DESIGN BRIEF

WHAT DOES IT MEAN FOR A BOAT TO BE ECOLOGICAL

- Increased efficiency in use of material and energy
- Built with materials which extraction or production involves lowest energy usage
- Minimise pollution caused by the use of the boat
- Ensure that the boat is durable and fulfils its requirements for a long time without becoming obsolete or undesirable with time
- Built with materials that minimise the effects of the end disposal of the boat

WHAT IS A FAMILY-SIZED RIVER CRUISER

(According to British Waterways surveys, 1991/1995)

- Typical family size: two adults and two children (with provision for two additional guests)
- Typical trip duration: 0.5 to 1 day is the most popular.

The boat is likely to be used as a "weekender'.

GENERAL ARCHITECTURE

The hull shape was determined by the search for low wave generation.
The ideal hull shape to minimise wave formation is long and slender with the finest possible entry lines. So, I could have gone for a very long, narrow boat or for a multihull.
The displacement must be reduced to a minimum for lower water disturbance.
I chose the catamaran because I felt I could maximise the usable space on board, thus allowing relatively small external dimensions for the given functional requirements.
In comparison with a long narrow boat, this also means lower material usage (cost /ecology).
Furthermore, a slender monohull tends to have larger roll motion, especially for light displacement, while the catamaran provides a much more stable (safe) platform.
The catamaran obviously does not comply with the 6 feet beam restriction for access to narrow locks, but I felt that this limitation was acceptable.

STYLING

It's difficult to think modem without thinking curves.
If we look at boat and car design it can be seen how a modern, contemporary styling is often characterised by curved surfaces, which economic producibility is very dependent on particular manufacturing processes - such as fibreglass moulding for boats and sheet metal cold-forming processes for cars, this latter only feasible on large production volumes.

It's difficult to think modem without thinking fast.
In the leisure boat market, modern lines are often associated with planing hulls and fast crafts.
Notwithstanding the real speed of the boat, modern lines are often streamlined, with angled windscreens, inspiring a feeling of speed.
Where the emphasis is on practical aspects like seaworthiness, sober usage of space and functionality, the styling reverts back to classic lines.
Shapes inherited from history have been developed through the centuries, with a process of refinement based on the requirements of sea and those of their function.
The Green way of thinking is for the elimination of all wastes and all the unnecessary usage of energy, disturbance to the environment, noises, smells.
It evokes a picture of moderateness, sobriety, and quietness. This is in clear contrast with the quest for speed as sensation, the artificial induction of strong emotions, the exhibitionism often related to all the motor sports.

The river

Unlike the open sea, a boat trip on the river has got no “transfer legs”. On a river the shore is always close, and the boat becomes a viewing platform to enjoy the countryside - in both its natural and human-related aspects.
To explore the natural aspects, the boat needs to be unobtrusive.
The human activities in the countryside are related to the exploitment of the land, and are dictated by rules which are aethernal, again recalling tradition.

I felt that such strong requirements in terms of impact on the surrounding environment, could only be satisfied by a "no frills" approach, a styling which looks unobtrusive, for coherence, also in esthetical terms, an appearance that blends in as much as possible with the natural and human landscape in which it operates.
There is one more, and not secondary, requirement, though. A too practical, functional approach could lead to an anonymous appearance, to a visual lack of character. While this could be not so important for the experienced boat owner, who has matured with time a pragmatic attitude, visual appeal is very important to expand the market and attract new potential boaters to the river scene. Appeal without intrusion (arrogance?) is called *elegance*, and once again what lines could be at the same time glamorous and discrete then the timeless elegance of a "classic”?

The idea (the challenge) is to transplant old stylish lines onto a non-traditional architecture like the catamaran, thus freeing the design from the "traditional" limits in terms of use of space on board. The other challenge is the cost: classic lines are usually expensive, related as they are to labour intensive building techniques that rely heavily on craftsmanship.

The organisation of space on board is conceived to maximise contact with the environment and the functional areas are optimised for use as a weekender.
The requirements are satisfied by providing berthing for four (plus two additional, transforming the settee), a cooking stove, a small fridge and a shower/toilet, but the interiors are voluntarily "spartan" to underline the concept that this boat is a "gateway to the environment", rather a place to lock oneself in.
Ample space on deck is made possible by the catamaran configuration, and the wheelhouse allows a panoramic view so that the focus can be on the surrounding scenery even when the weather is not so good. Plenty of covered, open-air seating is provided in the after cockpit.

