Building the Ice Opti
Ken Smith DN4137

I built two Ice Optis for a 10 and 13 year old daughters. Building any project is working toward a goal by solving a series of problems. The Ice Opti is a moderately simple wood project. It requires a limited set of tools, some skills at fitting and gluing, and considerable skills at scrounging and improvising, as some of the hardware is, to my knowledge, just not available commercially anywhere. [I am working with a supplier so the odd parts might soon become available…see part two next issue or post a query on the IDNIYRA bulletin board.] A fair dose of perseverance is required. If this is your first boat project, more time will be spent head-scratching than building. If you are confident and fairly efficient, this is a 30-50 hour project. Then comes the two real problems: (1) getting (and keeping) your young sailor interested; and (2) sacrificing your own sailing time to accomplish (1). I cannot assist with that, but this article is intended to walk through the major steps in building a sailable Opti DN. Many details are omitted for brevity. This also enhances your problem solving skills.

Materials list:

Hardware	Wood and Rig	Stuff
Steering chock and bearing (Sarns or similar)	1" x 6-3/4" x 8' planed to 9/16" thick. Qty. 3 or 4 ea. 2 side boards, internal structure (Light is good)	~2 quarts (L) of epoxy
Tiller post and bearing (Sarns or similar)	1/8" (3mm) plywood for skins and seat (approx ½ sheet)	1/8 x 3/4" x 24" aluminum bar stock for plank hardware, block attachment
Steering rod (3' version of Sarns, custom)	¾ x 6-3/4 x 5' for stern structure and internals	Ratchet block (1.5 - 2 inch)
Mast step ball (Sarns or similar)	Misc. scrap for tiller handle, or tiller	Turning block (1.5 – 2 inch) three required
Front chain plate (Sarns or custom)	Ash strips ¼" x 80" (enough for 14" when laid side by side) for plank skins	Line or strapping for hooking block to boom. Line for attaching sail
Plank attachment hardware (Sarns or custom as described	¼" x 7" x 80" (pine, spruce or fir) for plank core	Work table, hot glue gun, clamps, saber or band saw, drill, table saw, hand plane
Tiller connection hardware (Sarns or custom)	Optimist mast, boom, sprit and sprit hardware.	Misc. bolts and screws for attaching hardware
Two runner chocks (Sarns or similar)	Mast base (custom)	1/8" wire rope (cable) stainless or galvanized for mast stays
Two side chain plates (Sarns or custom)	Opti Sail with button (heavier cloth, corner reinforcement and flatter cut recommended)	Three shackles or shroud adjusters
3/8 Dia mounting bracket (hound)		Three short runners

Engineering thought. If your mindset is on the strength of a DN, think smaller. The power in the Opti sail is much less, there is much less mast rake, there is no need or desire to pull very hard on the sheet, the plank is short and the skipper is light. Nothing will load up more than the forces required to upset the boat. This means that the loads on the boat are very small in comparison to the DN. No bob stay is necessary. Less structure is needed to support the mast base. The plank can be very flexible and whippy. But the steering system should be bullet-proof and without slop. Light weight is desirable, but not a mandate. Adequate buoyancy is required and necessary for safety, and it comes from building a tight hull. The minimum Opti weight (12 kg or 26.5 lb for the hull, 5 kg or 11 lb for the plank, both include hardware) is easily achievable, though not likely to be critical. The maximum length is 3 m and maximum width is 2 m; build to the maximum. If you cannot translate that to archaic English units, asked the Opti pilot.

When I say "glue" I mean "epoxy." I use Gougeon's West ® System and use fillers as described in the West Technical documentation. Read that book! It provides wonderful guidance. If you only want to buy one speed of hardener, use the slow stuff. You'll need the extra time on some of the more complicated parts. I use two thin coats of brushed on epoxy to seal all the inside surfaces of the wood as I go along. This may not be necessary, but it is cheap insurance against rot and moisture, as the wood choices I made are not very rot resistant.

