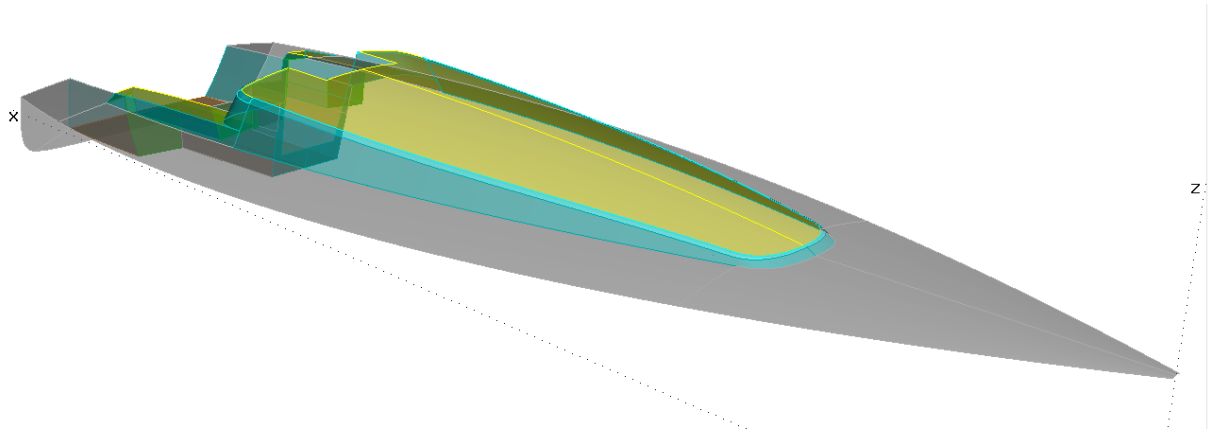


# Decks and Superstructures

## On decks, trunk cabins and bubbles

by Reinhard Siegel



## Introduction

Small boats have no deck or cabin, but those are indispensable parts of larger vessels. This article describes various methods to model surfaces for decks and superstructures in MultiSurf.

### Abbreviations used:

cp: control point (support point)

mc: master curve = support curve

cp1, cp2, ...: denotes 1st, 2nd, ... point in the list of supports of a curve. It is not an actual entity name.

mc1, mc2, ...: denotes 1st, 2nd, ... curve in the list of supports of a surface. It is not an actual entity name.

In the following the terms used for point, curve and surface types are those of MultiSurf. This may serve the understanding and traceability.

## 1 - Decks

Before we can model a cabin, we need a deck. Often a deck is little more than a foredeck and a deck at side. Nevertheless it is useful to start with a basis surface from bow to stern and then cut out the area covered by cabin and cockpit. In that way it is easy to change camber or sheer of the deck without paying attention to the fairness and joining of individual surfaces.

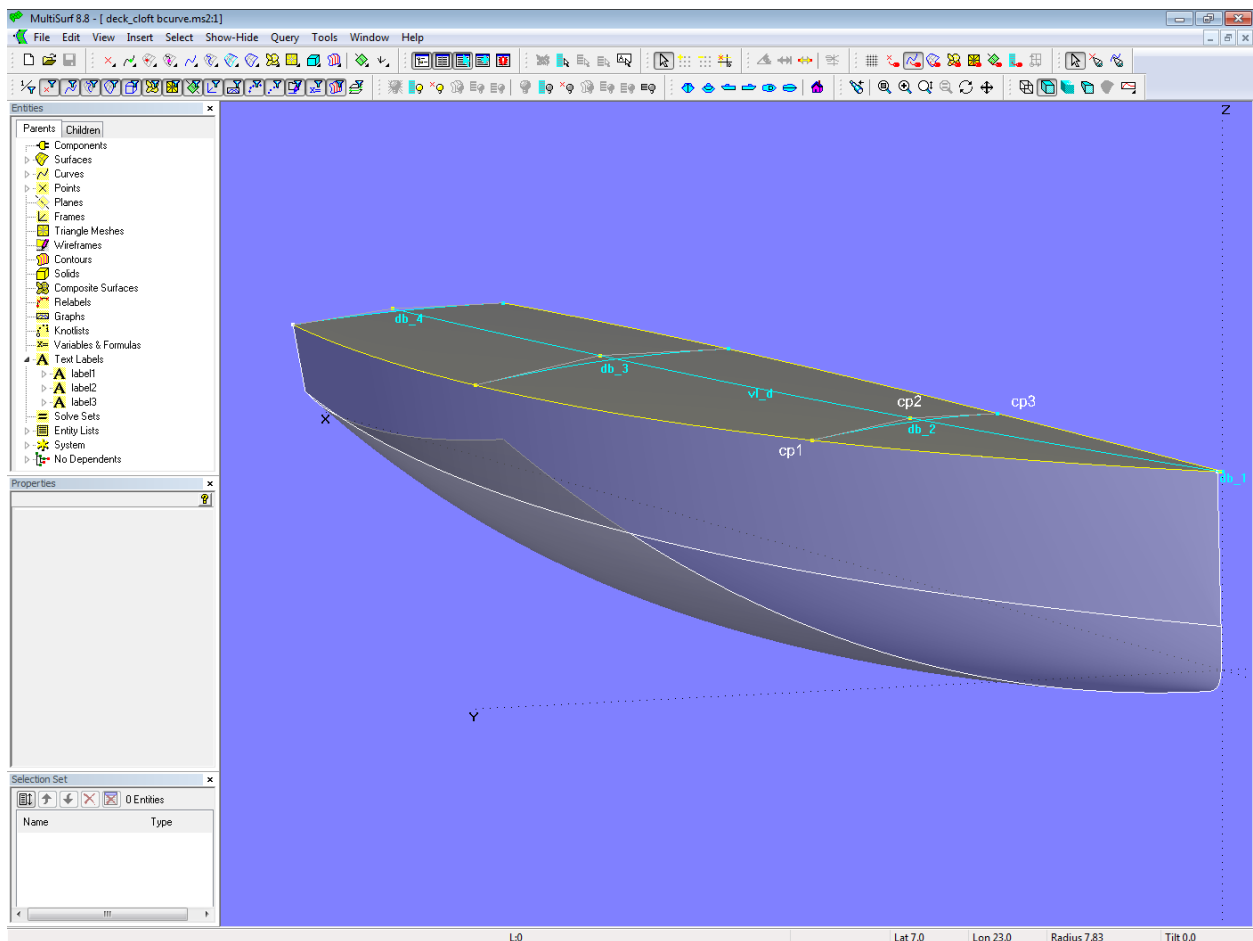
### Method 1: Freeforming

Like a boat hull, a deck can also be modeled using the "master curve planking" method. This method provides the greatest flexibility with respect to the variation of amount of camber in longitudinal direction and shape of the deck beams in transverse direction.

It is a good idea to use the same surface type for the deck as is used for the hull and to locate the deck beam master curves at the same position as the master curves for the hull surface. Then both surfaces join watertight at the common edge.

## C-spline Lofted Surface on B-spline mcs

Model *deck\_cloft\_bcurve.ms2* shows a deck with B-spline Curves as deckbeam master curves. Each one is defined by 3 cps, where cp1 is the first point of the hull master curve. In order to make the deck-mc end perpendicular to the centerplane, cp2 is projected onto it as Projected Point cp3.



Model *deck\_cloft\_bcurve.ms2* - deck surface by C-spline Lofted Surface on 4 B-spline Curve master curves

The vertex curve *vl\_d* runs through all points cp2 of the mcs to serve as a guide for the harmonic distribution of the amount of beam camber over the length of the deck. If you look in 3D along this curve irregularities can easily be detected.

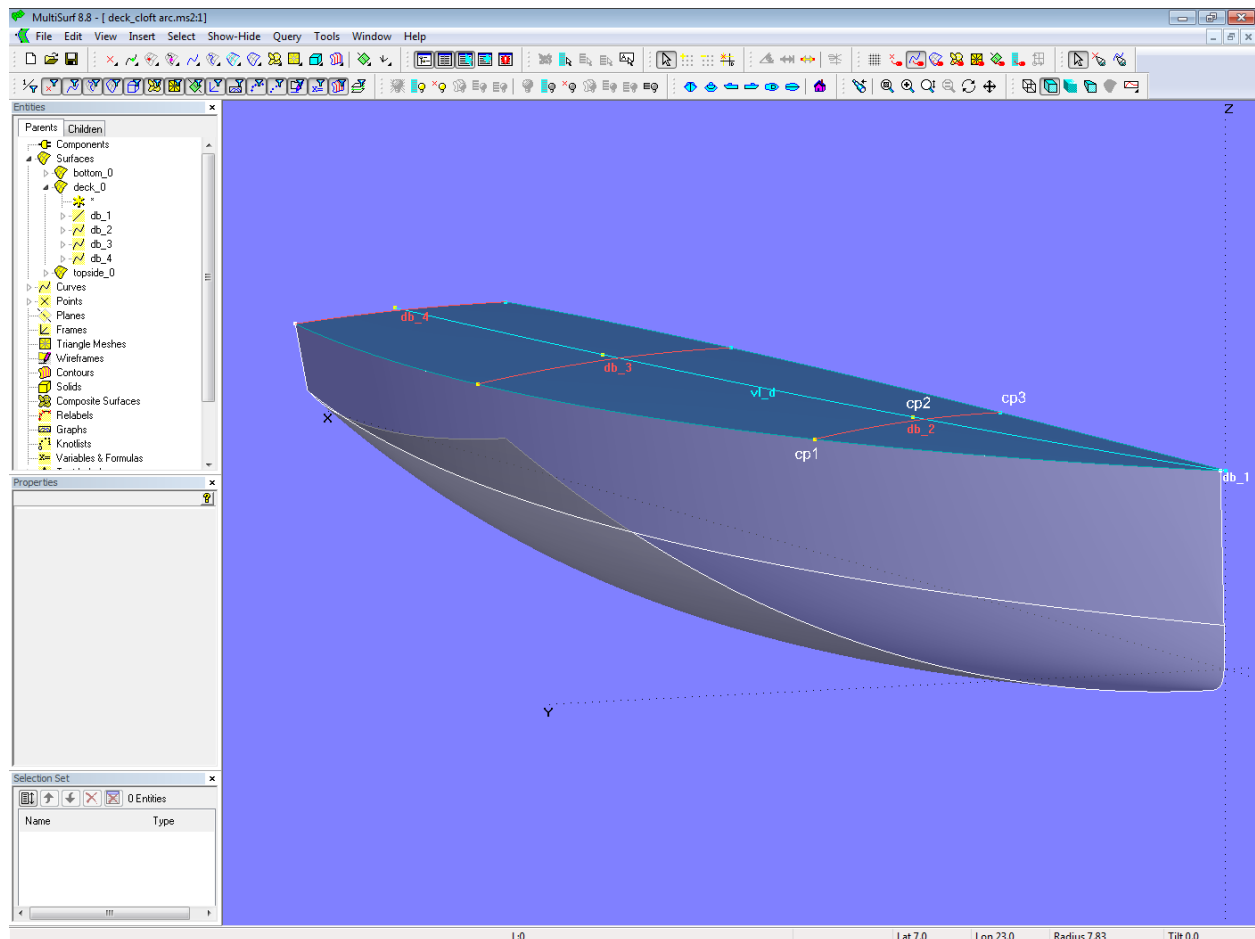
The further cp2 is positioned out towards the deck edge, the more parabolic the beam mc will be.

