



RODRIQUEZ RHS-140 'CURL CURL' - 1:20 SCALE MODEL

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DESCRIPTION:

The model is based on the Rodriquez RHS-140 surface piercing hydrofoil design. Thirteen hydrofoils of this type were built by Rodriquez in Messina, Italy from 1971 to 1977. The design is derived from earlier craft built by Rodriquez under license to the pioneering hydrofoil design company Supramar AG based in Switzerland.

The particular craft on which the model is based is *Curl Curl* built by Rodriquez in 1972 for the Port Jackson and Manly Steamship Company for operation between Circular Quay and Manly in Sydney. The craft operated on this route from 1973 until 1990 when it was replaced by 'Jetcat' catamarans. In 1991 it was transported as ships deck cargo back to Rodriquez for refurbishment for a new owner.

Detailed plans of the craft were not available when preparing the model plans. The model plans were therefore based on general arrangement drawings of the craft from publications such as Jane's Surface Skimmers and Hovering Craft and Hydrofoil. The hull lines can be derived relatively easily from these drawings as the vessel consists of a series of chines and knuckles. The arrangement of the foils has been determined from these GA drawings as well as photographs of the craft in drydock.

There are several minor features that distinguish *Curl Curl* from other RHS-140's and these are incorporated in the model plans. In particular, the arrangement of superstructure windows, deck fittings and life saving equipment differs from other RHS-140's in operation worldwide.

The craft operated under various colour schemes during its operation in Sydney initially under the control of PJ&MSC and later by the Urban Transit Authority which was later renamed State Transit Authority. The scheme on the model is that of the STA, the last it carried in Australia.

HULL CONSTRUCTION:

The model is built mainly from 2.5 mm plywood. This is more than strong enough to handle the occasional knock without major damage. A water resistant wood glue was used to assemble the hull. The hull side windows (or should they be called portholes?) are incorporated by using 2 mm Perspex strips along the hull upper sides. Separate Perspex strips are used for the forward and aft set of windows on the model, however in hindsight it would have been more practical to use a single continuous strip from forward to aft. The Perspex is bonded to the plywood with Selleys Supa Glue. Raised details on the hull such as doubler plates, lifting lugs and eye plates are of plastic and glued to the hull following priming and sanding. Pintles for windows are bent and cut from 1 mm steel wire and glued in place with Supa Glue. To maintain sharp edges at the chines and deck sides 0.25 mm steel wire has also been bonded to the plywood before priming and sanding.

FORWARD FOIL CONSTRUCTION AND CONTROL SYSTEM:

The foils of the RHS-140 are of a complex shape with various foil sections, chord lengths and dihedral angles. The forward foils of the model are fabricated from strips of hardwood of various thicknesses glued together side by side and then sanded to the correct section shape. Two separate strips of foil with different chord lengths were prepared as the 'raw

material' to construct the forward foils. These were both subsequently cut in half to create four foil elements, two on both port and starboard sides of the bow foil assembly. The upper foil sections are then sanded further to create the transition from wide to narrow chord and the four sections are assembled together in a jig to obtain the correct incidence and dihedral angles (I make it sound more exacting than it really was when built!).

The prototype foils suffered from insufficient tongue and groove joints and regularly cracked at these joints after accidental impacts. The problems were resolved partly by inserting a new hardwood joiner piece at the trouble spots.

Denting of the original hardwood foil edges was overcome by bonding 1 mm and 0.5 mm diameter steel wires to the leading and trailing edges respectively with Supa Glue. These wires, which are continuous from foil tip to tip also served to increase the strength at the section joints.

The RHS-140 *Curl Curl* is equipped with flaps on the forward foils to assist takeoff, trim the vessel and aid in turning. Some vessels of the type also featured a ride control or 'stability augmentation' system linked to these flaps to reduce motions in waves. The ride control was not incorporated on the earlier Sydney Harbour hydrofoils, and the flaps are simply adjusted manually from the wheelhouse.

Flaps were originally included in the forward foils of the model, however these were found to be un-necessary and were never fully tested. The control lines and linkages were difficult to include in the streamlined struts and suffered from excessive play and later also corrosion following immersion in salt water. The flaps were later glued in place and faired into the foils to reduce resistance and the control linkages and wires were removed. Nonetheless, flaps are a feature that could be added if desired, and the plans show ideas on how to incorporate them.

