Requirement

The aim of the antenna is to be cheap, lightweight, and flat-packable. It must be able to withstand burial without changing its characteristics significantly. There are two aspects to the electrical characteristics that are key:

- the bandwidth (when buried in snow) must cover 200-400MHz to handle the bandwidth of the radar

- there must be enough forward gain to increase the lateral isolation to acceptable levels: the FMCW system means that the receiver and transmitter are operating at the same time, and so the level of direct coupling between the antennas will be one of the main determinants of the maximum gain we can have in the receiver chain (or, equivalently, the amount of power we can transmit).

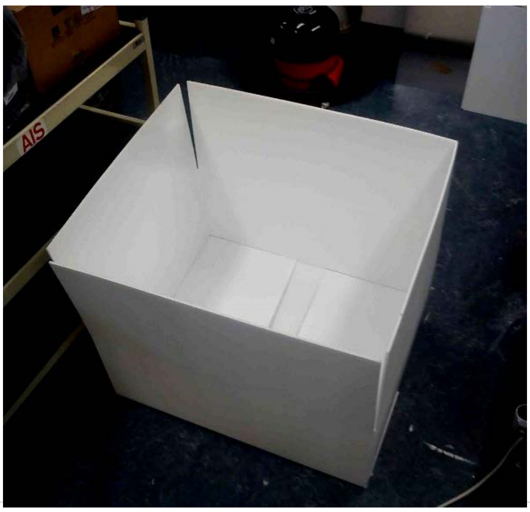
Solution

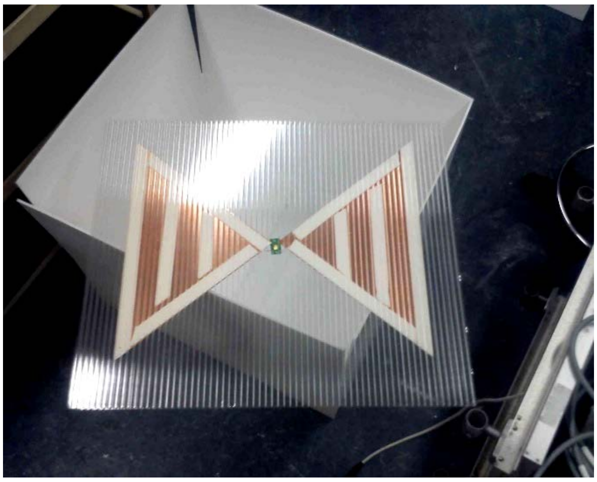
The solution was a bowtie antenna with a passive reflector. The essential components are a pair of triangular active elements, a balun (mounted on a small PCB) making the connection between the elements and the feeder cable, and a passive reflecting sheet around a quarter wavelength behind.

These elements are mounted in a Correx (twin-walled, corrugated plastic) box, which is taped up with duct tape to keep snow out. The boxes are then shallowly buried. The idea is that if snow cannot enter the box during the period of deployment, then the characteristics of the antenna will not change too much. The measurements given here are optimised for an antenna that is buried in snow of density typical of the upper metre or so.

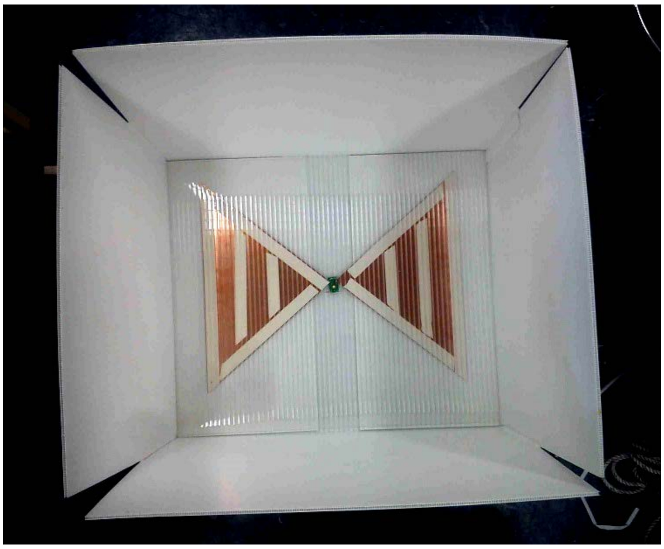
Pictures

The antenna is housed in a Correx (corrugated plastic), flat-packed box. The Correx is 5 mm thick. When flat, the dimensions are 1320x920 mm. The picture here shows the box opened out. The antenna needs to be housed in order to stop the permittivity of the medium within the antenna changing as snow fills in, thereby changing the tuning during the deployment.

