

The first flax-fiber reinforced composite racing boat : when performance meets sustainability.

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Huntsman Advanced Materials

Modena Fiere Exhibition Centre, October 2010



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Enriching lives through innovation

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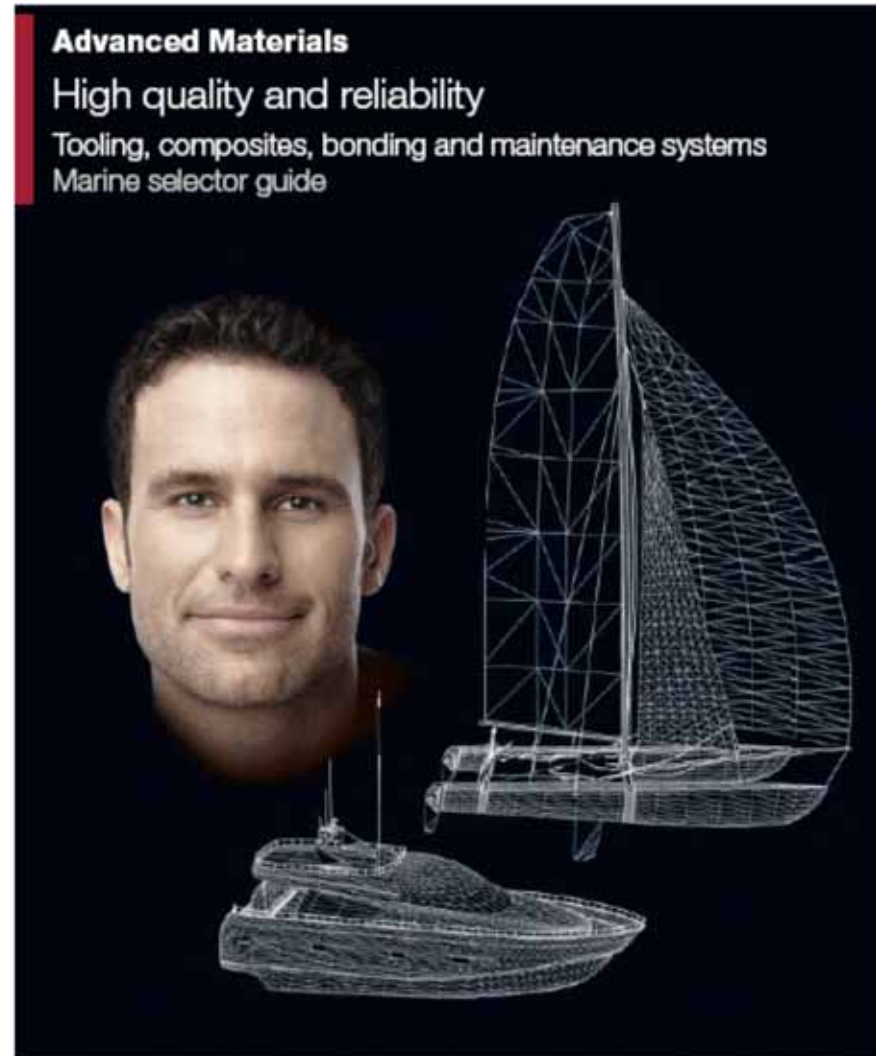


Summary

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Enriching lives through innovation

1. Huntsman Advanced Materials who are we?
2. The Araldite® boat sponsorship: challenges & construction main steps
3. The skipper's feedback



Advanced Materials

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Enriching lives through innovation

Huntsman Advanced Materials



Advanced Materials

Business highlights / Advanced Materials



Enriching lives through innovation

- We are a global manufacturer and marketer of differentiated chemical products aimed at several applications such as **prototyping, modeling, encapsulating, bonding and composites manufacturing**.
- We hold **global leadership positions** in segments such as Epoxy adhesives, Epoxy powder coating systems, Aerospace composites and Electrical insulating materials.