THE SHORT STORY

1. Find a flat surface for a bench. Hot-glue down the bottom skin including some excess for trimming later. Lay out the boat on the skin.
2. Build the stem (bow) pieces. Build the two internal bulkheads and mast support pieces.
3. Shape the straight side boards.
4. Glue all the little listings, the skinny sticks that outline the fuselage, below the inner bottom and separate the inner and outer bottoms. Glue some bigger pieces the same thickness in way of the plank. Glue the tail base to the bottom. All this is between the inner and outer skins.
5. Glue the inner bottom skin to the top of the listings. Trim it.
6. Glue the stem to the bottom. Glue a stringer between the stem and the bulkheads and glue it to the bottom.
7. Glue the bulkheads and mast support pieces to the bottom and to each other. Add some listings in the corners to increase the glue area where the wood joints are. Don't forget the block where the tiller post bearing will go.
8. Glue the rest of the stem.
9. Glue the side boards to the bulkheads, listings and stem, adding some listings in the corners of the bulkheads where they meet the side boards. Add a 1/8 plywood bulkhead 1/3 forward of the mast bulkhead.
10. Add a stringer from the front bulkhead to the stem.
11. Drill the holes for the steering chock bearing and for the tiller bearing; just drill right through the table.
12. Glue on the front deck.
13. With thinner side boards, a knee is desirable. Add it and gussets.

14. Shape the top portion of the tail piece and shape the seat. Glue them in place.
15. Add braces (if desired). Trim the excess from the top and bottom skins.
16. Build the plank. (See part ii)
17. Paint.
18. Mount hardware.
19. Add the hound to the Opti rig. Add the mast base piece. Tie on blocks at the tack and on the boom over the stern block.
20. Put up the mast, put on the runners, take pictures.

Building the Ice Opti –Part 2
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WORK TABLE AND LAYOUT

A flat table or ladder-bench 10 feet long and 2 feet wide works well as a building bench. I used a 2 x 12 x 10' joist on saw-horse legs, with plywood screwed to the top as my building bench.

After roughing out the bottom shape of the boat from 1/8 inch plywood, leaving an inch or so extra width on each side, I hot-glued the bottom skin edges to the bench. The skin was 4 inches wide at the bow and the stern was 2 feet wide, and the plywood was 8 feet long. On this, I struck a centerline the length of the bench with chalk line. I then laid out the boat on the bottom skin. I generally followed the drawings available on the web, except the hull is maximum length, the width fits my young skipper (20 inches at the top of the seat), and the sideboards are deeper at the seat back. To download a plan, see: http://www.icesailing.org/junior/index.htm .

On the bottom, I drew in the locations both inside and outside edges of the side boards, the two structural bulkheads and the plank contact area. The center of the plank is 2 m behind the center of the steering chock. The steering chock was laid out to match the hole in the Sarns chain plate, about 3.5 inches back from the bow. Now I had a full sized reference to use in making the rest of the boat parts.

Side boards. I picked three boards which were straight, knot free, and close to quarter sawn (i.e. looking at the end of the board, the grain went nearly perpendicular to the board). My first boat was built with basswood, the second with poplar, but pine, redwood, spruce, or fir would probably also work fine. I took all these boards to a millwright and had them planed to 9/16 thickness. Skip this step and the boat will be fine, just a little heavier. All the boards, for convenience, were the same thickness. The two best boards became sideboards. The other(s) became bottom structure.

Sidebar: I could not find basswood wide enough, so I edge-glued a piece to the side boards to get to the proper width. This is a bother which can be avoided by scrounging the proper sized lumber.

Remembering to account for the top and bottom skins, I then laid out the profile of the boat on one side board. I planned to use a seat back angle of 35 degrees and have the seat back intersect the side board at the rear corner. I made the boat deeper than a DN at the rear corner, 5-1/2 inches, the better to hold the skipper in the boat. I used a thin strip of wood (a batten) clamped to the board as a guide to draw a nice smooth curve. Using a table or saber saw, both side boards were cut to this profile. With the boards clamped together, a hand plane was used to make the profile smooth and fair. The side boards would be 8 feet long, except for a little trimming later at the bow.

HULL

The thickness of the hull is two skins (1/4") thicker than the sideboard. The profile of the side board is determined by three things: (1) the length of the bearings at the steering runner, (2) the length of the tiller post and (3) the desired sideboard height at the top of the seat back. The hull profile shape is a nice upslope and curve from the stem (bow), changing to flat between the mast step and tiller post. The hull then curves gently down until the rear seat. The finished hull thickness at the tiller post should be just less than 6-3/4 inches if you find or buy a standard Sarns part. The distance from the steering runner to the tiller sets where these parts will fall in the boat. If you build (or have a machine shop modify) a steering rod, I used 38 inches as the length between centers. Get these parts first, so you know. They can be new or from a scrapped DN hull. The steering chock location is fixed by the stem hardware if you use Sarns; otherwise, it should be a few inches back from the stem so the bearing does not touch the side boards.

Sidebar: I used old style solid steering rods and cut them to the desired length, then drilled and tapped the cut end in a lathe to accept the Sarns end piece. I then had an adjustable steering rod 38 – ½ inches long form bolt hole to bolt hole. Your solution may vary.