Incidence control of the entire forward foil unit on the model can be achieved by rotating the cross beam connecting the foils to the hull. This was a feature of earlier Supramar designs such as the PT-20 however the foils are actually rigidly bolted to the hull on the larger RHS-140 series hydrofoils. In the case of the model, the crossbeam allows for rigid attachment of the forward foil while still permitting its removal for transportation, repair or alterations. Trimming of the forward foil can be achieved by adjusting a control arm attached to the crossbeam inside the hull. Although in theory foil trim could be controlled by servo while underway, in practice it was found that this resulted in too much play in the forward foil incidence. Consequently, manual adjustment was considered sufficient for the prototype model where adjustments can be made prior to each run to obtain the best setting. Later even this manual adjustment feature was omitted after the optimal foil incidence setting was determined for a given battery load. Design incidence setting on the full scale RHS 140 are apparently 2.5 degrees on the forward foil and 1.5 degrees on aft foil, though the precise definition of these angles is not clear.

The cross beam is of 6 mm diameter aluminium rod and is connected to the hull through two aluminium tube bushes. The ball bearing units originally fitted to support the cross beam were removed following seizure due to corrosion. The rod slides through holes in the foil support struts and is secured to the struts by steel pins (nails actually). A pair of screws through the struts and into the hull on either side prevents the foil unit from rotating from its optimum incidence angle.

Fences are fitted on the full-scale foils to avoid a loss of lift due to ventilation (air drawn down from the surface). These fences seem to be less important at model scale but were added for authenticity, with the penalty of added frictional resistance. Following priming and fairing of the foil surface, the plastic fences were bonded to the foils as shown in the plans using Supa Glue.

AFT FOIL CONSTRUCTION:

Construction of the aft foil is similar to that of the forward foil, however requires essentially only one foil section shape. As with the full-scale hydrofoil, the foils and support struts are rigidly attached to a box beam and the entire assembly is bolted to the transom. On the model the foils, struts and cross beam are all fabricated from hardwood. The twin rudders are hinged at their base on brass ball joints and are snap connected to plastic sockets glued flush into the upper surface of the aft foil unit. The propeller shafts pass through brass tube bushes glued to the foils by Supa Glue. This system works well and has not fractured.

SHAFT STRUTS:

Two pairs of shaft struts are incorporated in the RHS-140 design, on the model these are fabricated from hardwood (struts) and brass tubing (shaft bossings). To give the bossing sufficient thickness a smaller diameter tube is glued inside a larger diameter tube. The brass tubes are glued to the wood struts using ... you guessed it... Supa Glue!

FITTINGS:

Fittings are made from balsa wood, plastic card, stainless steel welding wire and other odd 'nick knack'. Details and hints on construction of the parts are shown in the plans.

PAINTING & MARKINGS:

After innumerable painting and sanding back sessions, the final coat was applied with enamel spray paint. Hull and superstructure windows were masked off before the final coat of 'Fridge and Washing Machine White' which is the whitest white available! Weather deck paint is Humbrol Matt 64 enamel. Antifoul paint is Premium brand 'Blue' [alternatives are Australian Export Gloss Enamel 'WH Sky Blue', White Knight Gloss Enamel 'Bermuda Blue', or Power Plus Touch Up Enamel 'Blaze Blue'] which is a bit darker than it should be while cabin tops are to be finished in Taubmans 'Roper River Blue' [alternative is Australian Export 'WH Ocean Blue']. Life belts and carley floats are finished in Humbrol Matt 82 enamel and reflector strips are added with chrome stick on strips. All lettering is with Letraset or similar rub on decals.

