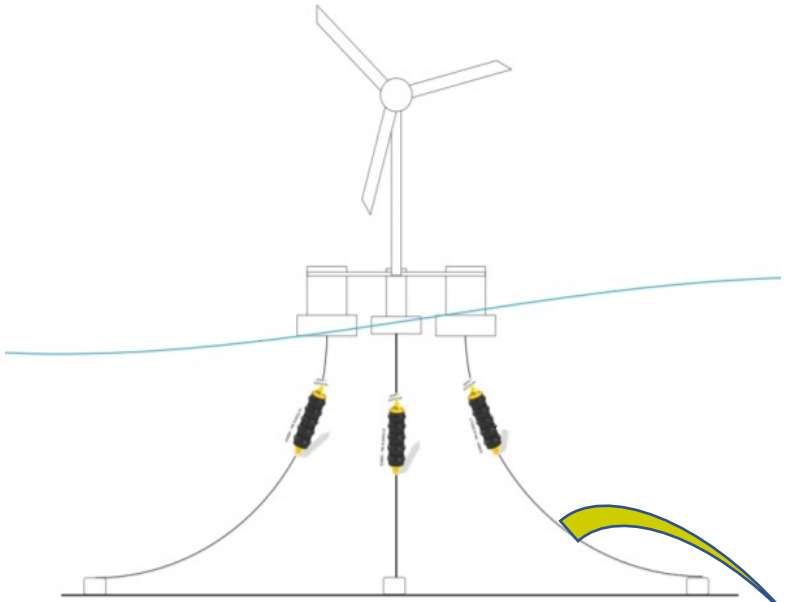
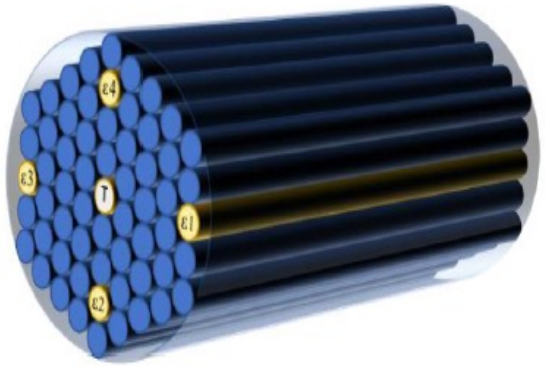
7. Case studies and example projects

Composite mooring cable

- Lightweight
- Fatigue performance
- High stiffness & strength
- Integrated load monitoring
- Antifouling and antibite to dope the mooring cables' raw materials
- Further Flotant information



