13 Designing a hull with developable surfaces

Maxsurf is able to facilitate the design of a hull using developable surfaces. A developable surface is one that can be formed from a flat sheet without stretching the material. There are several main processes to creating such a design:

1. Define the surfaces you will require e.g. topsides, bottom etc., and roughly position the edges, e.g. deck, chine, keel
2. Make the surfaces developable (in the surface properties dialog, Surfaces | Surface Properties from the menu) and review the rulings, which are displayed. Make these as regular as possible by manipulating the surface edges. Remember, these rulings lie in the developable surface. The rulings are defined only by the surfaces' longitudinal edges.
3. Define quite a large number of stations. Maxsurf will draw marker points where the rulings (of the developable surface) intersect the stations.
4. Add additional rows to the surface so that you can make the NURBs surface match the developable surface.
5. Check the developability of the plate by displaying the Gaussian curvature on the surfaces. Also, check the strains in the developed plate in Workshop.

We will now go through each of the steps in more detail. In this example, we will design a single chine, planing vessel.

13.1.1. Define the surfaces and roughly align the surface edges
Create a new design and add a longitudinal plane. Save your design; keep saving the design at regular intervals.

Add three extra control point columns:
13.1.2. Set surface properties

Now edit the surface properties so that the surface is no longer linear in the longitudinal direction. We will also make it a developable surface and call it "Topsides".

You should now notice a number of regular rulings drawn on the surface:

These rulings lie in the developable surface. They are defined by the surface's longitudinal edges. Your task is to make a NURB surface that closely matches the developable surface. However, we will first add a bottom surface to the design. Duplicate the Topsides surface and place it below the Topsides surface:
Bond the lower edge of the Topsides to the top edge of the new surface for a common edge; this will become the chine line:

Change the properties of the new surface so that it is called "Bottom".

Now we will get the basic shape of the hull edges, whilst trying to maintain regular rulings on the surface. If the rulings intersect inside the surface, you will not be able to form a developable surface. However, the rulings may go to a point. You can increase the number of rulings displayed by increasing the precision; conversely you can reduce the number of rulings by lowering the precision.

First get the Profile of the surface edges approximately correct:

13.1.3. Define shape with regular rulings
Now get the plan view approximately correct, it may be easiest to do this initially in the Perspective view, making sure that the points are being moved transversely and not longitudinally or vertically. Use
the shift key to constrain the motion and make sure that the direction indicator indicates movement in the Body Plan or Plan views.

Then refine the design in the Plan and Body Plan views:
You will notice that the rulings do not necessarily end on the edge of the surface. This simply indicates that the developed surface will not have straight ends. It is possible to force the last ruling to be on the surface’s edge. To do this the last two control points in the top and bottom edges must all lie in the same plane. This is easy to do in Maxsurf. Simply select the first three points which define the plane and then the fourth point which you wish to move into the plane of the other three. Then select align to plane. This is shown below:

Here the two transom control points and the second control point on the chine were used to define the plane. The second control point on the deck edge was then aligned into that plane. You can see how the aft Topside rulings now line up with the transom.

13.1.4. Fit NURB surface to ruled surface
Once the edges are defined and the rulings suitable, it is necessary to fit a NURB surface to the rulings that define the developable surface.
To do this we will add a number of sections. Maxsurf will indicate where the rulings (and hence the developable surface) cross the sections. It is then a matter of making the surface sections match these markers to within acceptable limits. Now it is just a matter of ensuring the sections pass through each of the markers by moving the control points. This is an iterative process and remember that moving a control point will not just alter the current section.

You can verify the developability of the surface by examining the Gaussian curvature. Here is the Gaussian curvature of the design as it stands. (Most of the design is red, indicating negative Gaussian curvature, or concave surfaces.)

The red areas show negative Gaussian curvature (concave), the blue areas positive Gaussian curvature (convex) and the green areas zero Gaussian curvature. A developable surface is one that has zero Gaussian everywhere so it is our task to modify the surface so that it is green all over.

Firstly, add some sections, 20 - 40 should be sufficient. Space them evenly along the length of the model. It is also a good idea to add sections at the longitudinal position of the control point columns.

Then go into the body plan view and add additional control point rows to the surfaces, depending on the amount and distribution of shape required you may have to add several rows. Start with one or two at first; then edit the surface properties so that the surface is no longer linear in the transverse direction.

Control point column by control point column, manipulate the shape to get the sections to pass through the markers. Make the markers display "Markers for Current Section", and you may want to reduce the intensity of the rulings (they are the same colour as the Datum Waterline). It may also be easier to visualise if you only have one section visible at a time, to do this turn off the sections by clicking the
section toggle icon. You may also need to increase the precision to get more marker points, especially if the rulings are near vertical.

![Body Plan](image)

The align to vector (or straighten in current plane) command can be useful for getting the internal control points on the straight line between the edges. To do this, select the edge control points, then the internal control points and then chose the align to vector command. The first two control points define the vector and the other selected control points are moved onto that vector.

**13.1.5. Check developability and refine as required**

Periodically, check the Gaussian curvature in the Perspective View:

![Perspective](image)

The Gaussian curvature plot sensitivity can be adjusted with the darkness setting, a value of about 3.5 to 4 is a sensible tolerance. For
example, when these plates are developed in Workshop, the maximum strain is less than 0.1%, which is to all intents and purposes developable. The diagram above was obtained with a darkness setting of 3.5. The concave and convex areas are still visible, although they are not shown to be extreme. This is born out by the strain maps on the plate developments in Workshop.

Final design:
You can compare the designs by locking the final surfaces. Then duplicate them both but make sure the offset is zero. Then unlock the copied surfaces and in the body plan delete the internal control point rows that you added. Now lock the copied surfaces again. Turn on the sections and increase the precision. If you zoom in you will be able to see that you pulled the surfaces out to make them non-concave and developable. This is typical of the procedure required for this type of hull form. If you had not pulled out the sections, you would have had to shrink the interior of the plates to get them to fit against the frames.