Of course, more than 3 cps can be used for the definition of the master curves, but the key to fairness is simplicity.

## C-spline Lofted Surface on Arc-mcs

Alternatively, one can use a circular arc as mc. This is shown in model *deck\_cloft\_arc.ms2*.

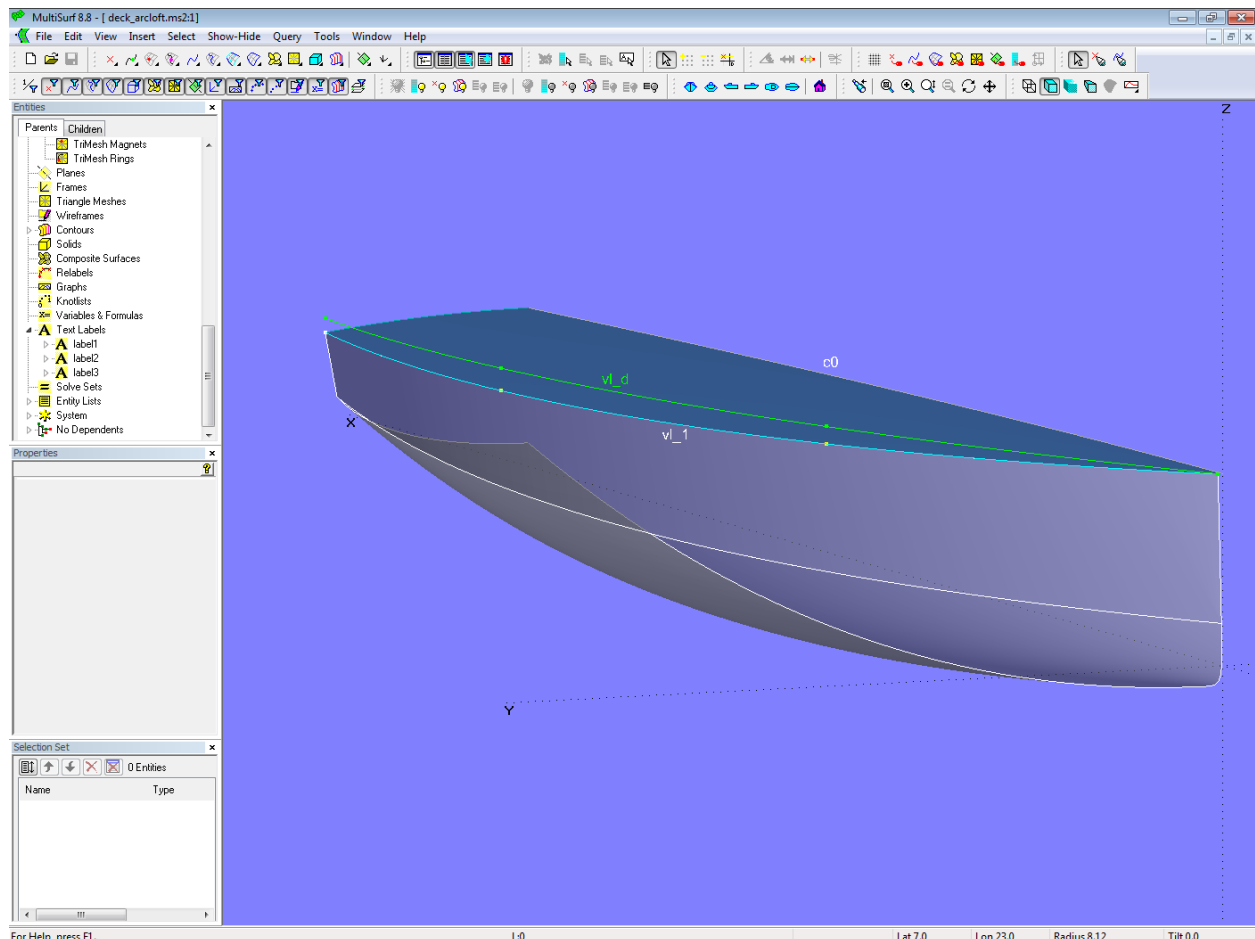
Only the height of cp2 over cp1 at the sheer line plays a role here, not its y-position. Type 5 of the Arc entity ensures that the curve ends perpendicular to the centerplane.



Model deck\_cloft\_arc.ms2 – deck surface by C-spline Lofted Surface on 4 Arc master curves

## Arc Lofted Surface on longitudinal mcs

Up to now, the deck was supported by transverse mcs, similar to the hull surface. In model *deck\_arcloft.ms2* the longitudinal mcs *vl\_1*, *vl\_d* and *c0* mount an Arc Lofted Surface. The curve *vl\_d*, which is of the same type as the vertex curve *vl\_1* of the hull, determines the height of the deck camber; its cps lie exactly vertically above the 1st cp of the hull mcs. In order to end perpendicular to the center-plane the Arc Lofted surface is of type 5, while *vl\_d* is projected onto it as *c0*.



Model *deck\_arcloft.ms2* – Arc Lofted Surface supported by longitudinal mcs; *c0* is the projection of *vl\_d* onto the centerplane.

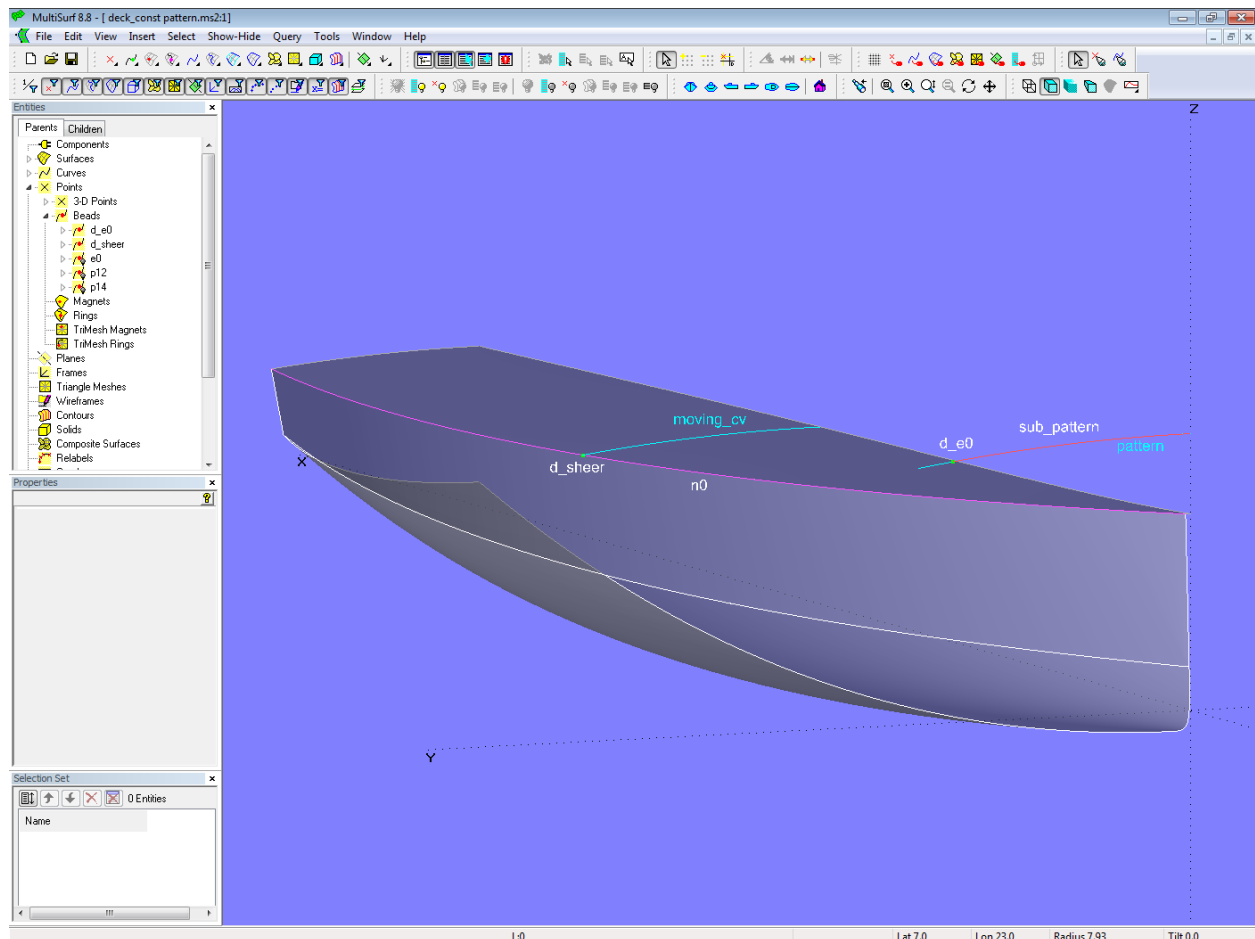
Alternatively, *vl\_d* could also be a Relative Curve based on the vertex curve *vl\_1*, its run controlled by a BGraph.