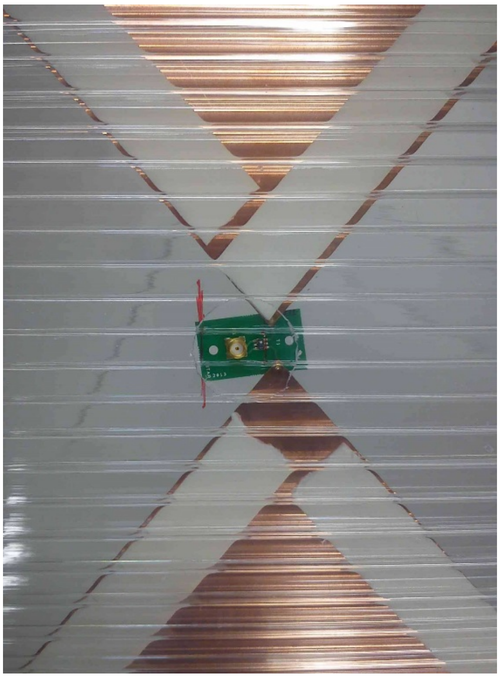




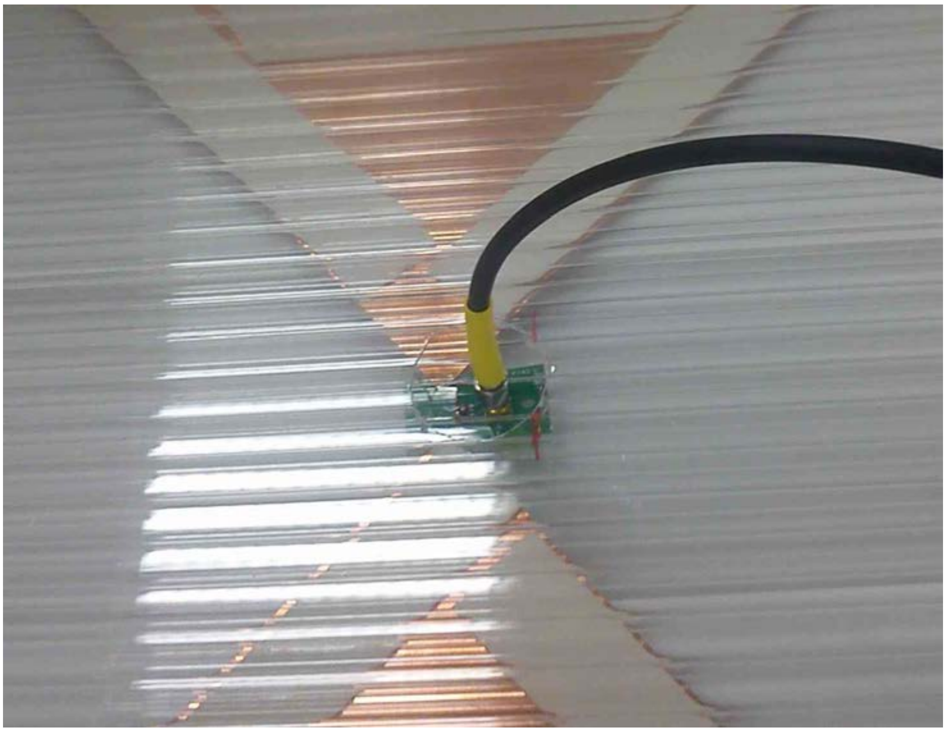
The active component of the antenna is a “bow tie”. It’s mounted on twin-walled polycarbonate roofing sheet, and consists of two copper triangles, connected to the feeder cable with a balun mounted on a small pcb. The copper is attached to the roofing sheet with double-sided adhesive tape.



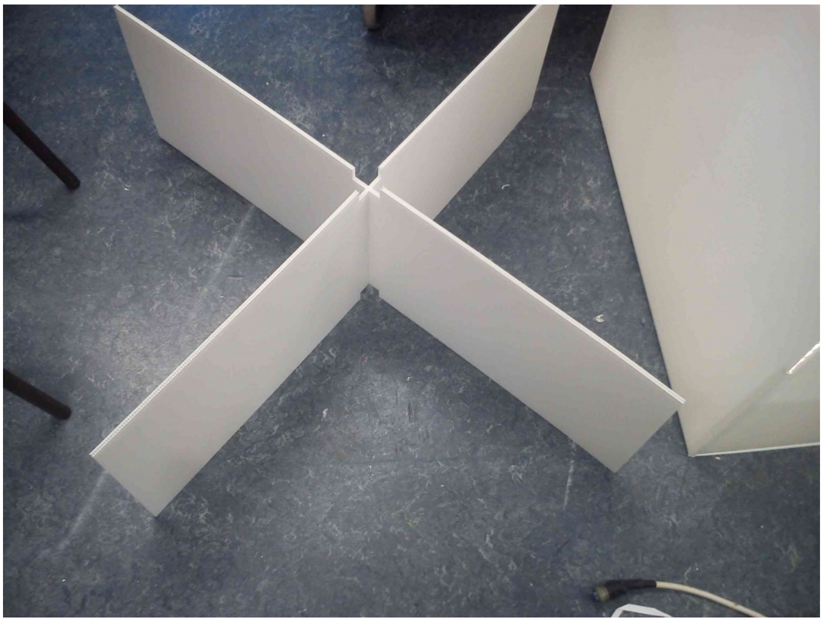
Here the bow tie has been dropped to the bottom of the Correx box, with the small coaxial connector (SMA connector) pointing upwards.