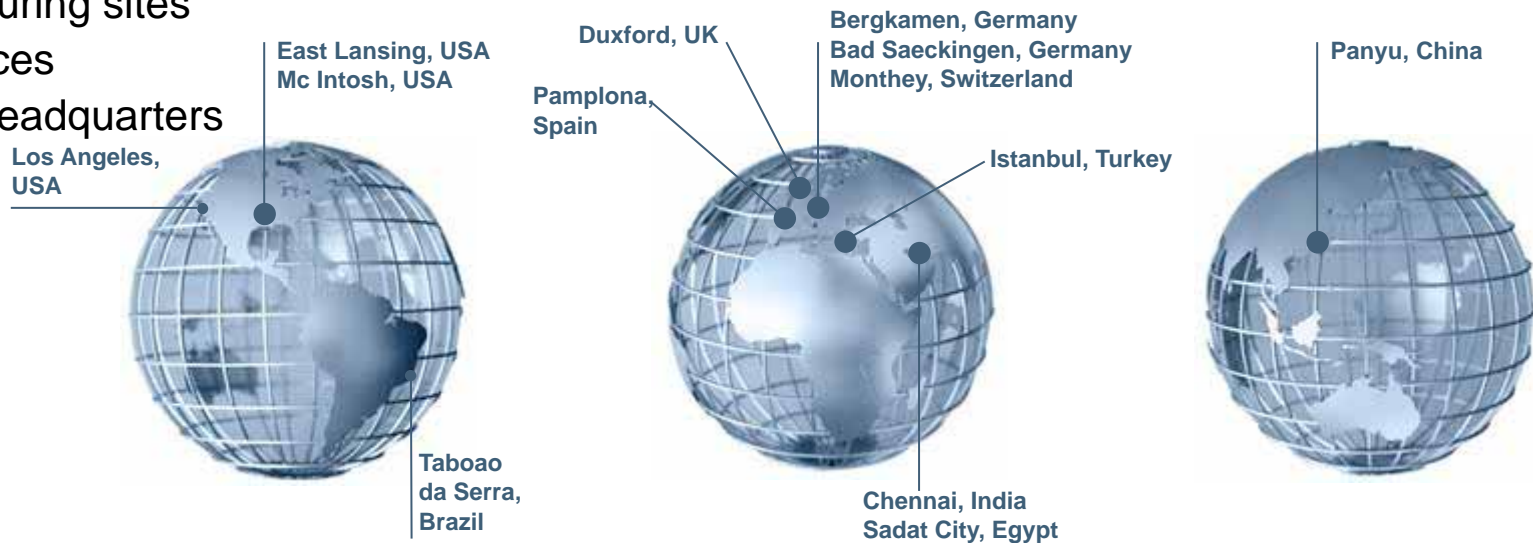
\$1,2 Billion Revenue in 2009
Global sales in more than **90** countries

~2,200 employees
Over **4,500** customers and **6,300** SKUs

13 Manufacturing sites

18 sales offices

3 regional headquarters



Business highlights / Advanced Materials



We serve different end-markets



Aerospace & Defense

Construction

Consumer Do-It-Yourself

Electrical Engineering

Electronic

Others Industrials

Rapid Manufacturing

Sport & Leisure

Wind Energy

Advanced Materials innovation is globally recognized by industry awards (**ICIS 2010, JEC 2009/2010, Materialica 2008, Euromold 2008, Frost & Sullivan 2007, ...**).



Sustainability & Green

We put a strong focus on **bio-composites** obtained from

- natural fibers in replacement of synthetic fibers (glass, carbon, ...).
- a matrix not derived from crude oil (use of bio sourced raw materials to prepare resins and hardeners, in replacement of oil-derived thermoset and thermoplastic resins).



Solutions to designers and shipbuilders

Design / Model



Stereolithography
& machinable board
products



Modeling boards
& Seamless
Modeling pastes

Maintenance

Master model
/ Plug



Surface coat
Coupling layer
Laminating paste
& systems for backing



Standard
& toughened
systems for part
production

Assembly

Mould



Standard
& toughened
adhesives

Parts
manufacturing

Picture : courtesy of Jean Marie Liot / DPPI for SAFRAN

The Araldite® boat sponsorship



The challenges

- **A technological challenge...**

- Build the first boat made up of 50% flax fiber reinforced material.
- Adopt a cleaner production process whilst combining renewable properties of a natural fiber with carbon fiber.
- Pursue our involvement to promote flax fiber utilization (e.g. 2010 JEC award together with Lineo for Artengo's tennis rackets).
- Demonstrate the capabilities of our products.