WEIGHT:

The initial intention was to ensure that the model weight was correctly scaled and therefore the model floated at the correct waterline. As the full-scale vessel displaced 66 tonnes full load the corresponding model weight would therefore be 8250 g. During preliminary trials before the model was fully completed performance was somewhat sluggish with a weight of only 5500 g. It was therefore accepted that the model weight should remain less than scale to maintain reasonable foilborne performance. The final model weight, once all fitting are included, is estimated to be 5920 g. A breakdown of this weight is as follows:

	grams	% of total
Hull	2440	41
Superstructure	645	11
Forward foils and cross beam	245	4
Aft foils	150	3
RC receiver, servos, RC batteries etc	550	9
1800 mAh NiCad batteries (2)	660	11

Motors and controllers	585	10
Deck fittings	250	4
Shafting, props and couplings	150	3
Tubing for fenders etc.	75	1 [may increase for strength]
Railing	170	3
Total	5920	100

PROPULSION:

Twin electric motors and NiCad batteries were selected as the propulsion system rather than an internal combustion (IC) engine arrangement for the following reasons:

- Quick and easy set-up, starting and stopping.
- Easy speed control over full operating range from reverse to full forward without the need for any clutch.
- Independent control of each shaft.
- Clean - Free of oil and fuel contamination, no plumes of smoke!
- Quiet and free of excessive vibrations.
- No splitting gearbox required (twin electric motors can be fitted easily).

In particular the difficulty in starting two IC engines (one per shaft) in succession or alternatively the complexity of linking the two propeller shafts to a single IC engine ruled out IC engines as an option.

Disadvantages of the electric motor option are:

- Less power available than the IC alternative.
- More weight due to combination of motors and batteries.
- Relatively short run time between battery change-out or recharging.
- Overheating of batteries and motors due to large current flow and difficulty in providing adequate cooling air.

No reliable powering prediction method was available to scale down the full-scale required power to model scale. This is because of the uncertainty in predicting frictional resistance on the foils at model scale.

Approximate powering calculations for the model indicated a requirement for two 28 to 42 W motors. The most powerful lightweight model motors readily available at the time were Mabuchi RS-550S DC permanent magnet motors rated at 36W each (6V and 6A with 7800 RPM at normal load). These were purchased with fingers crossed! While these motors performed satisfactorily, they have since been replaced with lighter but more powerful motors. One of the problems with the selection of small electric motors for such applications is that they are not supplied with any comprehensive input and output power and RPM specifications.

STEERING:

On the full scale vessel steering is sometimes achieved with a combination of rudder deflection and differential forward foil flap control. On the model the flaps have been deleted and foilborne steering is by rudder control alone. While hull borne, a combination of forward and reverse thrust from the propeller shafts allows for reasonable on the spot manoeuvring, though it is more practical to turn the model through a succession of forward and reverse movements while alternating the helm angles from hard port to hard starboard. The turning rate of the model while moving ahead slowly in hullborne mode with rudders hard over is

reasonable. The turning rate of the model while foilborne tends to be significantly better in one direction than the other. This may be due to the influence of the propeller slipstream since both propellers now rotate in the same direction which is preferable for the pair of motors.

DRIVE TRAIN:

The motors are connected to the propeller shafts through universal joints, the latter being off the shelf accessories available from hobby shops.

A pair of Tamiya 50253 Hornet Speed Controllers as commonly fitted to simple RC cars originally controlled the motors. These had five stages; in the case of a ship these are full astern, half astern, stop, half ahead and full ahead. They use a simple sliding contact and resistor bank to control the voltage to the motors. This is more than sufficient for the model. While these simple controllers were not cheap, there still appears to be scope for more efficiency with more expensive solid-state electronic controllers fitted. The model was therefore fitted with a pair of LRP Electronic 'Runner Plus Reverse' Digital 80 Amp speed controllers in 2002. These provide infinitely variable speed control and negate the need for two servos since they connect directly to the radio receiver unit.

A pair of 1700 or 1800 mAh 7.2V NiCad batteries supply power. More batteries have been linked to the system to try to increase run time, however this results in an unacceptable weight penalty (6% increase in all up weight for a third battery). At one time wiring from the batteries was modified so that the motors could be supplied with power from the batteries in either a parallel (7.2V) or serial (14.4V) arrangement. Although the serial setup of the batteries certainly improved the performance of the foilborne model, the overheating of the motors, controllers and batteries became quite serious and therefore the serial setup was not often used. This would only be viable if you owned your own model shop and had a good supply of replacement motors, NiCads and controllers! Somewhat larger 1700 mAh 8.4V NiCad batteries have now come on the market. These are assembled of seven 1.2V cells rather than the usual six cell packs. Running the model with a pair of these batteries improves foilborne performance and endurance, though the motors will become relatively hot after sustained operation at that voltage and corresponding current draw.