## Method 2: Procedural Construction

### Deckbeams of equal shape

Sometimes it is considered an advantage if all the beams of a deck have the same shape, that is, be sections of a single template. For example when laminated wooden deck beams are required.

Model *deck\_const\_pattern.ms2* shows this approach. The beam template is the curve *pattern*, which is defined at the bow front as an Arc. The upper edge of the hull is the EdgeSnake *n0*. On this lies the Ring *d\_sheer*. Now the curve *pattern* is cut in the Intersection Bead *d\_e0*, where the intersection plane is parallel to the midship plane while passing through *d\_sheer*. The portion from midship to *d\_e0* (SubCurve *sub\_pattern*) is finally copied to the position of *d\_sheer* (Copy Curve *moving\_cv*). The Procedural Surface *deck\_0* repeats this construction for all positions of *d\_sheer*.



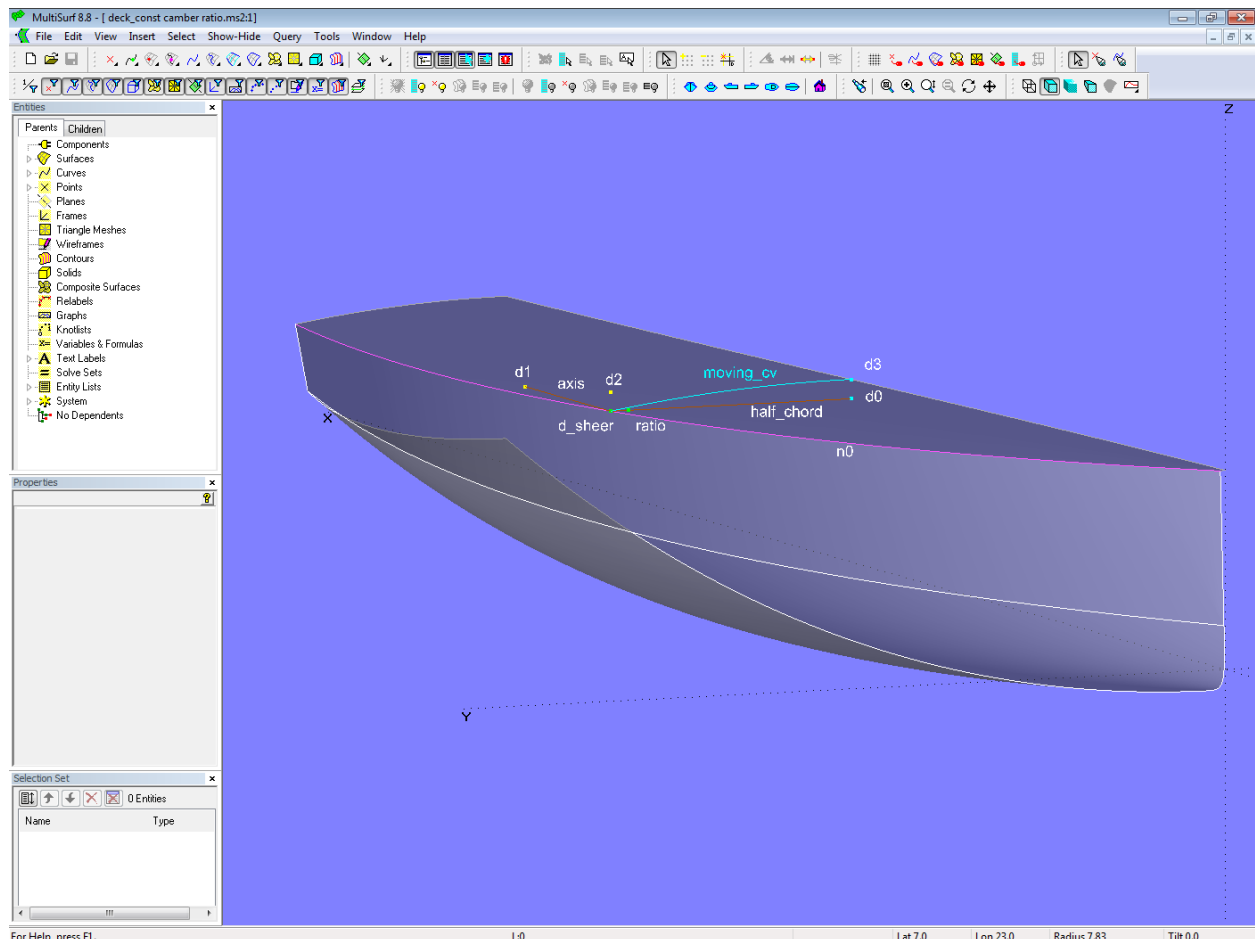
Model *deck\_const\_pattern.ms2* – deck surface with equal beams by Procedural Surface

Since Ring **d\_sheer** is located on the EdgeSnake **n0**, the deck has the same labeling as the hull surface; this ensures a watertight joint of both surfaces along the common edge.

### Deck with constant camber ratio

Also by a procedural design a deck surface can be produced in which the amount of camber is a constant ratio of the deck width. Model *deck\_constant\_camber\_ratio.ms2* shows this variation.

The construction is again driven by Ring **d\_sheer**, which lies on the top edge of the hull (EdgeSnake **n0**). This ring is projected onto the centerplane ( $Y = 0$ ) in Projected Point **d0**. The Line **half\_chord** between **d\_sheer** and **d0** is half the deck width at the position of **d\_sheer**. Now the Bead **ratio** is set on this line whose t-parameter value is half the camber ratio. If the camber ratio is, for example, 15%, the t-value for **ratio** must be set to 0.075. (The position of a Bead on a line corresponds to the value of its parameter t, for  $t = 0.33$  the Bead is at 1/3 of the length, for  $t = 0.5$  at the half, etc.)



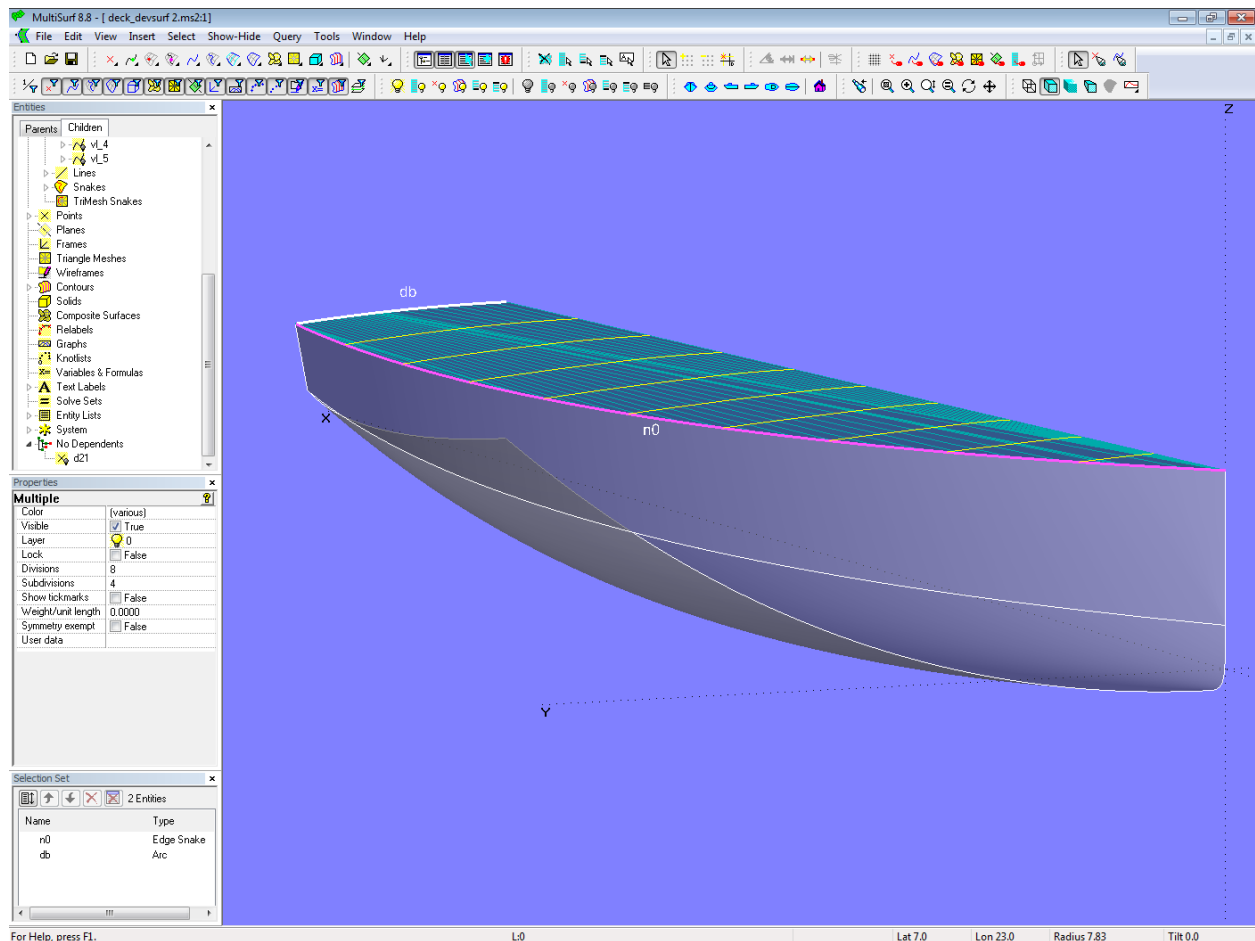
Model *deck\_constant\_camber\_ratio.ms2* – deck surface with constant camber ratio by Procedural Surface

The Bead *ratio* is now rotated 90 degrees upwards resulting in Rotated Point *d2*, which is then projected onto the centerplane as Projected Point *d3*. Finally, the Arc *moving\_cv* is defined with the points *d\_shear*, *d2* and *d3*. The Procedural Surface *deck\_0* now repeats this deckbeam construction for all positions of *d\_shear* on *n0*.