Close-up view of the balun PCB connected to the copper plates. (This one is slightly less well placed.)

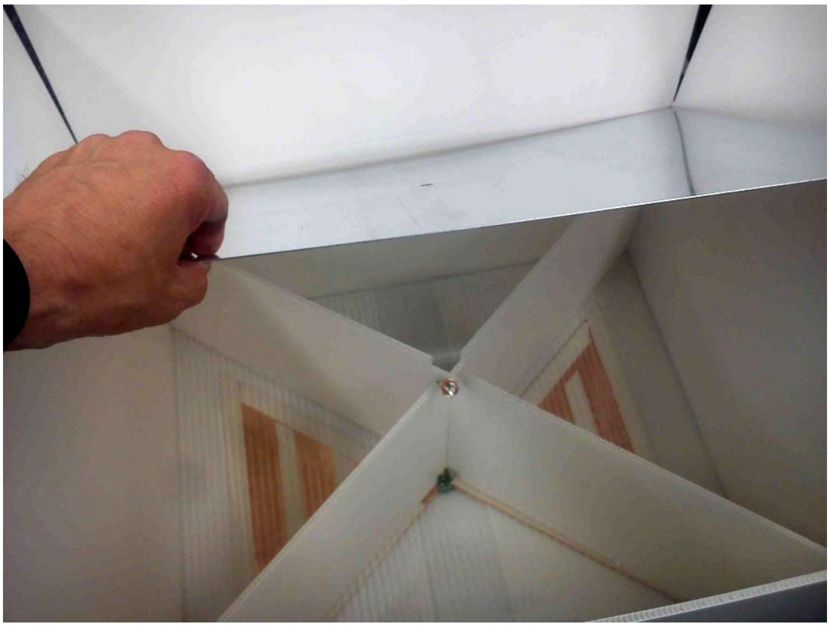


The feeder cable needs to be carefully screwed to the SMA connector on the balun PCB. Care should be taken once while making the connection, and once the connection has been made: the balun board is held to the copper plates by two soldered joints, which should not be stressed.