- **... coupled with a human and a sport challenge !**

- Take part to the 2011 mini-transat 6.50.
- Experience a strong partnership with a young and highly motivated team.
- Share social skills: skipper involved in 'Les Blouses Roses' charity.



Why flax as reinforcement material ?

- A very light yet rigid and very strong fiber.
- Coefficient of thermal expansion is close to the one of carbon; allowing compatible associations in hybrid structures with carbon fibers.
- A high environmental added-value.



Fiber type	Density (g/cm ³)	Tensile strength (Mpa)	Elongation at break (%)	E-Modulus (Gpa)	Moisture absorption (%)
Glass E	2.6	2400	3	72	-
Carbon HR	1.75	3200	1.3	230	-
Kenaf	1.5	350-600	2.5-3.5	40	-
Hemp	1.48	550-900	1.6	70	8
Jute	1.46	400-800	1.8	10-30	12
Sisal	1.33	600-700	2-3	38	11
Cotton	1.51	400	3-10	12	8-25
Flax	1.4	800-1500	1.2-1.6	50-70	7
Basalt	2.7	4840	3.1	89	1-2

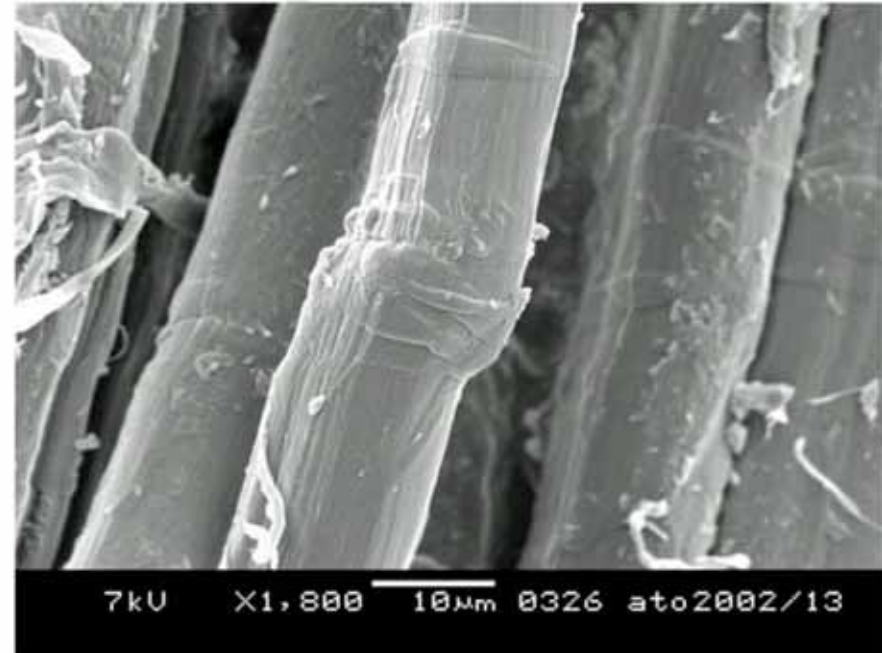
Specific E modulus
 Flax : 55 GPa/g/cm³
 Glass E : 30 GPa/g/cm³

Specific tens. strength
 Flax 1034 Mpa/g/cm³
 Glass E 980 Mpa/g/cm³

Source : Dictionary of Man-made fibers, Koslowski

Technical constraints

- **Produce good quality composite** owing to the poor interfacial bond strength between the flax fiber and the polymer matrix.
- Using UD flax fibers in epoxy composites usually leads to composites with an acceptable tensile strength but a **very poor compressive strength**.



kink bands

☞ Our partner, **Lineo**, provided the diverse fibers especially treated to ensure “compatibility” between the flax and the Araldite® epoxy resin.

Lineo has developed a technology to coat flax fibers with epoxy resins, helping kink bands reinforcement.