### Method 3: Developable Surface Deck

A deck can also be created by a Developable Surface. This is shown in model *deck\_devsurf.ms2*. The Developable Surface *deck\_0* is stretched between the top edge of the hull (EdgeSnake *n0*) and a deck beam at the rear (Arc *db*).

The price to pay for the easier production of a developable surface (only bending) is the limitation in form. The curve on the centerplane is straight, cross section cutting the deck run partially straight.



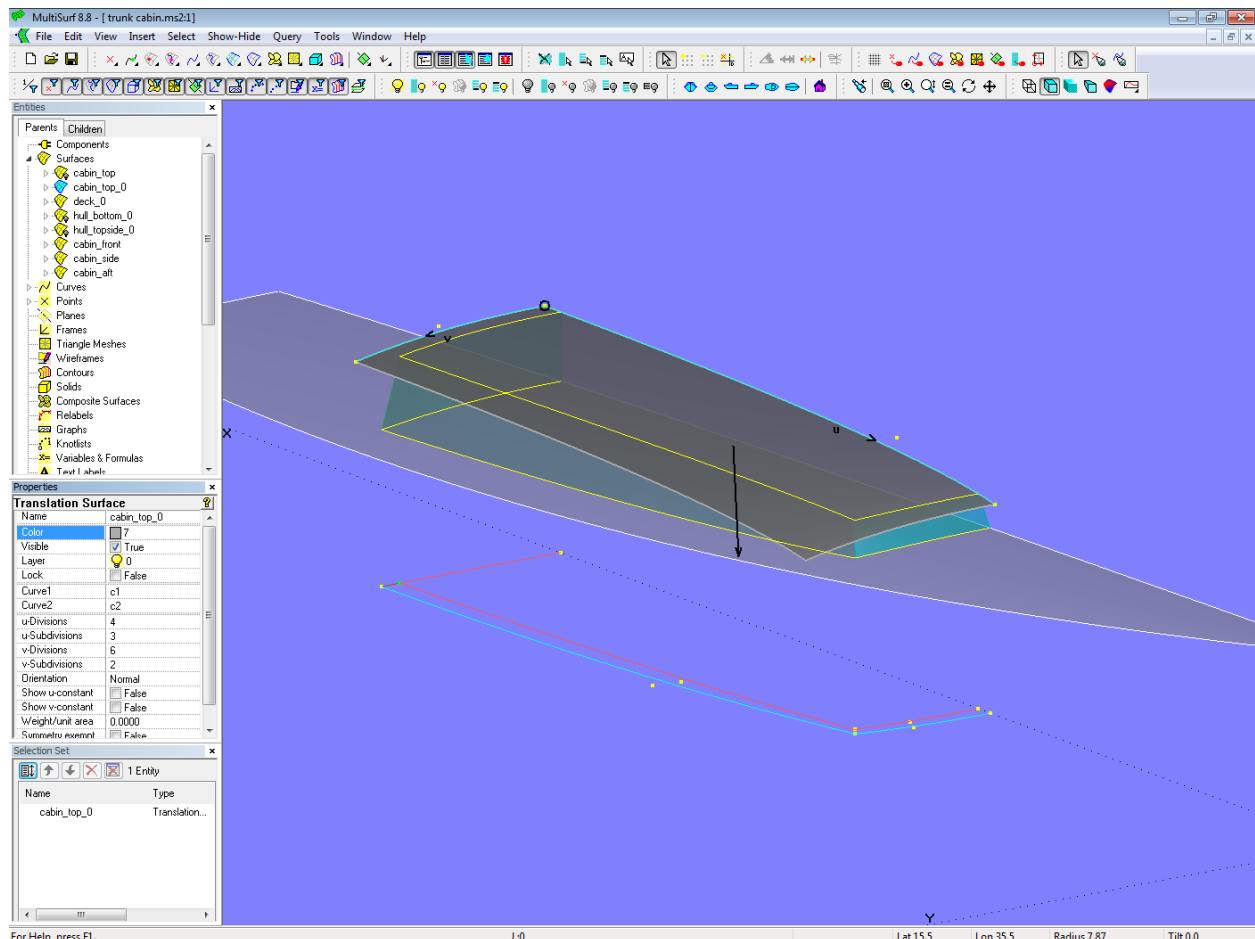
Model deck\_devsurf.ms2 – deck by Developable Surface spanned between sheerline *n0* and beam aft *db*

So much to deck constructions.

## 2 – The Trunk Cabin

### Cabin 1 - Freeform

The simplest form of a superstructure is the box. It consists of side wall, front wall, rear wall and roof. The model *trunk\_cabin-1.ms2* shows an example.



Model *trunk\_cabin-1.ms2* – box shaped superstructure

The base surface of the cabin top is a Translation Surface; its guiding curve is a B-spline curve on the centerplane, the moving or generating curve is a circular arc. The lower and upper edges of the cabin walls are defined in the XY-plane, then projected onto this base surface (as Projected Snakes). As a result, the superstructure remains the same in plan view when the deck is changed.

Note: it is important that the deck is a fair surface. Because a Projected Snake, which maps a smooth curve onto a non-fair surface, is not smooth. Consequently, a surface which depends on this snake will be unfair

All deck beams (cross sections) of the roof are the same. All sides are truly developable, but the roof is not. It would be developable too if the the centerline of the cabin top is straight.

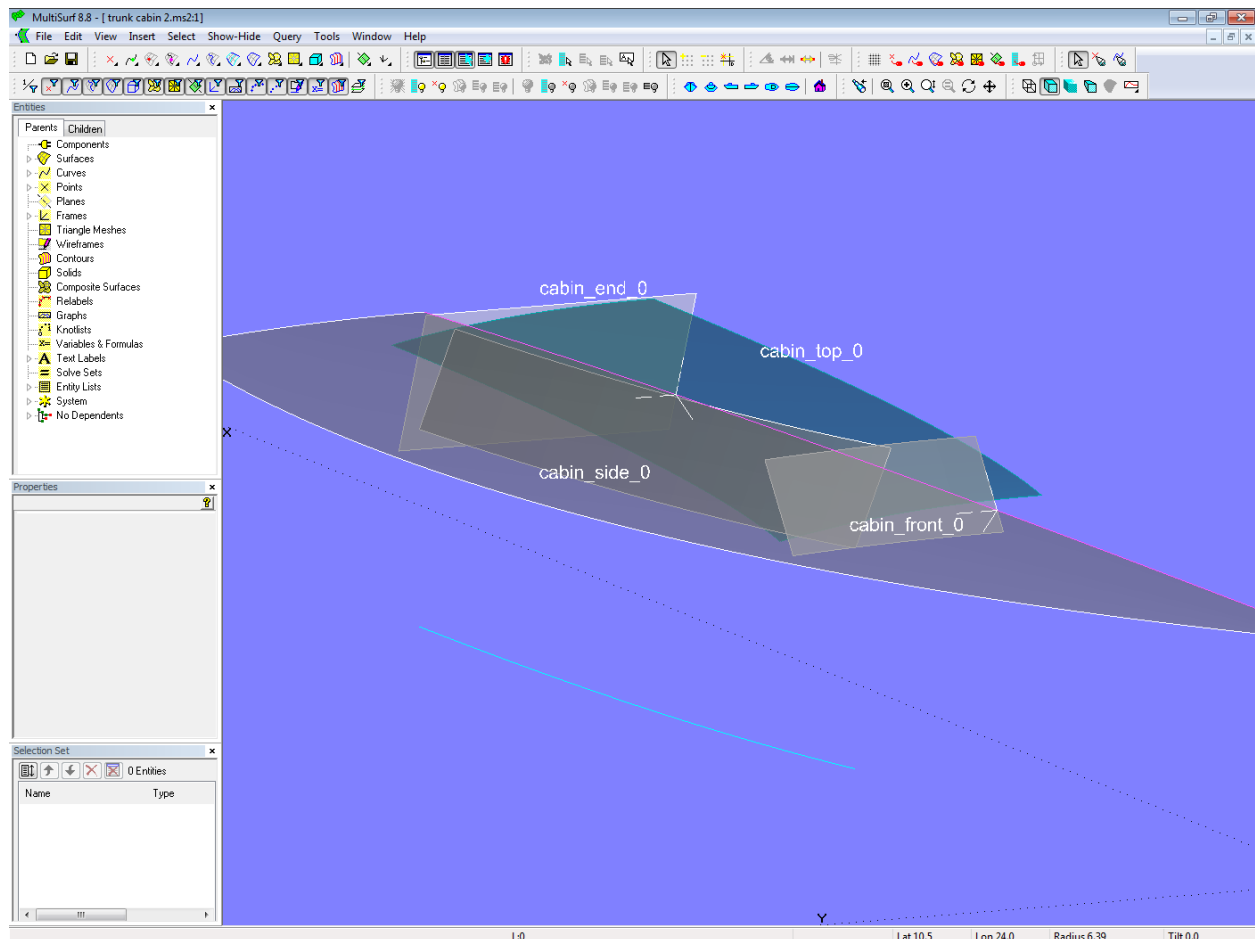
With this method only the roof surface is larger than the final parts, that is, all other elements do not need trimming.