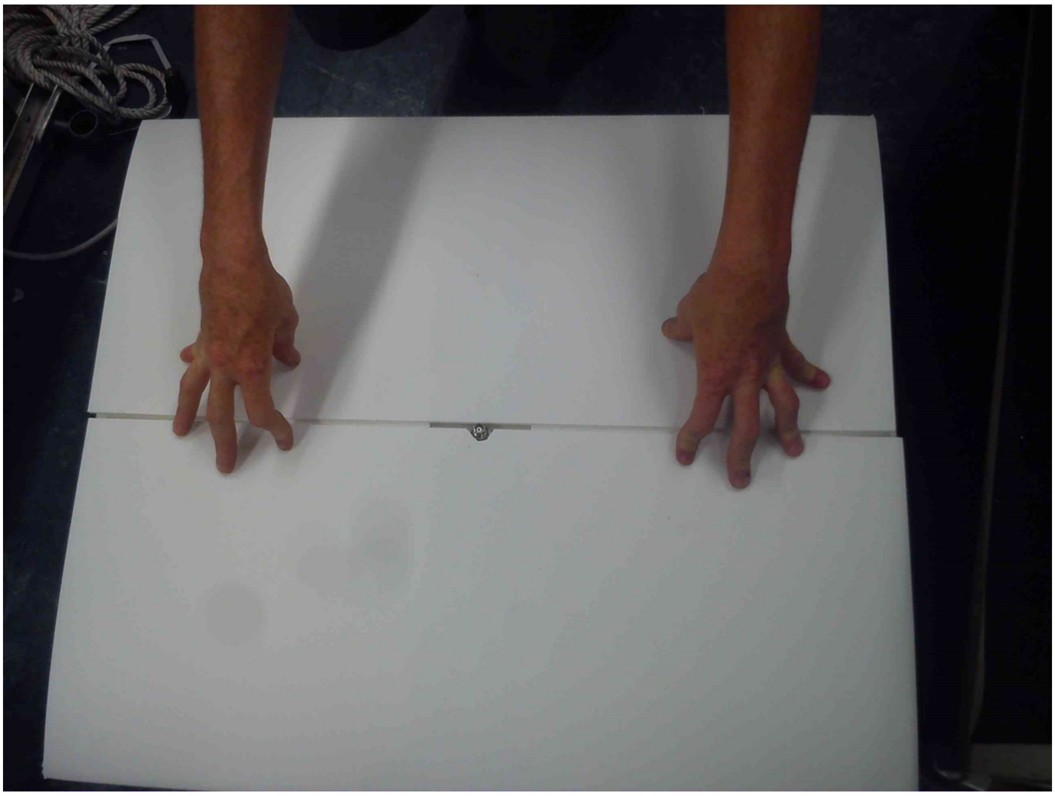


The pair of dividers fit together and forms the support for the reflector that ultimately will go in the top of the box. They have cut-outs at top and bottom so that they don’t get in the way of the feeder cable connections.

Drop the dividers into the box, making sure that the cable comes out in the quadrant that contains the SMA connector (and therefore the feeder cable). If the cable comes out into the wrong quadrant, it will get pushed over and stress the soldered connections between balun PCB and the copper bows.