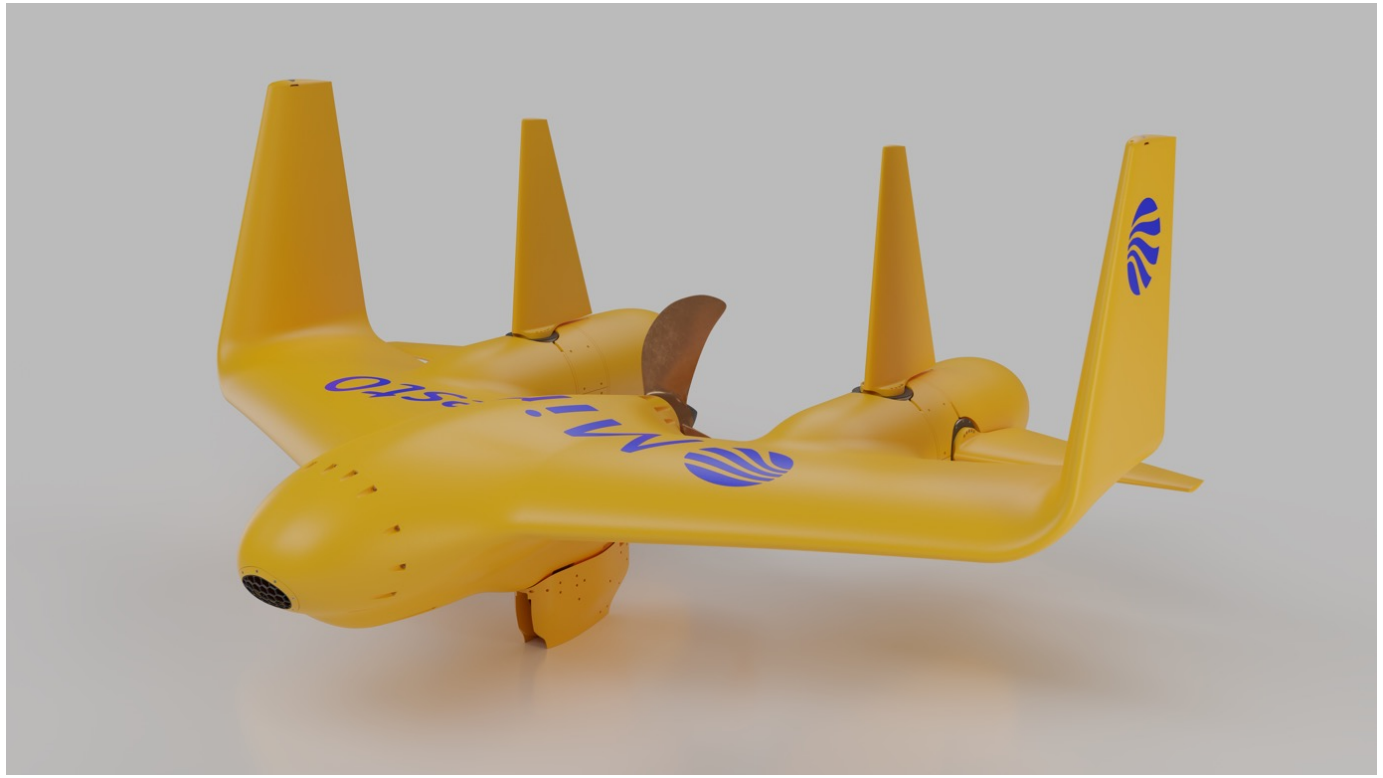


Multistrand cable section. Structural and FO rods

MINESTO Dragon 4 & 12

Anchoring each Dragon to the seabed is a PBO tether from specialists in composite cables Future Fibres. Selected to provide a low-drag, high strength solution, with minimum stretch, Future Fibres' manufacturing process lays PBO fibre in a unidirectional orientation that aligns with the load placed on the tether, meaning that the electrical cables running alongside it are not put under strain. Needless to say, this is essential for the integrity of the electronics and the reliability of electricity generation.

With the minds at Minesto pushing forward with their plans to expand Deep Green marine energy power plants to multiple locations, Future Fibres is proud to be working with leaders in the next generation of tidal energy, and to be playing a part in crafting a brighter future for the energy market.



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TENSILE RIBBON SUSPENSION

ACCIONA BRIDGE

- The world's longest stress ribbon bridge was awarded the JEC Innovation Award 2012 in the construction category. Future Fibres provided composite fibre cables as the primary load-bearing supports of this footbridge built in Cuenca, Spain.
- Increased deck length allowing longer bridge spans between supports
  Lighter construction making bridge erection up to 70% faster (cables handled by people not machines)
- Reduced maintenance costs compared to traditional construction materials with longer service periods than standard wire and rod systems.
- Inert to environmental elements with high fatigue resistance.

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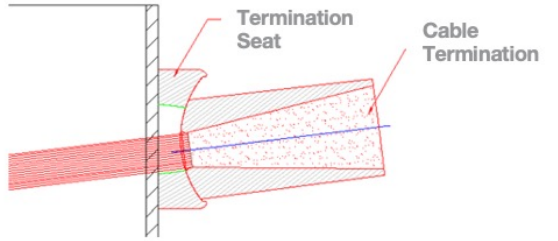
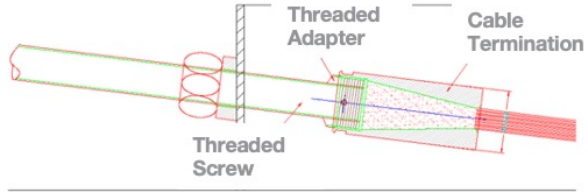
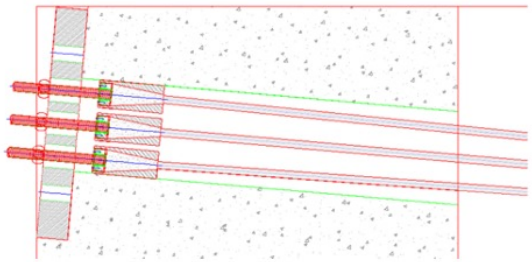
PRE-TENSION & POST TENSION CONCRETE BRIDGES

- Terminations can be designed with any exterior profile to adapt to existing jacking systems.
- Millions of loading / unloading cycles with zero degradation.
- Environmentally inert
- High strength to weight
- Exceptional fatigue characteristics
- Zero creep
- High damage tolerance
- Can be coiled for transport or storage
- Option to build in load monitoring
- Ability to terminate cables on-site, allowing custom lengths and flexibility (high design-length tolerance!)
- Short, compact fittings available to save space in the cable direction
- Many options for cable termination arrangement.