Next I set to work on the table saw. The Opti is a double-bottomed boat where the pilot sits (the cockpit) with wood listings separating the inside skin from the bottom skin. With the spare board, I cut off 18 inches to use for interior bulkheads. From the remainder, I cut five or six ¼" strips for listings. This left a board wide enough to use for a plank support structure and the bottom part of the tail structure.

Now the mast support structure. Unlike the DN, there are only two structural bulkheads. One will become the front of the cockpit and the other just forward of the mast. Since the mast compression loads are so much less than a DN, less wood is necessary in this area. See the diagram to understand what the wood structure under the mast looks like. The parts were sized so that the screws from the mast step would end in the vertical pieces.

The two structural bulkheads were trimmed to fit as marked on the bottom skin. The table saw was set to about 6^{o} so the edges of the bulkheads would be flush against the side boards. The heights of the bulkheads were checked against the side boards. The top edges of the bulkheads were beveled to accept the top piece of the mast support structure.

The stem consists of two boards trimmed to be inside the side boards on top and bottom and a few small blocks of wood at the very front to hold them apart. The shapes look tricky, but a belt sander takes them to shape quickly. This is similar to the DN standard plans as in the yearbook.

A strip of wood ¼ by ¾ is required as a stringer between the stem and the front bulkhead to support the top and bottom skins. Notches are left in the bulkhead and stem boards for these stringers, or plan on a generous epoxy fillet where they join.

The outline of the cockpit bottom was glued to the bottom made from ¼ inch listings. More of these ¼ inch listings were glued as cross pieces every three inches. From the 9/16 thick remainders, blocks were placed touching the outline and in about three inches, where the plank mountings would attach. Also from this wood, the bottom of the tail piece was glued to the bottom skin. This piece begins over the plank and extends aft. Listings to close out the bottom were added aft.

The bottom of the fuselage, a.k.a. the inner bottom, was glued to the top of all the listings, leaving about an inch of overhang all around. After the glue set, the overhang was trimmed. The slick way to do this is with a router and bit designed for trimming the edges of formica. One can be found at any good hardware store. It has a straight cutting blade and a little roller. Walking the router around the edges with the roller riding on the surface of the listings does a magnificent job. Alternately, careful trimming with a dremmel saw or a sharp box cutter, and finishing with a small hand plane is also effective.

The mast support structure was glued together with epoxy and structurally strong filler. Care was taken to fill all the gaps in the joints with epoxy and filler. Care was also taken to ensure everything was square and straight for this gluing operation. An extra listing or gusset is desirable to increase the strength of these joints. After the epoxy partially set, the mast structure was glued to the bottom skin. The bottom stringer and stem were glued to the bottom, and the stringer to the front bulkhead. The block that will support the tiller bearing was glued in place under the mast support structure. The rest of the stem parts are glued together, if they weren't already.

At some point, the tiller and steering bearing holes have to be drilled, and I do it now. I can see when everything is lined up and straight. I drill a guide hole first with a 10 inch drill bit of ~1/8 inch diameter and then use a very expensive bit of the right size. I drill right through the table. On purpose. Honest.

Now the side boards get glued on one at a time. Check the fit, as glue is likely to have squeezed out and will degrade fit if it is not removed with a sharp chisel or knife. This gluing operation means filled epoxy on the bottom edge of the side board, on the edges of the bulkheads and the stem. Do not forget the long listing under the cockpit floor along the side board. This is a lot of epoxy to get down before it starts to kick This is one place where an extra set of hands is particularly helpful. Repeat tomorrow on side two.

In the cockpit, I put two knees including a joining cross piece. I also added two small boards as heel braces. I added two gussets set at 45^{o} running from the knees to the end of the boat. The gussets were made from 3" x 1/2 inch wood. The seat back was fit over the top of these.

I glue two pieces of skin together to make the seat back. The trickiest fit-up is to get the seat back to fit tightly against both side boards and the floor in the right position. It needs also to fit tightly against the top piece of the tail stinger. At least in the Opti, the side

boards are straight in this area, unlike the DN. The seat is a structural member. It connects the sideboards to the top part of the tail piece. This means that the fit should be good, a strong filler in the glue and a generous fillet behind the seat where you cannot fit your hand. To be sure, I added a trim piece behind the seat back running side to side.

The front skin can go on at any time now. And the boat can be removed from the table by knifing through the hot glue at the edges of the bottom skin. They get trimmed like the fuselage bottom did.