Araldite® LY 1564 / Aradur® 3487 system



☞ **A successful system ensuring perfect compatibility with Lineo's treated flax fibers.**

Tensile strength (ISO 527)	max 72-76 Mpa
Ultimate tensile elongation	8-9%
Flexural strength (ISO 178)	max 118-130 MPa
Ultimate Flexural Elongation	10-12%
K _{1c}	0.95-1.05 mPa Vm
G _{1c}	255-305 J/m ²
Maximum Tg	82-86°C
Pot Life at 23°C (100g)	130-160 min
Gel time at 60°C	65-85 min
Mix viscosity at 25 °C	220-320 mPas
Mix ratio	100-34 (weight)
Recommended Cure Schedule	8 hours @ 60°C

The boat construction (1/5)

- This boat was built following the plans of the naval architect **Julien MARIN** and the manufacture was coordinated by the **IDB Marine de Tregunc** shipyard in France.
- The flax fibers are used for the manufacture of the hull and deck of the boat.

1. Preparation of sandwich panels



- Sandwiches reinforced with flax and core of the sandwich is of Corecell™(*).
- One to two plies of UD flax fabrics (215 g/m², nominal thickness 0.96mm) used in the laminate sequence depending on the areas.
- A taffeta of glass E integrated in the hull's bottom planking.

(*Corecell™ is a trademark of Gurit

The boat construction (2/5)

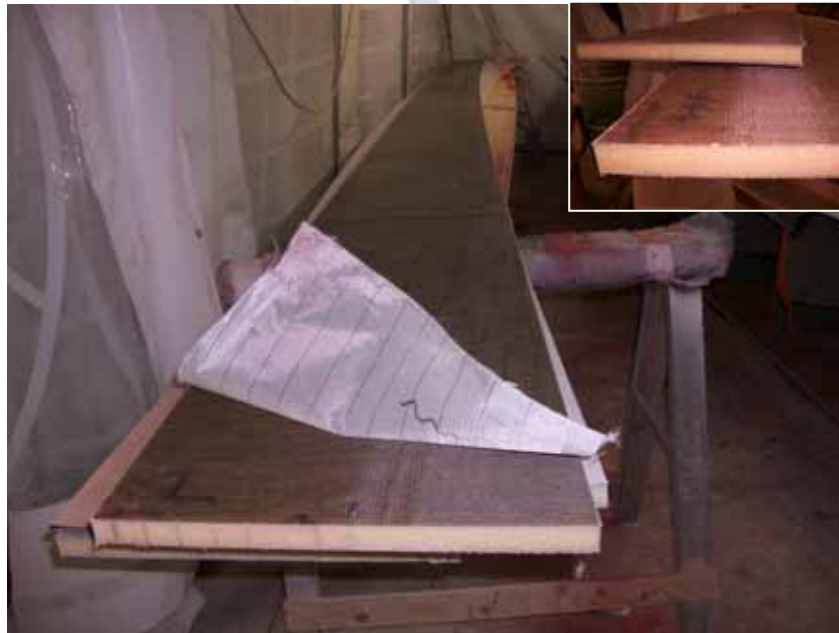
2. Infusion of sandwich panels

- Germanischer Lloyd (GL) certified epoxy system **Araldite® LY 1564 / Aradur® 3487**
- Curing at 50C, 10 hours
- Length of panels produced : 7*1.2 m



The boat construction (3/5)