ECsix Carbon Rigging designed for use within scale bridge model at FIU





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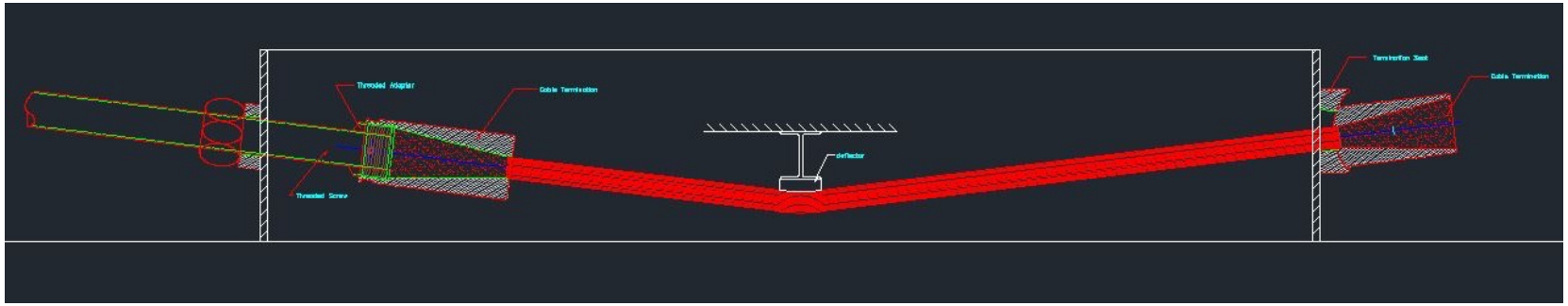
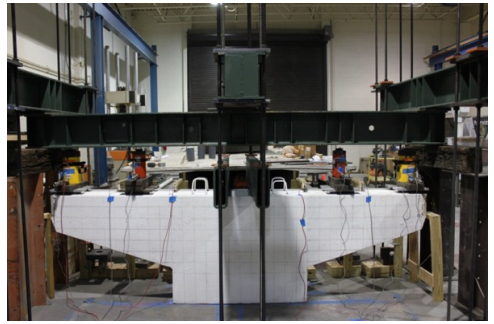
PRE-TENSION & POST TENSION CONCRETE BRIDGES

- Ability to terminate cables on site, allowing custom lengths and flexibility (high design-length tolerance!)
- Short, compact fittings save space in the cable direction
- Many options for cable termination arrangement
- See Florida International University report on application of multiC for concrete bridge structures.



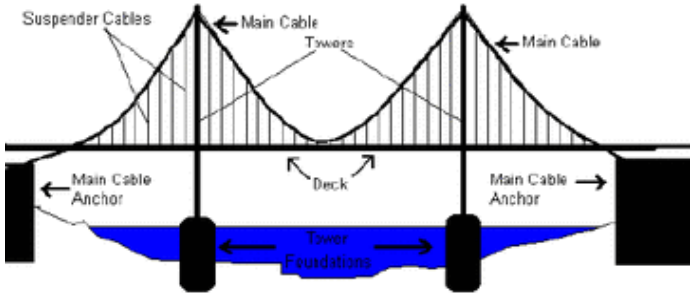


CABLE HUNG & SUSPENSION BRIDGES

Low mass cables require less tension and therefore less deep foundations or less massive attachments, in order to present the cables straight. Straighter cables are able to better support a structure such as a tower, antenna, pylon or bridge deck.

multiC can be used for:

- Main cable
- Spreader / deck cables
- Substantial mass saving reduces engineering and installation overhead.
- Diameter reduction reduces aerodynamic concerns.
- Aero profiling possible and/or vortex shedding devices can be incorporated on the outside surface.
- Composites are environmentally inert, thus reducing maintenance costs.
- Various finishes possible for aesthetic and protection purposes, painting, metallic and braiding options can be utilise alone or in combination.