MATERIALS

Materials can be 'ecological' in three ways:
- Energy used in the production and in its modification
- Durability
- Disposal

In addition, the material needs to be suitable for use in a boat and in this particular case cannot be expensive to buy and process. Since the boat is going to be used in locks, the material needs to provide good impact resistance.

Fibreglass and all the fibre-reinforced plastic are among the least ecological materials. They are a mixture of very diverse substances that cannot be easily separated, and the resins currently used emit highly toxic vapours when processed.

Wood is arguably the most environmentally desirable material, provided that care is taken to the source. The indiscriminate exploitment of Tropical forests hardwoods is in itself an ecologic catastrophe, while timber produced in North American plantations is usually grown in a sustainable way.
One problem with timber in boat construction is its need for continuous maintenance. Recently, though, wood has come back as a popular boat building material with the addition of impregnant

resins that substantially improve its durability in water by transforming it into a chemically stable material.
These resins, however, are comparable to those used in fibreglass - and thus unsuitable for an environmentally-friendly construction.
The only option for wood in boat construction to be both cheap and green is in the form of marine plywood assembled with 'traditional' glues. The shapes are to be kept simple (developable surfaces), and the building technique is relatively easy, thus allowing semi-skilled or even "do-it-yourself" construction. A greatly economical solution is to provide kits with all the pre-cut (C.N.C.-machined or laser-cut) wooden parts to small boat yards for assembly, thus radically reducing the building time and cost.

Metals, notwithstanding being finite resources, can be considered suitable materials for a "green" craft.

- The amount of energy consumed in modern industrial processes for the production of steel and aluminium alloys is low.
- The materials are durable and are easily recycled.

Steel was discarded for its intrinsic weight, making it unsuitable for a light construction.

Aluminium is not the cheapest material and complex shapes can be difficult to obtain, thus affecting the manufacturing costs. As for plywood, provided that the shape is kept simple it can still represent an economical option. In ecological terms it is probably even better than plywood: joints in aluminium boatbuilding are welded or riveted with no need for glues or chemicals (provided that proper anodic protection is placed, it does not even need painting); recycling is not only feasible but economically very convenient, given the high quotation of aluminium waste.

With this considerations in mind I left two material options open, *all plywood* and *aluminium/plywood*. In the latter, aluminium is only used for the main structure of the boat (hulls and the crossbeams), while the superstructure, accommodation and the deck, are in plywood. In this areas wood is not replaceable: it provides thermal insulation, it is pleasant to see and touch, it does not require particular protection (not being immersed) and it is in tune with the "traditional" look chosen.
Care must be taken in isolating the two materials in joints.
The shape of the two hulls is kept as simple as possible, (single chine) in order to minimise building time.
The first option would be preferred where the design is intended to be supplied to a number of yards or even to amateur boat builders. The second would be better for production by a single yard with the required technological capability.

PROPULSION

A few options of propulsion systems are available for a "Green" cruiser. At the high end of the emission scale the "softer" option is a petrol engine adapted for PGL gas.
Going down in emissions we could think of:

- diesel engines running on bio-diesel (low-emission fuel made from vegetable oils),
- vegetable oil engines (such as the German Eisbett-KPM)
- electrical engines.

Since the reduction in emissions is our main priority, I decided to go for the "hard" line and install an electrical engine and a set of solar panels to recharge the batteries. The drawback with such a system is, with currently available components, a limitation in performance. Maximum obtainable speeds are modest, as well as range offered by a reasonably sized battery bank. This is not due to the technology but by its current cost: motors and batteries are very expensive when compared to normal internal combustion engines.
I decided to forget the comparisons and base my evaluations on the real performance requirements for an inland water cruiser *as most boaters are likely to use it*. I could see the same approach on other existing electric boats, where the top speed is between 5 and 6.5 knots but the economical

speed to obtain a reasonable range (45/50 miles) is around 4 knots. I opted for an outboard for simplicity of the installation.