The propeller shafts are mild steel rods of 5/32" (3.97mm) diameter. These suffer from corrosion almost immediately and it would be desirable to change them to stainless steel... if only the correct diameter to fit the existing brass rod bearings was available!

The propellers currently fitted are a right hand pair of Graupner three blade 40mm diameter [originally a left and right hand pair of 55mm diameter three blade propellers were fitted, and 40 and 42.5mm diameter two blade pairs of left and right handed propellers have also been used]. The pitch of the propellers is not specified and has not been measured as yet. These are fitted to threaded ends of the rods. But be warned, trying to cut a thread in the mild steel shaft rods without heat treatment will ruin at least one thread cutting die! The most suitable propeller type for the model is still subject to experimentation. The real propellers are of a much greater blade area ratio than is normally available for models, so the props are not to scale. At any rate, the real propellers are not made of red plastic either!

RADIO CONTROL:

The radio control functions consist of three channels with an optional fourth:

1. Speed control port motor
2. Speed control starboard motor
3. Rudder control
4. Optional forward foil incidence control (never fully implemented on the model).

The speed control could be reduced to a single channel if independent speed control is not required for each shaft or if only a two channel radio control unit is used. On the model a fairly old Multiplex Combi transmitter and receiver are used with a Multiplex servo driving the rudders. There is probably some room for a slight weight saving with a more modern RC set, though with the addition of the new electronic speed controllers, two servos could be eliminated as noted previously.

TRIALS AND PROBLEM FIXES:

Initial trials generally followed a pattern of good one day followed by bad the next. On occasions the model became foilborne easily and smoothly remained foilborne, at other times it would either not become foilborne or would porpoise (front foil repeatedly lifts gradually then drops suddenly).

Problems encountered during early trials and how they were resolved are as follows:

- o Excessive vibration from starboard shaft - particularly between aft strut and foil. Strut brace failed due to vibration. Hull vibrated noisily as a result. Port shaft ran smoothly. Solution: carefully straighten shaft [this was in fact only a partial solution as once bent, the shafts are difficult to straighten well again].
- o Foils, struts, shafting and propellers collect seaweed. Solution: Don't operate in Lake Burley Griffin!
- o Shafting corrodes quickly following operation in salt water. Solution: Either operate in fresh water or replace with stainless steel shafts (difficult to get correct diameter shafting in stainless steel).
- o Batteries, resistors and motors overheated badly. Solution: provide ventilation to aft deck and install small circulation fan units on shafting or via separate motor.
- o Model porpoises at front foil. Solution: fix foil more rigidly so it cannot rotate. Needs to still be adjustable within small range for optimal angle of incidence. Note: this may also be due to Grunberg principle: +ve angle of attack acts on forward foil while hull borne and as forward foil lifts out, but as aft foil rises, -ve angle of attack develops on forward foil and consequently it plunges. The occurrence of this behaviour seemed to be more rapid than would be expected if this was indeed the problem.
- o Propellers ventilate when foilborne. Solution: Fit smaller propellers? Move weight further aft to keep aft foil submerged or reduce stern foil incidence angle slightly. Reduce power slightly.
- o Starboard speed controller does not have electrical contact when full ahead selected. Solution: clean carbon and grit from contacts.
- o Front foils rotate forward when reversing but don't rotate back when going forward. Solution: They should not rotate, fix more rigidly!
- o Model rolls alarmingly when riding high on front foil. This is due to the low righting moment in this condition. Solution: If worried kill the power and let craft settle. Is it self righting? Have not roller it over yet to find out!
- o Water leakage into steering gear compartment. Solution: revise aft linkage seal arrangement, move rudder servo one compartment further forward.

- o Water leakage into motor compartment. Solution: Screw superstructure in place when operating in choppy conditions.
- o model looked tiny in the water at a distance! Solution: Build full scale vessel next time.
- o Rudder servo sluggish. Solution: fix the other servo again and change over.
- o Rudder angle not large enough for tight turn. Solution: none yet.
- o Quick hullbourne turns with props alone are difficult. Solution: Fix speed controller.

The model has since been tested in the Australian Maritime College Ship Hydrodynamics Centre Towing Tank. Resistance data has been obtained over a range of speeds. Head seas motion tests in various wave heights and lengths have also been conducted.