PLANK AND RIGGING

Make the plank by building a cold molded slightly curved assembly ¾ inches thick. There are several descriptions of building strip and core DN planks on the internet builder's forum. (http://cerebus.winsite.com/DNboard/DNconst.html and find the "plank construction details" string.) This is the same, only shorter and thinner. I left out two strips on the bottom in the middle for the light-weight (45 pound) version of the pilot. To be cheap, ¾ inch high quality plywood would probably work, but for the ugly shape.

Mounting the chocks follows guidelines as described in folklore. There are many methods. I made a BIG triangle of aluminum angle and square extrusion. I use it to glue down both chocks on the OPTI. If it isn't right then, I use shim tape and check on a deflected plank using a dial indicator riding on the edges. I think THINK ICE describes the process.

To mount the plank, I bedded two ¼ inch steel pins in the plank on 15" centers. I took some Ace Hardware aluminum strip (3/4" wide) and drilled it to match. These I mounted on the bottom of the hull with countersunk screws going into those blocks I talked about by the plank location. The plank is held to the hull with parachute cord tied through a couple eyes mounted on the side of the boat. It sounds weak. It IS cheap. I sailed a DN with the same set up in terrible ice, and never had a problem.

The single rear block is mounted to two more pieces of the aluminum strip. They are mounted to the rear stinger at the top rear corner. A clevis pin fastens to the block.

The hound is made from a 3/8 inch screw mount from a good hardware store. I drilled through the mast and fasten a shackle to the hole in the mount. Inside the mast end is foamed to keep it water tight. The base is made from a 1.3" long piece of aluminum bar and is turned to fit inside the end of the mast with a small lip to hold it in place. It is riveted in place. A ¾" inch hole about 7/8" deep serves as the retainer for the mast ball. The shrouds are 1/8 inch Ace hardware galvanized wire with eyes in each end. Shroud adjusters from a dinghy are on all three ends.

The tiller is a Sarns tube with a plywood box over it, with a handle set on it. Since the tube is so long, the handle is not past the end. This is great for telescoping, but I am not happy with it and it may change. The sheet is soft line of about 10mm. Comfort and non-slip is more important than non-stretch. The line came from Fleet Farm.

The outside of the wood parts are sealed with epoxy and the sides are also painted in fluorescent colors, for visibility. I adopted the European preference for the front portion of the sides to be fluorescent yellow-green on the right and fluorescent red-pink on the left. That way, the young pilot knows green means go and red means stop, as an easier concept to reinforce port and starboard right of way rules.

I considered closing the tail to look more DNish. My plan was to use 3mm plywood for the sides and decks. I may yet do this, but am working on problems (1) and (2) first.

OPTI DN -- The Plank

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The plank is the suspension system for the boat. It needs to flex in a gust and flex when the boat hits bumps. The plank should be stiff enough to keep from hitting the ice when the boat is sheeted tight in a high wind. As a rule of thumb, the plank should flex 1-3/4 inches (45 mm) under the weight of the skipper.

Plank flex is measured using an adjustable square or ruler. Measure the height of the plank from the floor in the middle. Stand on the plank and measure the height again. The difference should be at least 1-1/2 inches (38 mm) and not more than 2 inches (51 mm). The following show three examples of the plank thickness, using different thicknesses and woods. The wood and the number of layers make a big difference.

Table 1. Three planks, all seven inches (178 mm) wide.

Skipper Weight Lbs (Kg)	**Wood layers (in inches) ¼ inch = 6 mm**	**Deflection In (mm)**
70 (31.7)	ash ¼ inch; pine ¼ inch; oak ¼ (2/3 of plank width)	1 – 5/8 (41)
90 (41)	ash ¼, pine 1/2	1 – 7/8 (48)
110 (50)	ash ¼, pine ½, 1/8 ash (1- ½ wide) and 1/8 pine rest of width	1 – 5/8 (41)

If the plank is too soft, another thin layer of wood is required. If the plank is too stiff, then the width can be reduced to as little as 5 -1/2 inches (140 mm), the front and back can be carved into an airfoil, or both.

I like three layer planks and here is how I make them. Opti planks are 2 meters long, or 6 feet – 6.6 inches.

The top layer should be a strong wood. Ash or birch or other hard woods are best for this layer. Pine will work as will douglas fir. If you can find a very straight piece and a millwright to re-saw it, you can get him to cut it into one or two boards 7 inches wide and ¼ inch thick. I can never find boards with straight enough grain, so I buy a good board at least one inch thick and long enough. I then use a table saw and cut it carefully into 5/16 inch (8 mm) thick strips as wide as the board is thick. I will tell you how to edge-glue it in a minute. After edge gluing, the piece is planed to final thickness.