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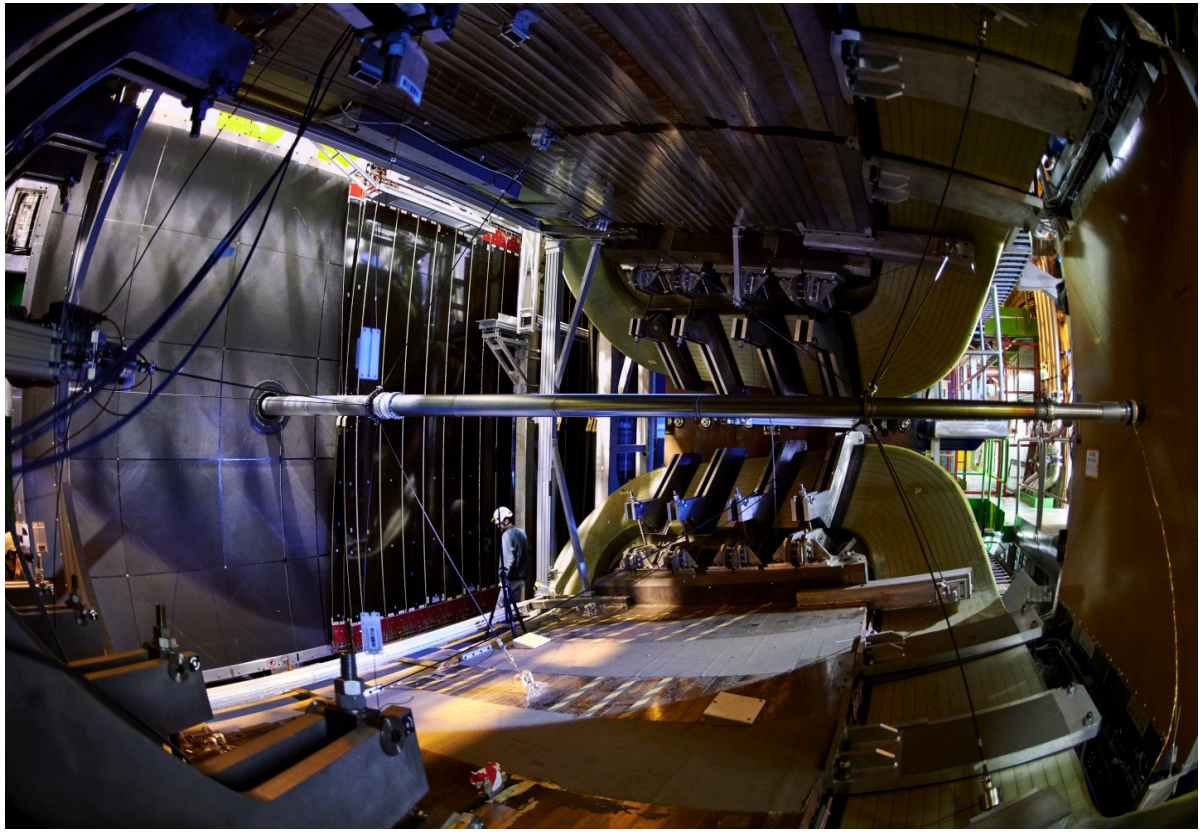
CERN LHCb beam pipe support

The LHCb experiment beam pipe is supported by a highly innovative, lightweight structure designed to minimise interference with particle detection while maintaining strength under vacuum forces.

At the core of this system are advanced carbon fibre cables supplied by Future Fibres. These cables form part of a spider-web-like support network, working alongside composite rods and beryllium collars to precisely position and stabilise the 19-metre beam pipe.

The carbon fibre cables are critical because they provide exceptional strength-to-weight performance, allowing the structure to remain extremely light while withstanding significant mechanical loads. This ensures the beam pipe remains stable without adding excess material that could disrupt particle measurements, making them a key enabling technology in the detector's design.