With this design you can only change the curves for the upper and lower edges of the sides and then see if it pleases you. Special requirements, such as the slope of cabin side or front, are not possible.

## Cabin 2 - Specifications

If there are geometrical specifications such as inclination of the cabin side is to be  $10^\circ$ , front is circular and sloped aft by  $35^\circ$ , a procedure as shown in model *trunk\_cabin-2.ms2* is convenient.

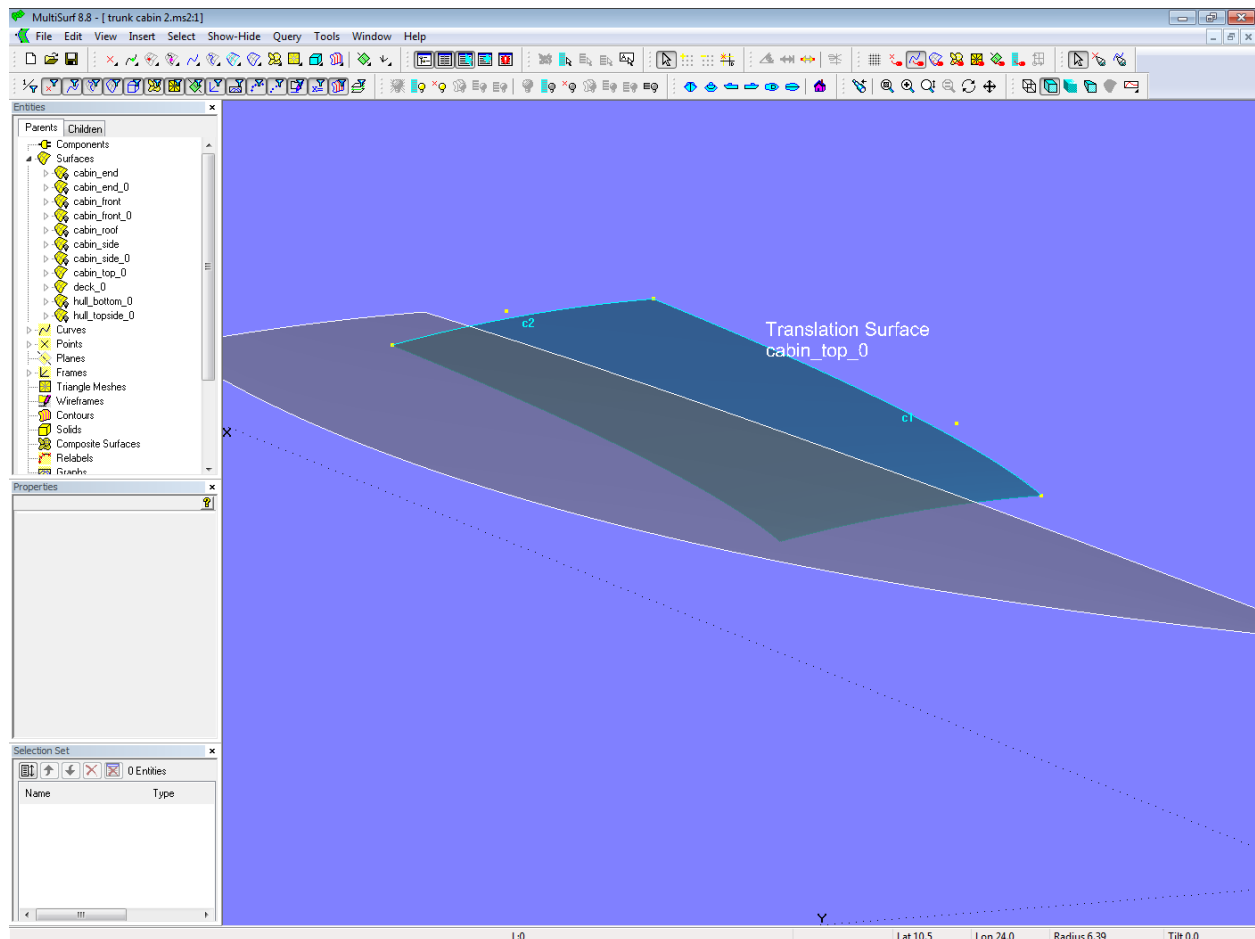




Model trunk\_cabin-2.ms2 – basis surfaces of trunk cabin

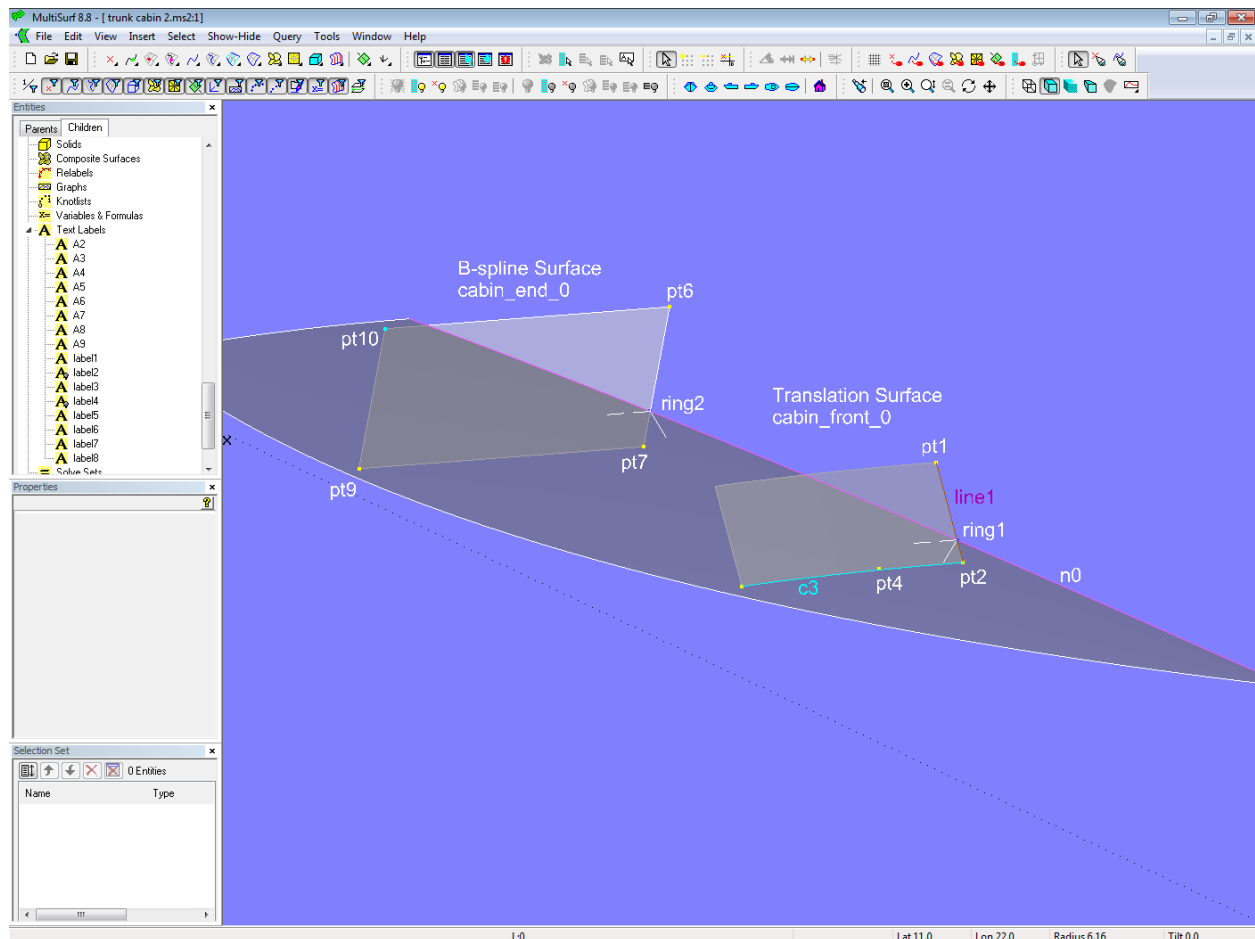
The cabin surfaces are created initially as somewhat larger basis surfaces, each one shaped in accordance to the specifications.

Let us start with the roof. Required are beams, which can be laminated using a single template. A Translation Surface is chosen for this purpose. Guiding curve is the B-spline Curve **c1** on centerplane, moving curve is Arc **c2**. Via the property "Dragging" their control points are constraint that **c1** sticks on the centerplane and **c2** is perpendicular to the centerplane.



Model trunk\_cabin-2.ms2 – construction of the basis surface for the cabin roof

The cabin front should be variable in position and inclination, and the curvature in the transverse direction an arc. Therefore an XYZRing ([ring1](#)) is set on Snake [n0](#) and together with the points [pt1](#) and [pt3](#) a 3-point Frame is defined. Based on this frame are the points [pt2](#), [pt4](#) and [pt5](#), which determine the circular arc [c3](#) (here it is an Arc, but it could also be a RadiusArc entity, which allows to specify a wanted radius value). The Line [line1](#) is spanned between [pt1](#) and [pt2](#), and together with [c3](#) the Translation Surface [cabin\\_front\\_0](#) is created.