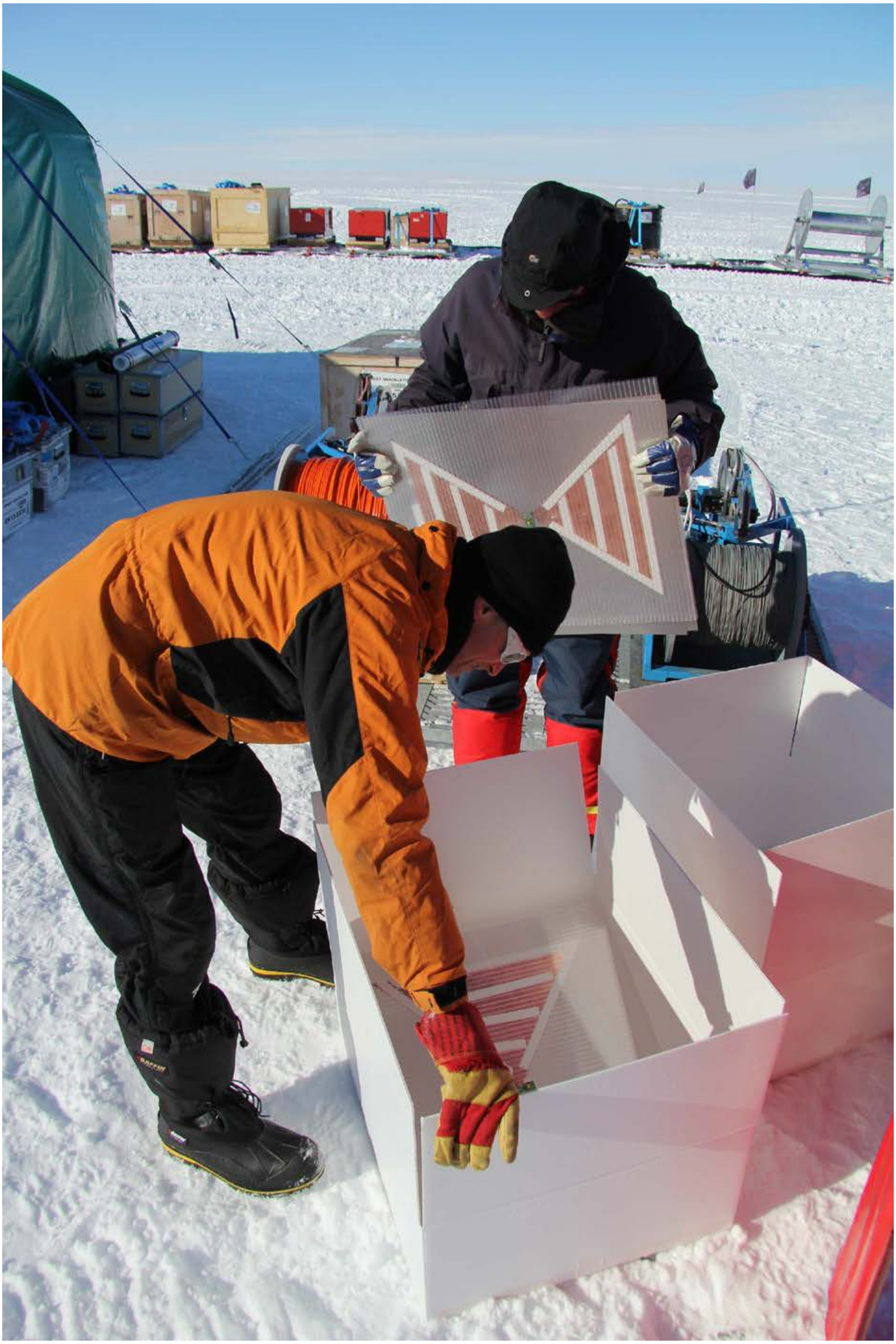


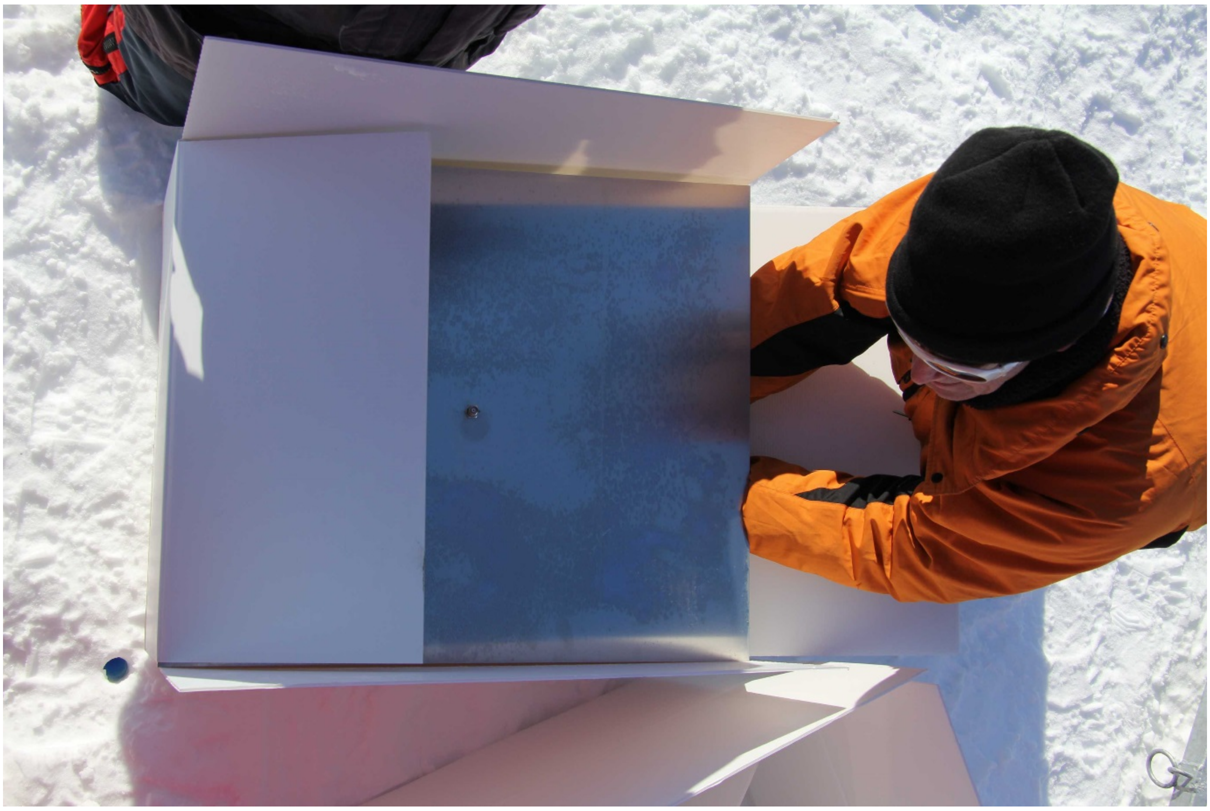
Place the reflector on top of the dividers. It can go in one of two ways round. Place it so that the flat in the hole best lines up with the flat on the TNC bulkhead connector on the feeder cable. With one hand under the reflector, fit the TNC connector through the hole in the sheet and add the grip washer and ring nut to secure it in position. Wiggle the reflector plate around to make sure the back of the bulkhead connector isn't caught up on the top of the dividers.