CHERENKOV TELESCOPE ARRAY LST-1

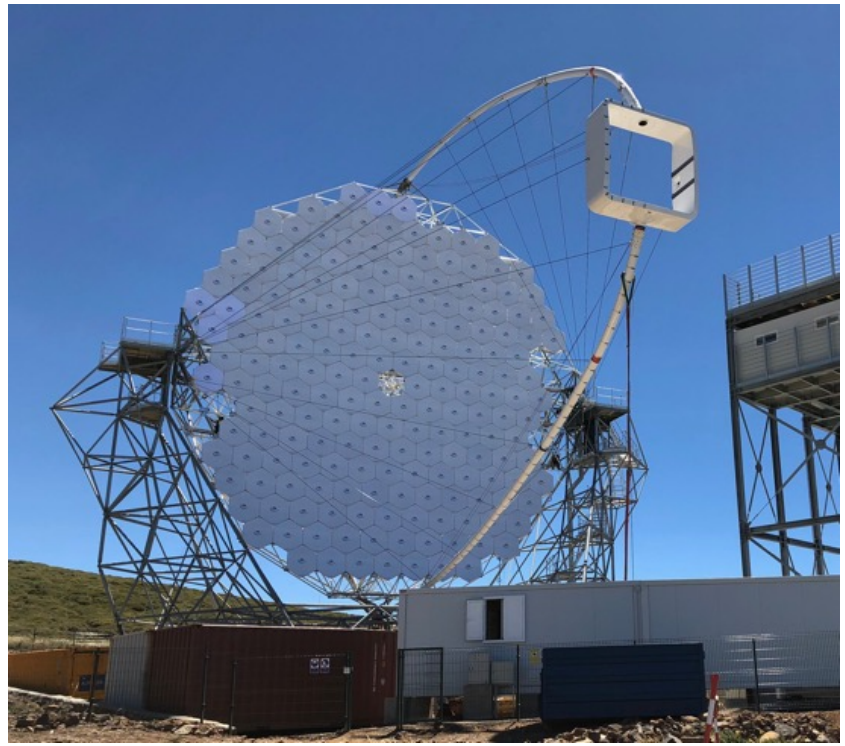
The CTA is the next generation ground-based observatory for gamma-ray astronomy at very-high energies. CTA's unique capabilities will help to address some of the most perplexing questions about astrophysics, seeking to understand the origin and role of relativistic cosmic particles, probe extreme environments and explore physics frontiers. The array will be using more than 100 telescopes spread between two sites in the northern and southern hemispheres.

26 Intermediate modulus multistrand structural carbon cables were manufactured by Future Fibres to integrate into the prototype LST-1, the cables were coiled for transport to telescope's remote position. Their low mass and very low CTE are key to telescopes accuracy and ability to position accurately.

In addition, the location is subject to tough environmental conditions, high winds, high UV, salt in the air and icing up, are all regular events on the mountain top. The composite cables have performed exceptionally.

LST-2 and the follow telescopes are set to being constructed. Following the success of the first installation, Future Fibres are looking forward to supplying to future builds.

https://www.cta-observatory.org



STRATOLAUNCH COMPOSITE CABLES

Stratolaunch is designed to facilitate the launch of hypersonic and aerospace vehicles, with the goal of being ready to deliver services to government and commercial customers. It has an astounding 117-metre wingspan and six Boeing 747 engines providing the immense power needed to take flight.

The set of 34 Future Fibres multiC tensile cables vary in length from 1.48-30.53 metres. They have been designed with minimal cross-sectional diameter, a break strength of 2000kg, titanium Nanolite ends and a white spectra braid – designed to a very precise specification.

Well-proven durability characteristics coupled with consistent temperature performance of multiC technology, made Future Fibres the choice to the engineers at Stratolaunch LLC.

SOME NOTABLE INDUSTRIAL PROJECTS

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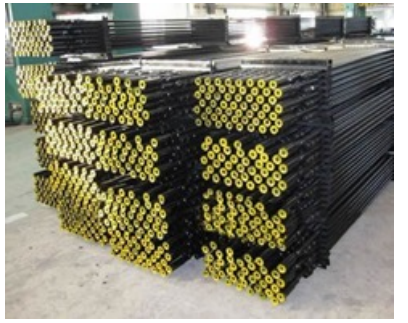
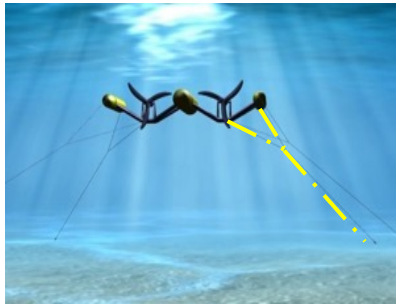
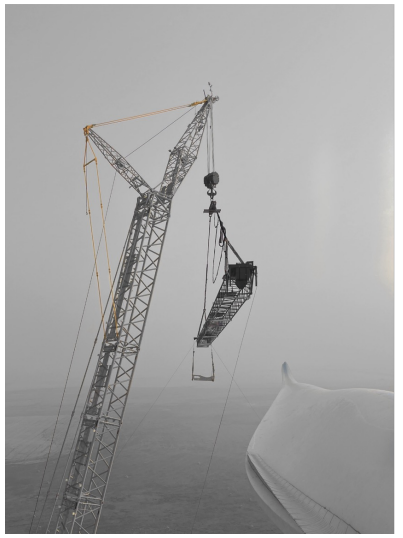
- CNT implementation in CFRP Rigging
- Crane tendons
- Solid Carbon EA1000MN CFRP Cables development and manufacturing implementation.
- Carbon Sucker Rods for oil and gas industry.
- MBDA TBUS Tethers program.
- Automotive/Wheel Tethers – FIA Approval
- Sub Sea tether cables SUSTAINABLE MARINE ENERGY LTD