The middle layer and sometimes the bottom layer can be a softer wood, such as pine, poplar or white fir. You can find these at any lumber store. I found 5-1/2 by ¼ pine in the trim section of Home Depot. If you are heavier, then using a hard wood on the

bottom is a good idea. The hard woods on the top and bottom can make a thinner plank. Soft woods including pine mean the plank should be a little thicker to get the same stiffness.

If any boards are not wide enough, then you must edge glue them to make the right width boards. Put a piece of wax paper down on your work table so you don't glue anything to the table. Lay out the pieces or strips to make the full sized board. I like to have an inch or so (30 mm) extra length at this stage. Pull the pieces together and put filament strapping tape on one side to hold them tight. I like to have a little tape hanging over the ends and fold it so I can get it off later. You should use a piece near each end and another piece every six inches or so.

Using the tape like a hinge, I fold the first board over so the touching-edges are visible. I then paint the edges with epoxy, then I repeat with the next one. After I have them all, before the epoxy sets, I paint the edges again with a thick coat epoxy filled to mayonnaise consistency with a medium density (or high density, if no medium is available) filler.

I then lay the board flat on the table (taped side up) and lay wax paper on top. Short scrap pieces of wood are put on top and then clamps or weights put on the scrap. Gallon jugs filled with water make great weights. So do zip-lock bags of sand, dumbbell weights. At least four clamps which will hold the plank to the table will be needed later. If you don't have them, 2x4 and long bolts can work.

A word about glue: I use West ® Brand epoxy from the Gougeon Brothers. Epoxy is expensive, but it is waterproof, fills gaps very well, and does not require much clamping pressure or as perfect a fit. Other glues can work, but must be done more carefully to be strong. Epoxy is a two part system which is mixed, and starts reacting. For a while the glue is spreadable, then it gets warm and turns into hard plastic. The epoxy parts are designed by a chemist too stay soft for a certain "working time." For some pieces, a longer working time is a good idea. If your shop is cool or cold, the working time can be extended. Heat speeds thing up. Everything needs to be in place when the epoxy cooks – off. Fillers include milled polyester fiber (flocking), cabosil or silica, or any of the medium or heavy fillers sold by WEST ® or other boat supply place.

If you have two or three pieces to edge glue, and you can work fast, you can stack them on top of each other to cure. Let them cure over night. If you are in a hurry, three or so hours in a warm room is usually good enough for the next step.

Now you are ready to glue the strips together to make a curved plank. It is important to not warp your plank as you build it, so use a level to make sure the pieces are even before you start!

Make a building jig by cutting eight 10 inch pieces of 2x4 on a table saw. Two should be 2-1/4 inches wide and two should be 1-1/2 inch wide. Lay out your table and mark two lines 10 inches from the center of the plank layout, two more 12 inches from the ends of the plank, and two at the ends of the plank. Sit the two bigger blocks next to the middle

lines and make sure their tops are level. The two smaller blocks go on the other lines. Use a hot glue gun to hold the blocks in place. Screws work, but the hot glue gun is easier.

Put wax paper on the blocks and by the end lines so nothing gets glued to the jig. Trim the boards to the right length plus at least ½ inch. If one or two are a little too wide, you can fix that later. Get your weights and clamps ready. Think about how you will hold the edges together. Spring clamps, electric tape, shrink wrap, and small c-clamps all work. Or you can make clamps with scrap and some bolts.

Lay the bottom board on the jig. Paint the top with epoxy. Paint the bottom of the middle layer with epoxy. Before they cure, cover one of these painted sides with a thick layer of filled epoxy. If you have one, use a glue-squeegee to make little ridges of the filled epoxy. Mix in small batches and use lots! Lay these two boards together. Paint the top of the middle layer and the bottom of the top layer with plain epoxy, then spread filled epoxy on one side. Stack the third layer on top. Now clamp the ends of the boards to the table. Add clamps or weights over the blocks. Use spring clamps, or small clamps or tape to hold the edges together and straight. Let cure over night.

Trim the ends to the correct length. Lay the plank on edge and hand plane until there is a nice edge. Check stiffness. If the plank is too stiff, use the hand plane to round out the front and back edges. Keep working until the stiffness is right.

You probably will find some gaps in the edges. Use epoxy with a little thickener to fill the gaps.

Put a coat of epoxy and/or three coats of poly urethane or paint on the plank to finish. Now it is ready for hardware.