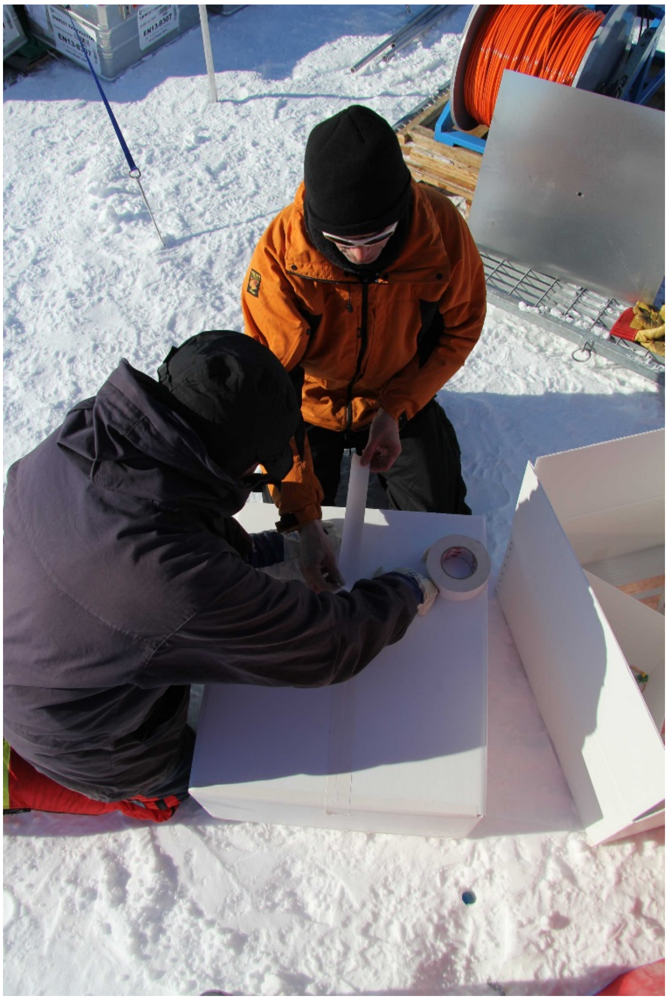


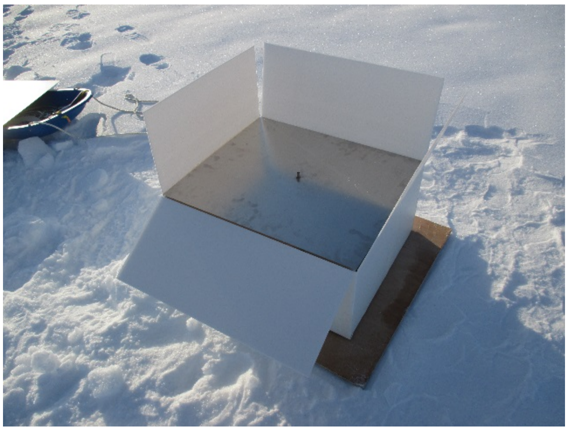
Close the top flaps of the box. Use a sharp knife to cut whatever notch is needed to allow the flaps to close around the TNC connector. Use duct tape along the gap and the two sides to seal the box.

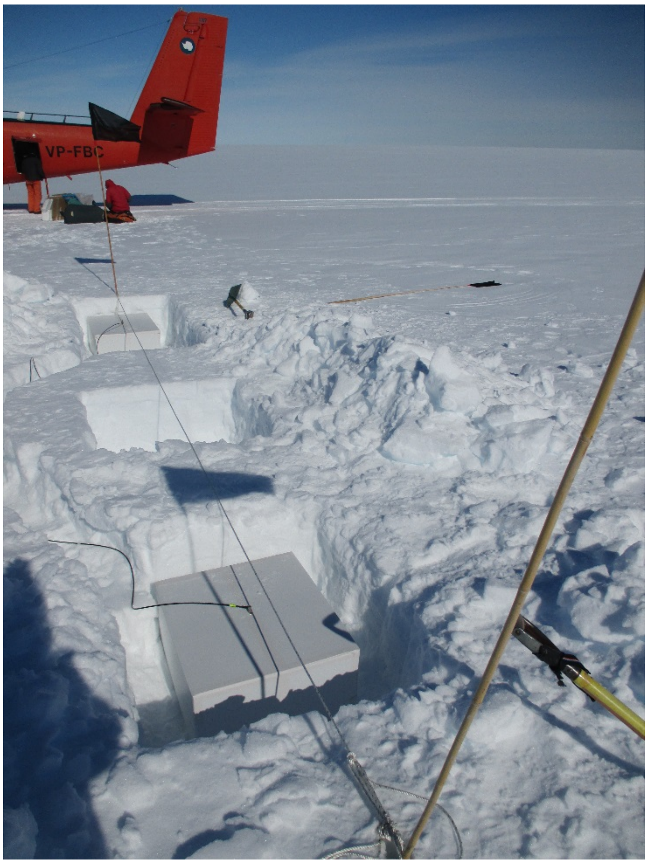
Sequence of photographs showing this done in the field.











To deploy the antennas, we usually dig a hole to accommodate the box, and deep enough so that, when the snow is back-filled and levelled off, there is enough on the top of the boxes to cover them fully. If there is a danger of summer surface melt draining into the hole, then further thought is required – these antennas are designed for cold dry conditions. We have used them in the Greenland ablation zone, tied to a board which is allowed to drop down (non-metal) poles drilled into the ice, and that seemed to work.

Components

Correx box and internal dividers

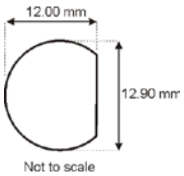
This is the box that contains the antenna, and provides the necessary structure. **Internal** dimensions are 600 mm wide, 700 mm long and 300 mm high. The sides are hot-seam welded, but in the past we have used galvanised staples, which work fine also. We use Correx that is 5 mm thick, 1050 gsm. I prefer white Correx, which is less prone to causing any snow lying on it to melt in the sun. It is advantageous to have the box manufactured so that the corrugations in the sides of the box are vertical, to give better resistance to crushing.