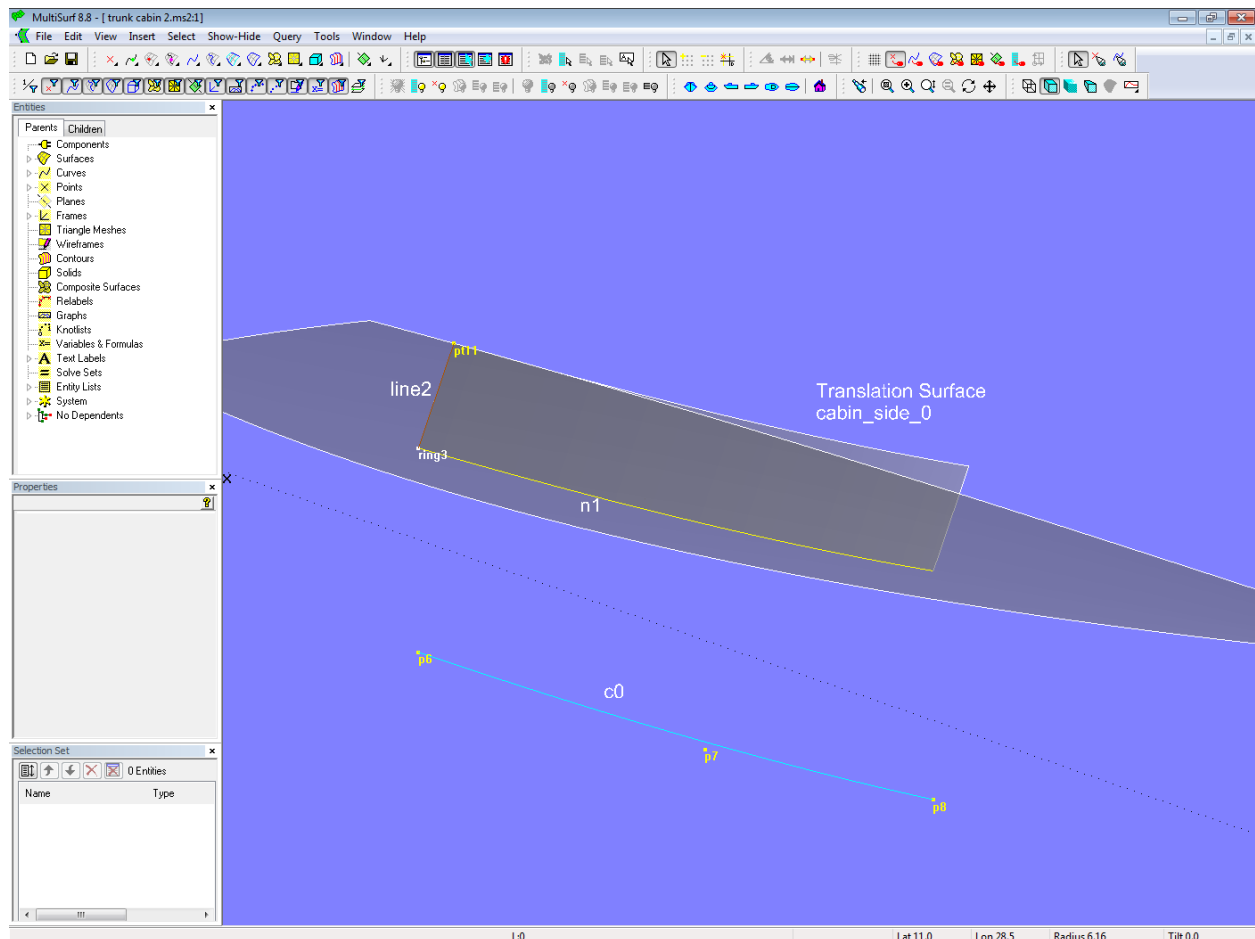


Model trunk\_cabin-2.ms2 – construction of the basis surfaces for cabin front and cabin end

The cabin end should be flat and only variable in inclination and position. With Ring **ring2**, points **pt6** and **pt8** the aft frame is created and points **pt7** and **pt9** based on it. **Pt10** is a CopyPoint that ensures flatness of the rectangular B-spline Surface **cabin\_end\_0**.

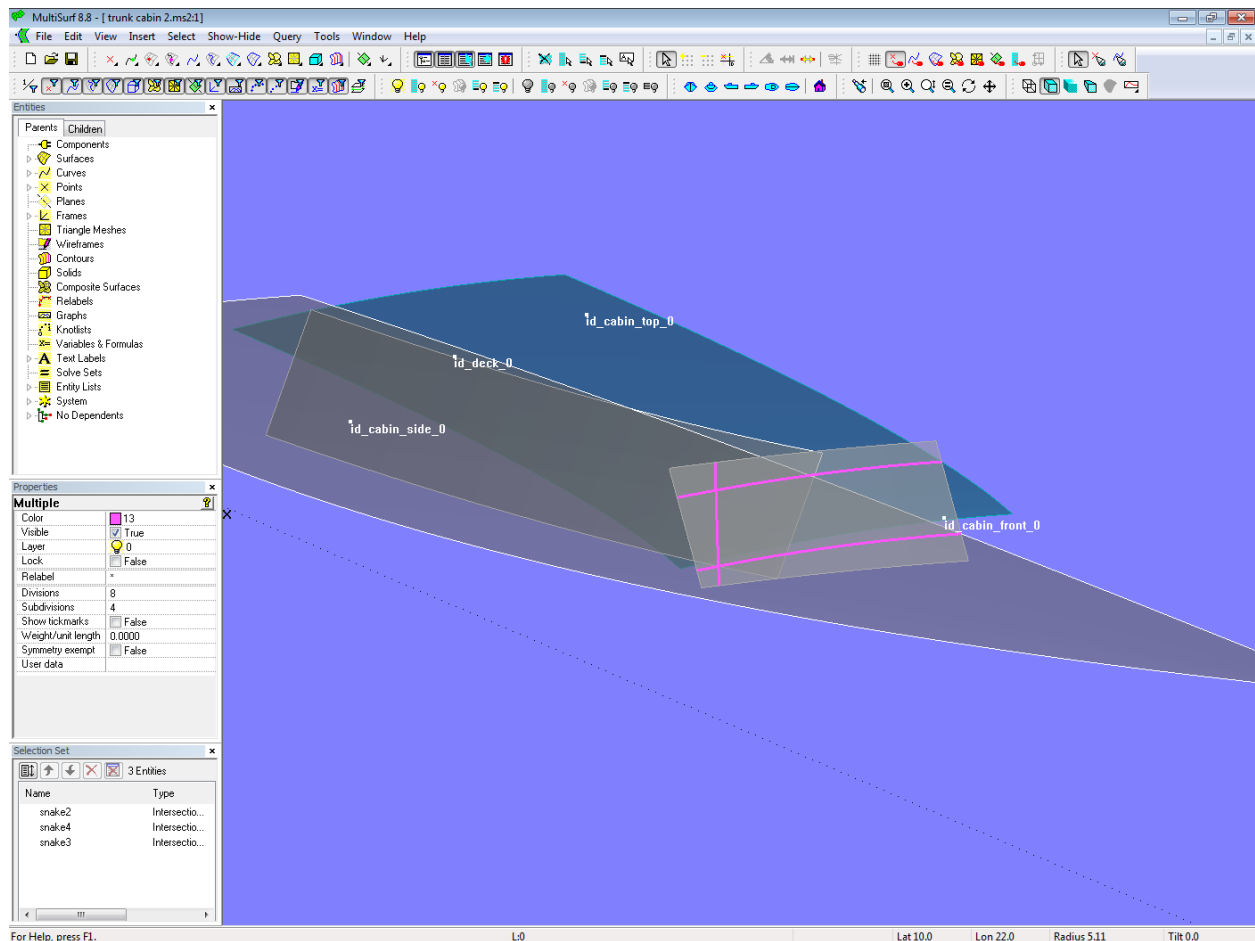
Note: a flat rectangular surface can be generated with the fewest objects simply by 4 points and a B-spline Surface of type 1 in both the u- and the v-direction. Three of the points determine the location of the surface in 3D space, while the 4th point is a Copy Point with the other points as parents.

The cabin side should have a constant inward slope. It is made by a Translation Surface also. On the XY-plane the form of its lower edge is defined by the B-spline Curve **c0**. This one is then projected onto the deck as Projected Snake **n1**. At the aft end of **n1** resides the Ring **ring3**, being support for Point **pt11**, which controls height and inclination. With Line **line2** between **ring3** and **pt11** as generator and snake **n1** as path the Translation Surface **cabin\_side\_0** is determined.