8. R&D Department

R&D DEPARTMENT

GOAL

To innovate in the composite cable industry proposing new solutions to our customers and to maintain Future Fibres technical leadership in the industry.

TEAM

The global R&D department is composed by a multi-skilled team of 10 people including:

Mechanical Engineers, Master of Science in Plastics and Polymer processes, Industrial Engineers, Master of Science in Materials, Aeronautical Engineers, Chemical and Process Engineers and specialised composite rigging manufacturing and testing technicians.

TESTING

Capability to develop and test innovative products.

Testing

- Electron Microscopy-Studies and analysis.
- Macrotesting-Tensile strength, Fatigue, Impact.
- Microtesting-Composite Coupons testing.
- DSC & DMA.
- FEA-Cable end model
- NDT Analysis

Future Fibres R&D workshop is equipped with modern instrumentation and equipment for rigging research and development including:

- 100,000kg Testbed (Dynamic and Static) -12m in length
- 50,000kg Testbed (Static) – 60m in length
- 20,000kg End Spreader Join Test Bed (Static and Dynamic)
- CNC Mill and CNC Lathe
- Composite Workshop (Autoclave, Prepreg, Infusion, Machining and complete Rigging Cables Processes)
- Winding, taping, whipping, braiding, molding and curing setups.

QUALITY ASSURANCE

futurefibres

Within our build process, every cable is tested thoroughly to ensure the finished cable will perform to its design specification.

Furthermore, **Future Fibres** achieved **DNV** approval for its range of composite cables back in:

- Unidirectional Wound Fibre Cable – 2007
- Solid Carbon Cable – 2009
- Multistrand Carbon Cable - 2010

DNV has been setting standards in technology, safety and quality and is recognised by the industry as a leading authority in its field.

SGS performed an independent ISO9001:2015 approval for our **Sri Lanka manufacturing plant** together to ISO laboratory tests for ultimate strength, fatigue, resistance to chafe and resistance to impact. Production methods, storage and traceability of materials and installation & usage manuals were all scrutinized.