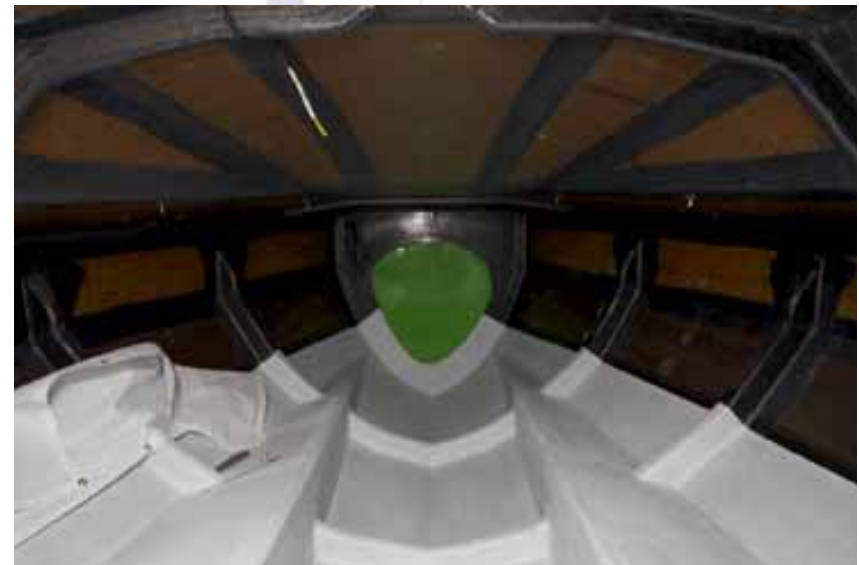
3. Hull and deck



- Panels are slit into boards and then assembled on the mold of the hull and the deck.
- All the composite surfaces are assembled using UD or biaxial carbon fibers bands and epoxy resin.
- A second curing is performed.

The boat construction (4/5)

4. Final assembly



- Mechanical testing of the sandwich composite (deck) : shear modulus of 17.3MPa, flexural modulus of 20.7MPa.
- The mast & spars, bulkheads and the keel are made up of traditional carbon fibers. Other processes were used.

The boat construction (5/5)

- In total, flax fiber constitutes **50% of the weight of the boat's reinforcement.**
- It accounts for **75 to 80% of the hull and the deck's reinforcement.**

'Araldite®' boat	
Hull length	6.5m
Hull width	3m
Weight	750kg
Sail surface	120m ²
Draught	2m
Headroom	12m

The final result gives a boat amongst the lightest of its category considerably increasing its winning chances in the upcoming races.



The sailing boat in action



photo F.Reinhart

Total project timescale : 10 months



September 2010

Conclusion

Building the Araldite® boat allowed us to

- Demonstrate the compatibility issue of flax fibers with epoxy resins can be overcome;
- Share our technology competencies;
- Provide a new application example of our diversified product portfolio in the marine area and show it is possible to merge bio-sourced raw materials and high performance for the marine market;
- **...and share with our partners the same passion for marine, innovation and advanced materials !**

The skipper's feedback Thibault REINHART



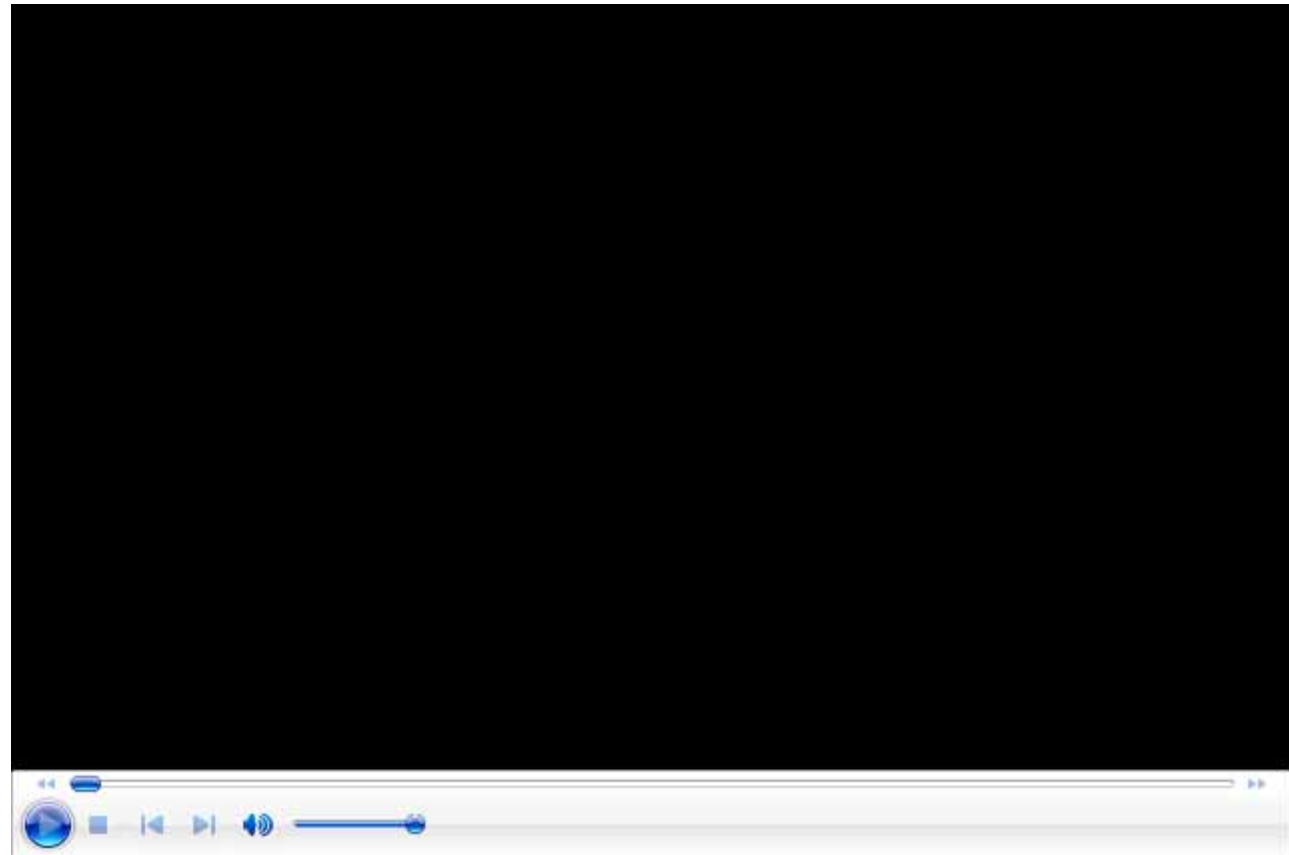
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THE 6.50 TRANSAT 2011 ON A FLAX FIBRE BOAT