PERFORMANCE

To predict the performance of any powerboat we need to estimate its drag in water. Usually, the friction component can be calculated while the wave component is obtained experimentally (via direct model test or extrapolation from systematic series).
Due to the lack of published experimental data on catamaran hulls, I made a fairly gross simplification and estimated the friction drag only, then assuming certain values of the ratio friction/total resistance to obtain the total drag. The results are:

Speed: 7 knots (Fn=0.42) Total Drag: 710 N
(assuming Rf/Rt = 0.5, propulsive efficiency = 0.6)

Speed: 4 knots (Fn=0.24) Total Drag: 186 N
(assuming Rf/Rt = 0.7, propulsive efficiency = 0.6)

Required Brake Power: 4.26 KW (5,7 hp)

Required Brake Power: 0.64 KW (0.85 hp)

MOTOR

The motor chosen is a RESERVOIR RUNNER (USA) 500 OUTBOARD ELECTRIC MOTOR. It provides 6 Hp at 60 V, drawing 95 Amps. It is dimensionally similar to an Evinrude 6Hp, while the propeller is fitted with a KORT thrust nozzle to maximise efficiency at slow speed.

ELECTRICAL SYSTEM

The electrical system was designed to provide a range of about 60 nm at 4 knots, utilising SIEMENS SOLAR (D) components. The chosen system allows, in fact, a range of more than 70 rim. The photovoltaic panels are able to fully recharge the batteries in 4.3 days of average 'British' sun exposure. They are then adequate for a weekend use of the boat. For longer journeys or more frequent use the batteries can be charged overnight from a shore 220V supply.

ACCOMMODATION

The after end of the boat is occupied by the covered cockpit. The cockpit can be fitted with net fences to provide a covered play area for children. The outboard motor is enclosed under the after seat, while under the two side seats are storage bays.
The wheelhouse is accessed through a door in the cockpit. On the left there is an 'L' -shaped settee and table that can be doubled as an “emergency” double berth for guests. On the right there is the shower/toilet cubicle with chemical toilet and sink. The toilet has a separate black water tank (located further down, in the hull) to be emptied ashore with a pump.
Forward of the toilet is the galley, with a two-fire gas cooking stove (the bottles are stored in the cockpit), 35 litre fridge, sink and cupboards.
Forward of the settee there is the steering wheel and dashboard. Steering position is standing (a removable backrest is provided).
On the right side, steps to a companionway give the helmsman easy access to the forward deck for in-lock mooring when short-handed; this is also the preferred (safer) access to the forward deck.
The forward deck is fitted with stanchions and lifelines for safety (this area is also under the constant eye of the helmsman), and storage bays for anchor, ropes and fenders is in the hollow crossbeam.
Forward of the wheelhouse, a low coachroof covers the berth area.
The central dividing panel can be moved, giving the choice between two 4' berths or a larger double and a single. Storage space is provided under the berths.

WEIGHT AND COST ESTIMATION

All costs in GBP

	PLYWOOD		ALU/ PLYWOOD	
	Kg.	£	Kg.	£
PROPULSION				
Outboard electric motor - Reservoir Runner 500	26	2580	26	2580
Batteries - 10x Siemens Solar S10Oss (100Ah, 60V)	250	1240	250	1240
Charge Regulator, Siemens Solar SR20	15	100	15	100
Photovoltaic Panels - 5x Siemens Solar SR100	54,5	2000	54.5	2000
STRUCTURE				
Hulls & Crossbeams - Aluminium - thk. 4 mm (1)			500	3200 (2)
Hulls & cross beams - Plywood - thk. 15 mm (1)	470	2810 (3)		
Superstructure, deck and accommodation - wood	620	3720 (3)	650	5600
Windows	50	250	50	250
OTHER				
Mattresses	30	100	30	100
Kitchen & toilet	70	465	70	465
Fresh water / waste	200		200	
Crew	320		320	
Hardware / Cutlery / Provisions	200		200	
DISPLACEMENT (FULL LOAD)	**2251**		**2311**	
COST		13265		15535
RETAIL PRICE (35% MARGIN)		**17908**		**20972**

NOTES:

(1) Scantlings are probably excessive

(2) As quoted by I.M.S. (Italy) for one-off; production would be cheaper

(3) The estimate includes a 30% reduction in work cost for pre-cut kit