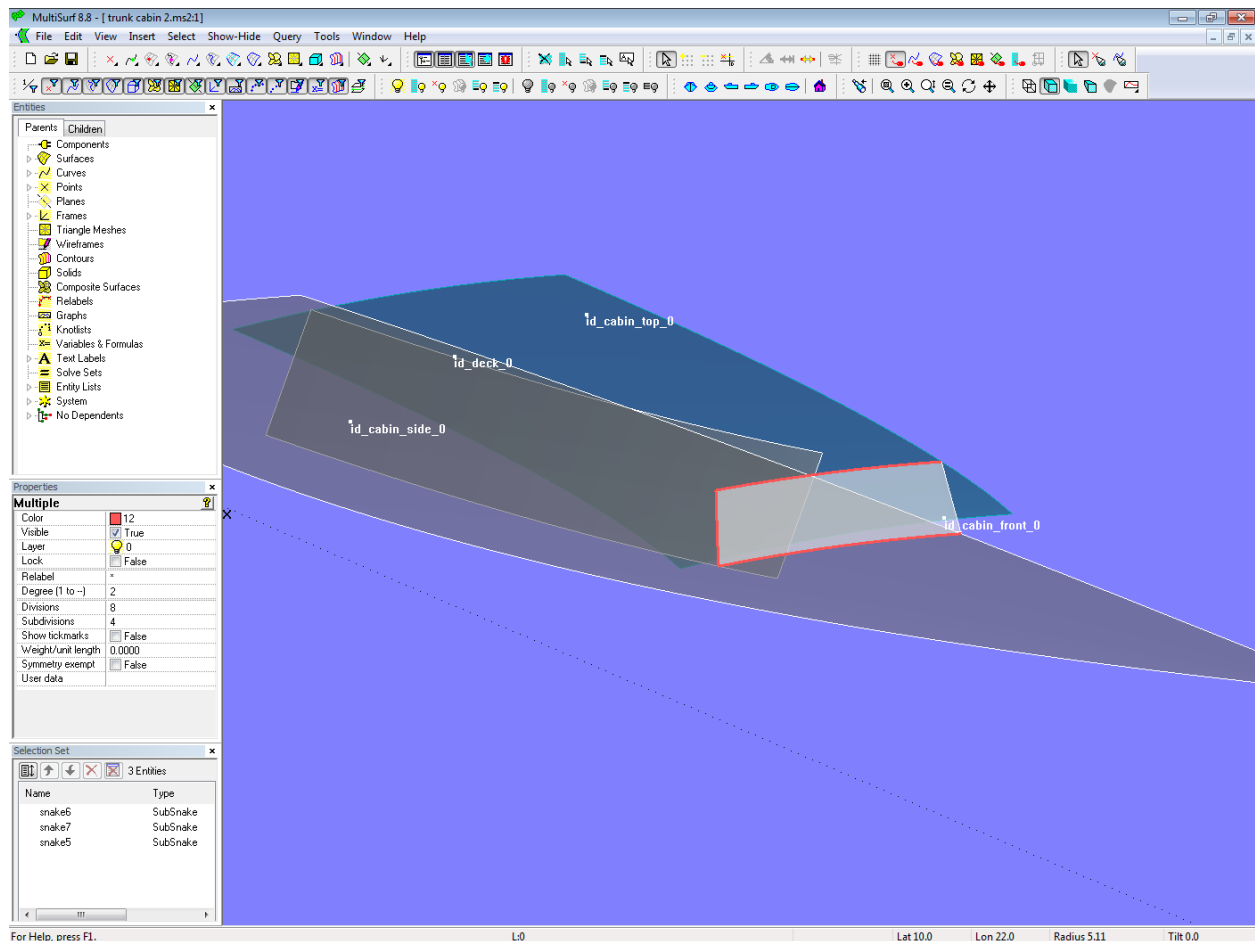
Model trunk\_cabin-2.ms2 – construction of the basis surface for the cabin side

Now, that the basis surfaces are created, the next step is to trim them against each other. Let us look first at the cabin front.



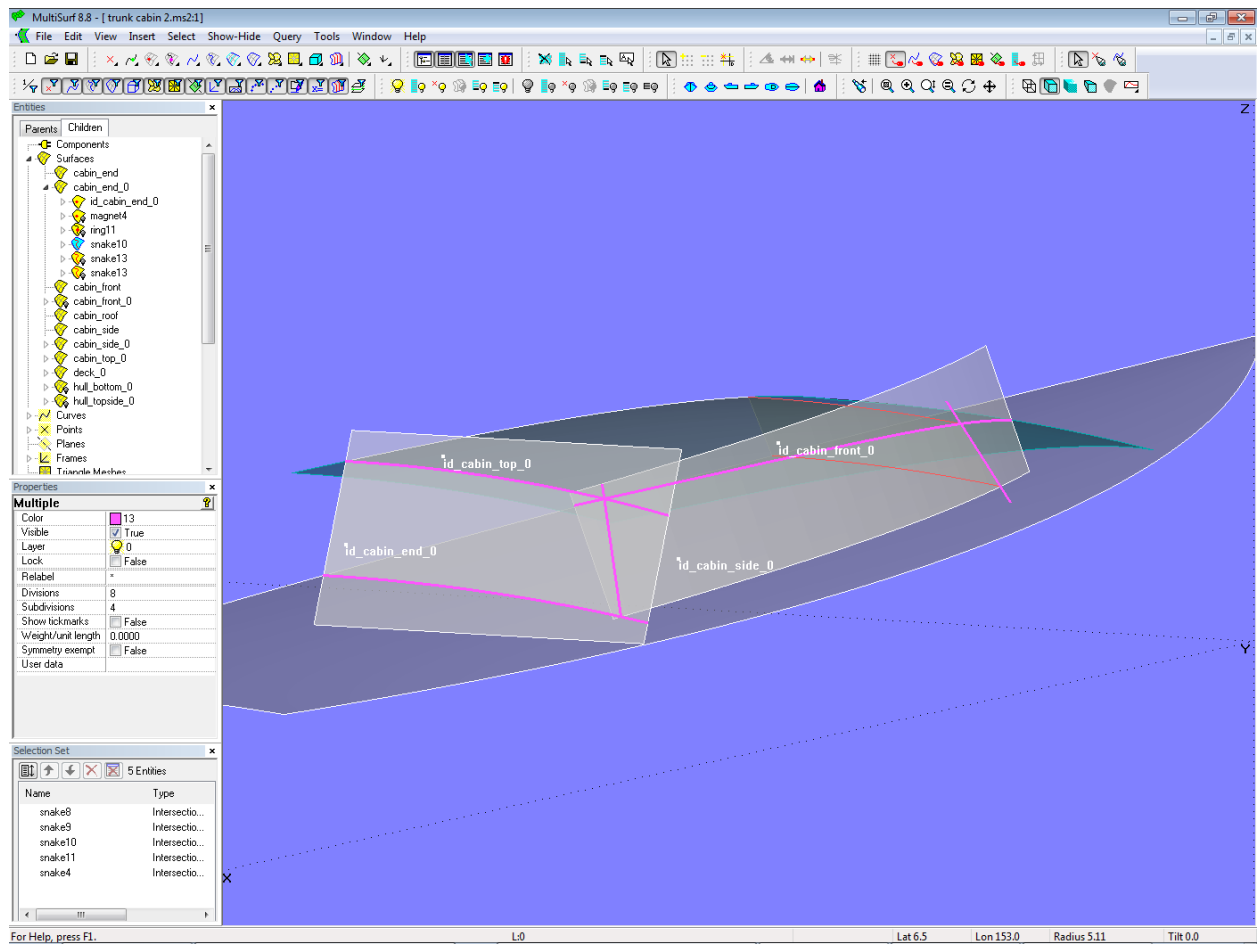
*Model trunk\_cabin-2.ms2 – intersections of front by deck, roof and side*

The front is cut by the roof, deck and side, resulting in 3 Intersection Snakes, all residing on the Translation Surface [cabin\\_front\\_0](#). The extending portions of these snakes are cut off by SubSnakes serving as the boundaries of the final Trimmed Surface [cabin\\_front](#).

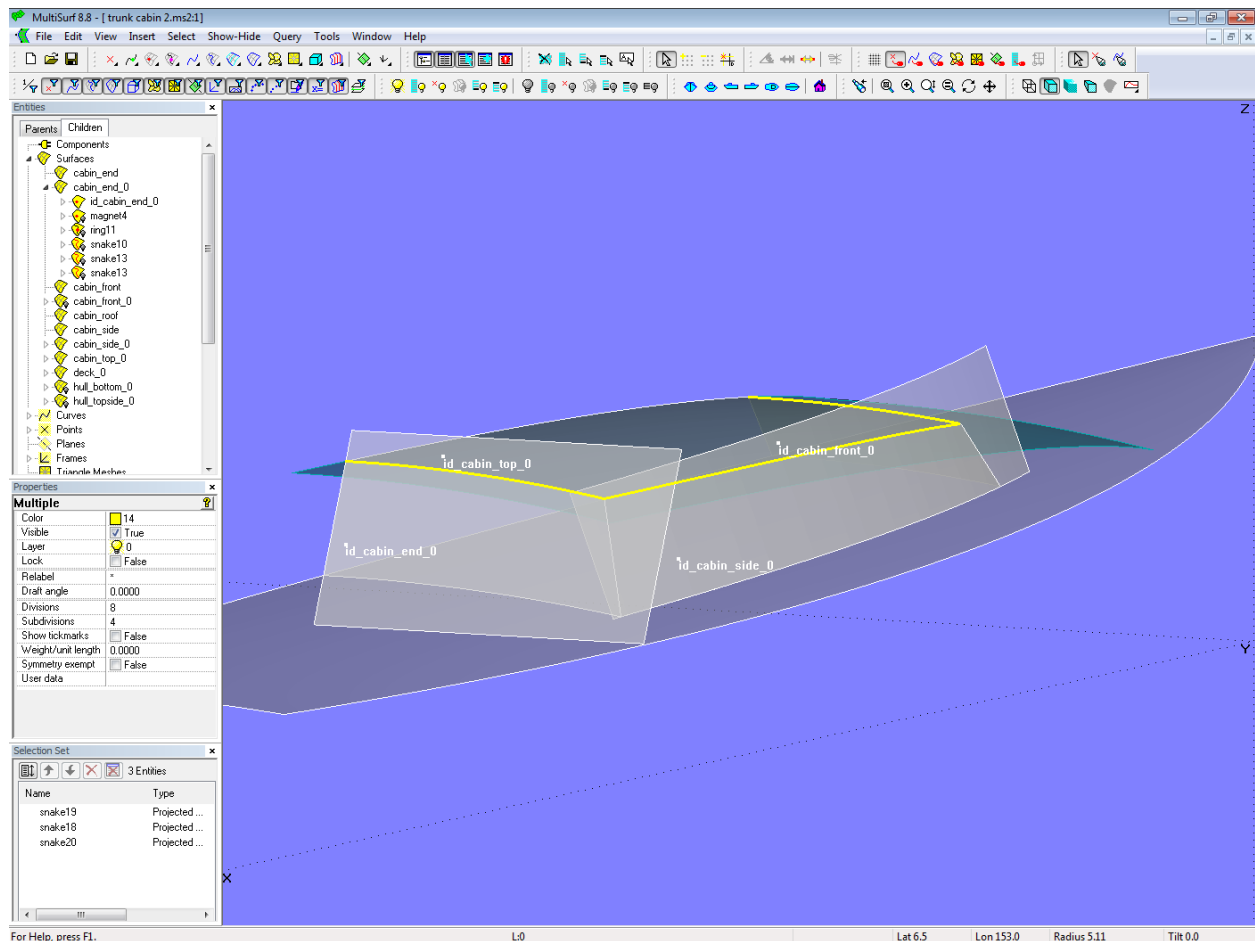


*Model trunk\_cabin-2.ms2 – final front of cabin by Trimmed Surface*

Cabin side and end surfaces are treated in the same way. First, the intersection with the neighboring surfaces are determined (Intersection Snakes), next, extending portions trimmed via SubSnakes, and finally Trimmed Surfaces created.