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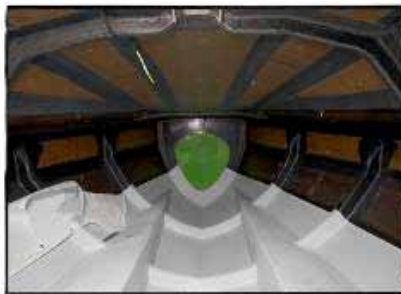


ORIGINS OF THE PROJECT

Why build a racing boat integrating Flax Fiber ?



- Environmentally-friendly crops and mechanical properties similar to fibers often used
- Double ecological and technical aspect for future evolution in a great number of applications (nautical, automobile industries...).



A concentration of power and high technology based on natural flax fibers: a world premiere!

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Araldite®
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PARTNERS

Araldite®

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IMPREGNATION
DE FIBRES DE LIN



Julbo

HARKEN

SELDÉN



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WHY TO CHOOSE HUNSTMAN AS THE MAIN PARTNER FOR THIS PROJECT ?

- ➔ FOR THE TECHNICAL SUPPORT**
- ➔ FOR THE BROAD RANGE OF PRODUCTS**
- ➔ FOR THE INOVATIVE PRODUCTS**

AND BECAUSE WE HAVE THE SAME WILL TO WIN !

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THE 6.50 TRANSAT 2011 ON A FLAX FIBRE BOAT

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2010 – 2011 PROGRAMME

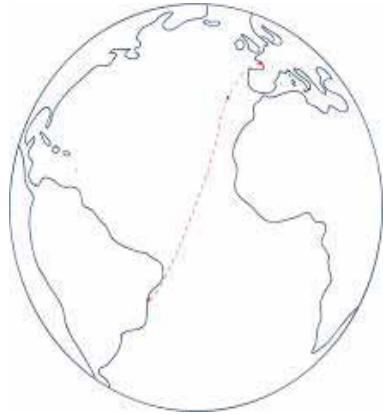


-2010:

- 18-21 September: Mini Empuries (300 Milles, Double)
→ L'Escala (Espagne) – Balearic Islands – L'Escala
- 16-19 October: Mini Barcelona (300 Milles, Solo)
→ Barcelona – Balearic Islands – Barcelona

-2011:

- Training at Douarnenez' 6.50 Pole
- Complete Mini 6.50 racing Season:
Gran Premio d'Italia, Mini-Pavois, Trophée Map, Mini-Fastnet
- September 2011: TRANSAT 6.50 (4500 Milles, Solo).
Main OBJECTIVE
La Rochelle (France) – Funchal (Madeira) – Salvador de Bahia (Brasil)



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THE 6.50 TRANSAT 2011 ON A FLAX FIBRE BOAT

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Thank you for your attention !

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Case story soon
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Marine selector guide



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