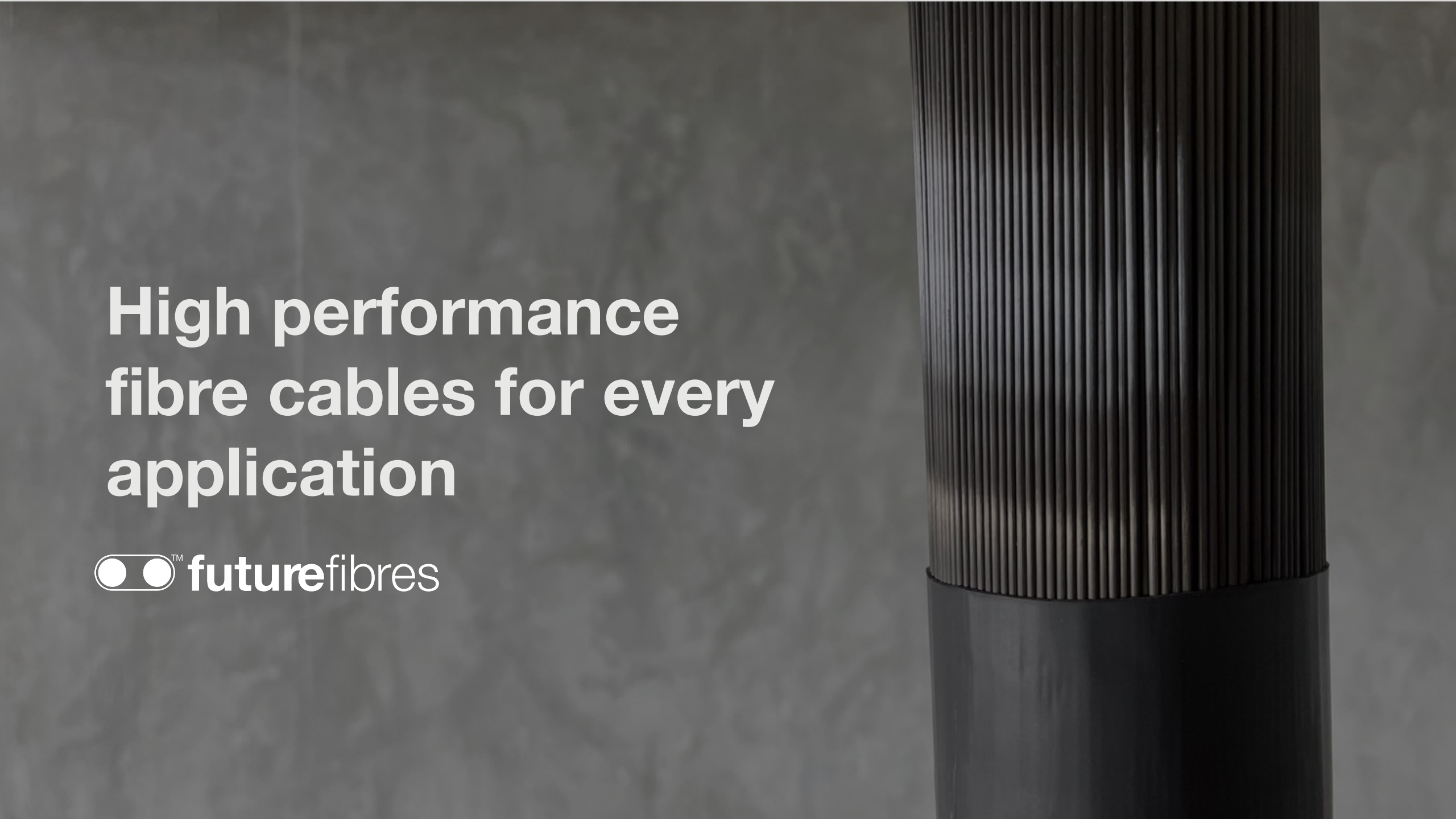
Future Fibres have recently been awarded AS9100D status. We are proud to have passed the stringent auditing process.

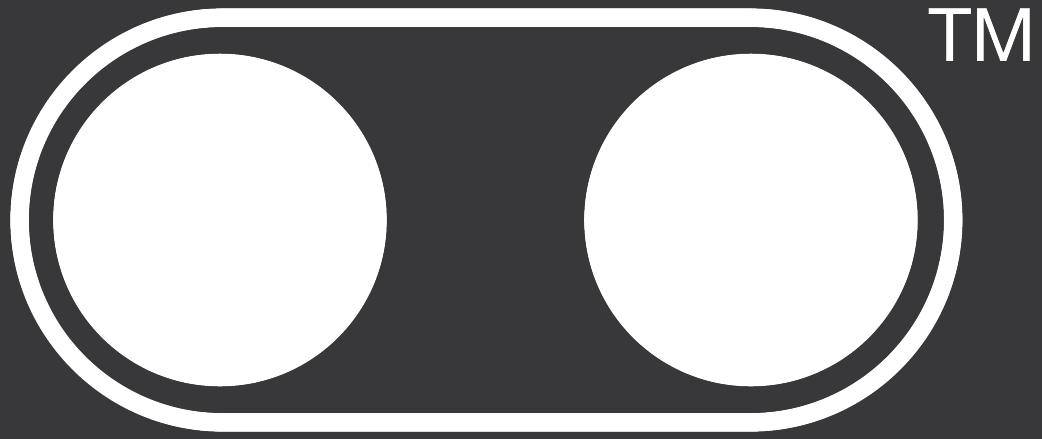
FIA APPROVED
MANUFACTURER: Future Fibres
MODEL: FF-6KJ-103
FIA STANDARD: 8864-2013

DNV

SYSTEM CERTIFICATION ISO 9001 SGS
UKAS MANAGEMENT SYSTEMS 005

AS9100D CERTIFIED ISO 9001


High performance
fibre cables for every
application
futurefibres



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