The internal dividers are cut to slot into each other, and again should be made so that the corrugations are vertical when fitted. We include cut-outs in the upper and lower edges to give space for the SMA connector on the balun and TNC connector in the reflector. (See pictures.)

Polycarbonate roofing sheet

The board that holds the active components on the antenna is a piece of Twinwall, 10-mm, polycarbonate sheet. The dimensions are 700 x 600 mm. It is convenient if the direction of the internal channels in the sheet run parallel to the 600-mm edge.

Aluminium reflector



We use a 1-mm thick aluminium sheet with an aperture cut in the centre for a TNC connector. Again, the dimensions are 700 x 600 mm. One mm thickness seems to work well. We did tinker with the idea of using diagonal creases in the sheet to give added rigidity, but after initial experiments we decided that wasn't necessary. Could be done though.

Copper bows

The copper bows are made from 0.5 mm thick material, and are isosceles triangles, 470 mm along the base, and 280 mm high (so 80, 50, 50 degrees). In principle, there is no reason why we can't use a roll of sticky-backed copper foil. 300-mm wide rolls are available. But it is tricky to position it accurately, and this has never been field-trialled (ie, will the adhesive work at low temperatures over a long period etc).

Balun PCB

We can supply the PCB with the balun transformer mounted.

Internal coaxial cable

This is simply a 33-cm long length of coaxial cable connecting to the SMA on the balun board. It has a TNC panel connector on the top end that is mounted in the reflector. Longer than 33 cm starts to give unpleasant characteristics in the antenna performance. But much shorter than 33 cm, and it will be difficult to mount the TNC in the reflector. We can supply these if needed.

Double-sided tape

Used to stick the bows to the polycarbonate sheet. We use an expensive double-sided tape, and it works fine (Tesa 62936). I'm sure cheaper tapes would work just as well, but it's possible for the best of us to get a bit superstitious about changing something that works.

Method

There will be more than one way of doing this. I describe here how I did it for the last batch of antennas that I built.

1. Strip any protective film off both sides of the polycarbonate sheet.

2. Mark an “X” at the centre of the sheet using a long straight edge laid between opposite corners. For marking, I use a dry board marker, which can be easily rubbed off for tidiness. When we have finished, the “X” should end up halfway between the inner corners of the copper bows.

3. Use a 50-mm hole-saw (diameter not critical), centred on a point 13 mm along the corrugations from the board centre. The idea is to drill through one skin and the walls of the sheet, but NOT through the second wall. The centre of the hole is aligned with the coaxial connector to allow finger space to make the connection. The centre drill of the hole-saw makes a hole in the second skin, which is fine.

4. Using a craft knife or equivalent, side snips, long nosed pliers etc, cut away the circular disk, and the attached walls. This is a bit of a fiddle.

5. Turn the sheet over and use a craft knife to cut out a 20 mm square aperture. The aperture is to allow the connector and the connections to the antenna to fit into the sheet, with the balun board fixed from this side.

6. Solder two 50 mm or so pieces of stripped, flexible, multi-stranded wire onto the PCB (see sketch below) and then fix the PCB into place using a glue gun. Traditionally, I used two M3 nylon bolts through the holes in the PCB. Most recently, I have gone the glue gun route, which seems to work well (and is quicker).

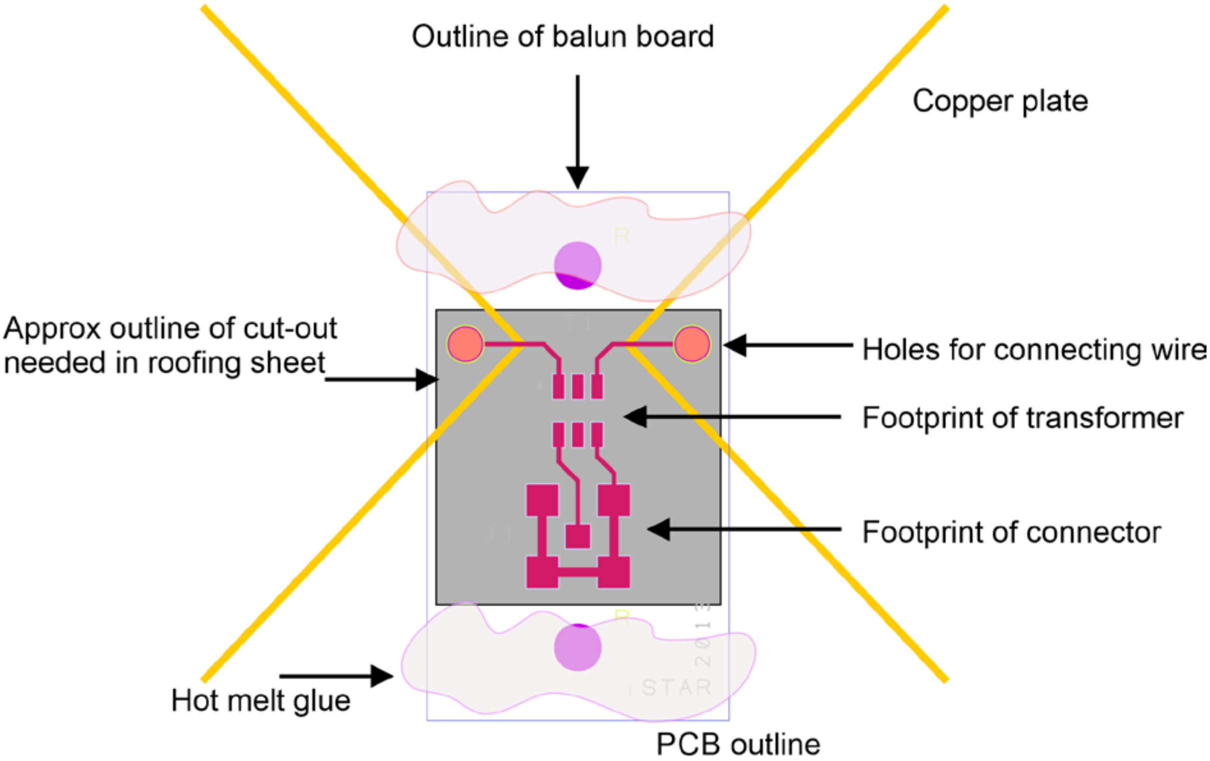
7. Carefully stick the copper bows into position, with the ‘central’ corners separated by the required distance (10 mm). They will therefore be overlapping the PCB. The connecting wires can then be brought around the edge of the copper and soldered onto the top, using a high-power soldering iron (~75 Watts, with a large bit). Snip off any excess wire. It is important for there not to be any loopy wire that is going to change the properties of the antenna.

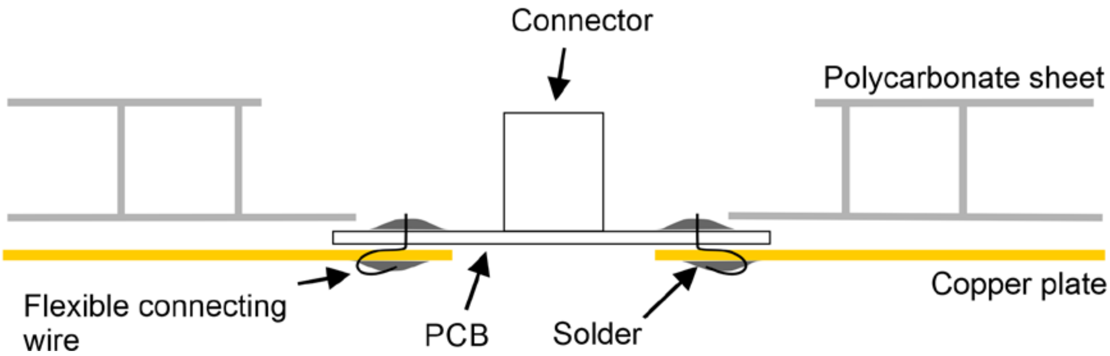
I should mention that the original design used solder posts that directly coupled the PCB to holes drilled in the bows. The problem with that approach was that the solder posts connecting the copper bows to the PCB were inflexible. As the bows are well-bonded to the polycarbonate roofing sheet, any flexing of the roofing sheet was transmitted via the solder posts to the PCB. We then occasionally got cracking in the tracks linking the plated-through holes to the transformer. This was easily checked by testing for DC continuity between the copper bows. The new design has the disadvantage that it has not been well modelled, and I have been working on the assumption that the introduction of the wire will not mess up the antenna performance, hence my desire to keep the wire as short as possible, while still mechanically decoupling the PCB from the bow. That said, most of the antennas in the field are now using the new design and seem to be working fine.

Quick test of the antenna

To get some confidence that the antenna is ok, I have been checking that there is DC continuity between the bows, and also across the SMA connector. There should be no DC connection between the SMA connector and the copper bows. This is, of course, a very basic check, but it is a simple antenna, and if that continuity is present, I think it should work fine.

Keith Nicholls
30 July 2018
Updated March 2022


Outline of balun board
Copper plate
Approx outline of cut-out
needed in roofing sheet
Holes for connecting wire
Footprint of transformer
Footprint of connector
Hot melt glue
PCB outline


Connector
Polycarbonate sheet
Copper plate
Flexible connecting
wire
PCB
Solder