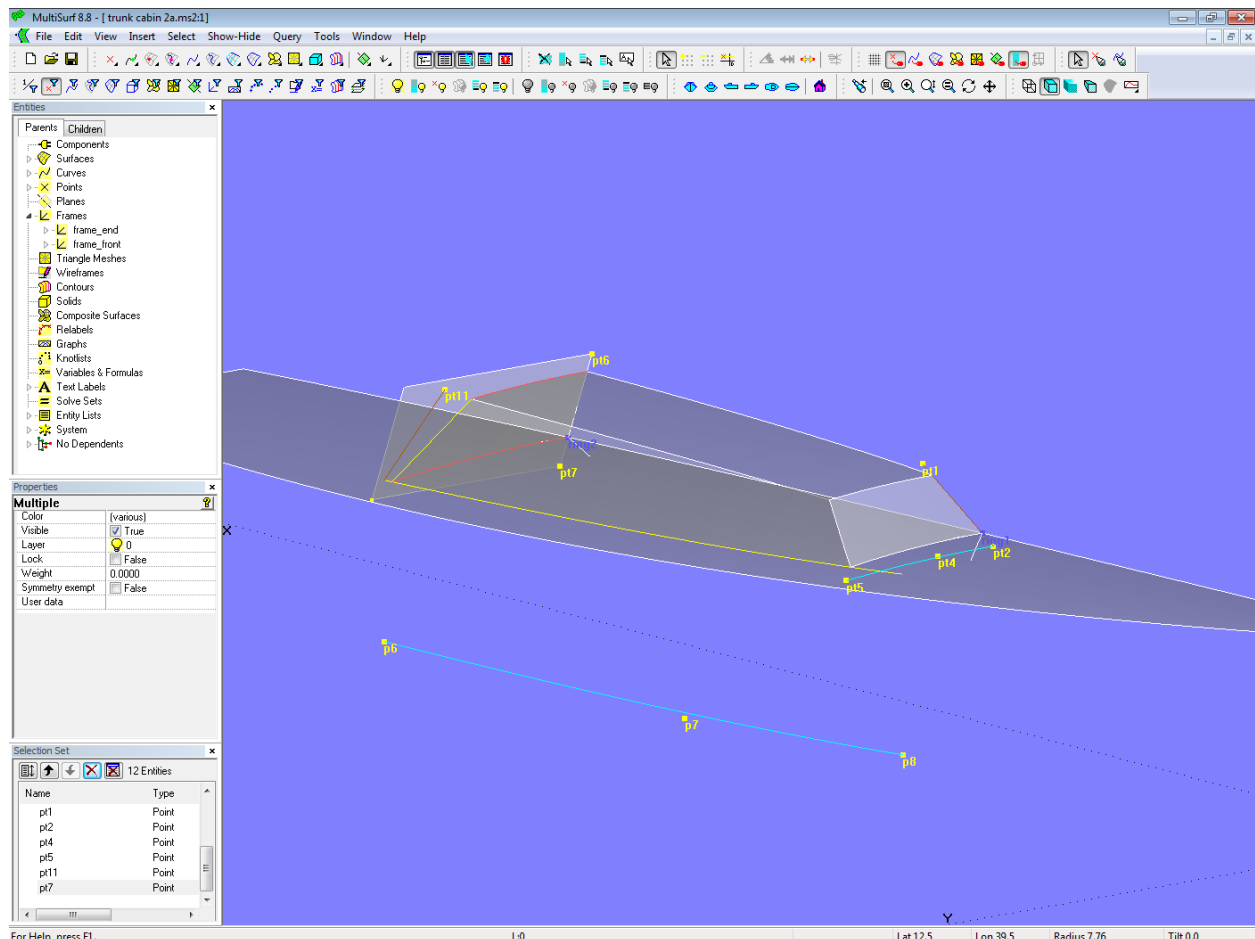
Model trunk\_cabin-2.ms2 – intersections of deck, side, roof and cabin end



Model trunk\_cabin-2.ms2 – use of existing SubSnakes for Trimmed Surface *cabin\_top*

With regard to the cabin top surface there is no need to intersect it with the surrounding basis surfaces. Simply project the already existing SubSnakes onto the roof (Projected Snakes). This saves repeated work.





Model trunk\_cabin-2.ms2 – final surfaces and their defining points and curves

It is very convenient to maintain an Entity List which holds the objects that define the shape of the super-structure. Then you can quickly get all the points and curves on the screen, which really control form and position of the individual surfaces. Auxiliary objects such as rings for trimming intersection snakes, these themselves or their SubSnakes do not need to be displayed, these are just things which can stay in the background. Of main interest are the finished parts and the points (handles) and curves which control their shape.

To show the content of an Entity List:

- in the Entities manager right-mouse-click on the name of the Entity List, then select “Show Parents” from the context menu
- in the Entities manager click on the name of the Entity List, then click the button “Show Parents” from the “Show-Hide” toolbar

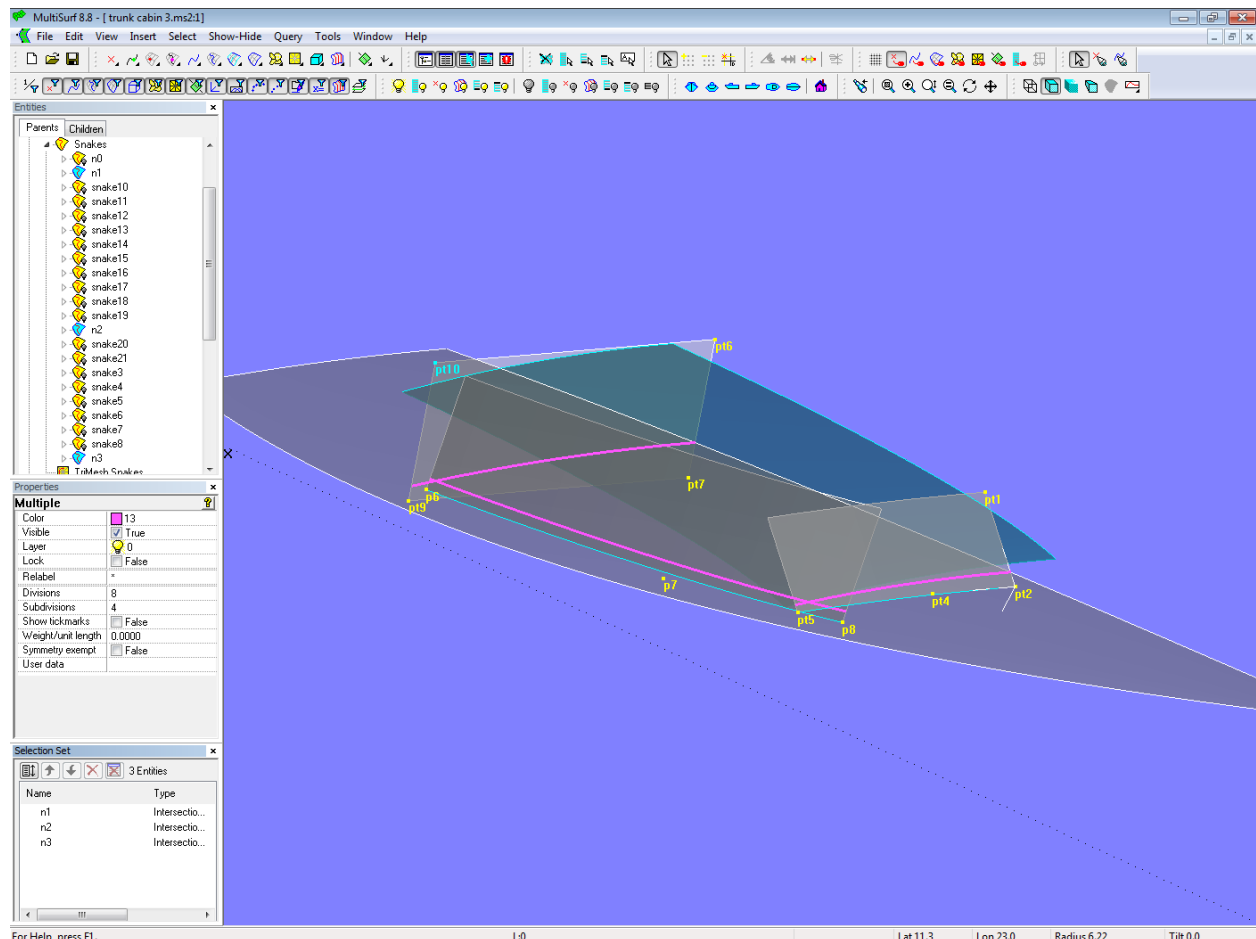
In this model here in question, the lower edge of the cabin side is a Projected Snake on the deck. This has the advantage that one immediately knows where the side of the cabin meets the deck, so one can see immediately how wide the gangboard is.

The two Rings [ring1](#) and [ring2](#) determine directly where the cabin front and the cabin end are located on the deck centerline.

If, however, the deck is changed, for example, it is given some more camber, then the position of the snake will change in height, and thus the bottom edge of the cabin side also moves slightly upwards.

While the rings on centerline remain in place with respect to the longitudinal position, they go up a bit, dragging their frames along, and everything that depends on them.

In model *trunk\_cabin-3.ms2*, on the other hand, all basis surfaces are independent of the deck. The basis surfaces are basically defined in the same way as before, but the bottom edge of the cabin is below the deck surface. The position of the front and end surfaces is defined only indirectly by the points [pt2](#) and [pt7](#).



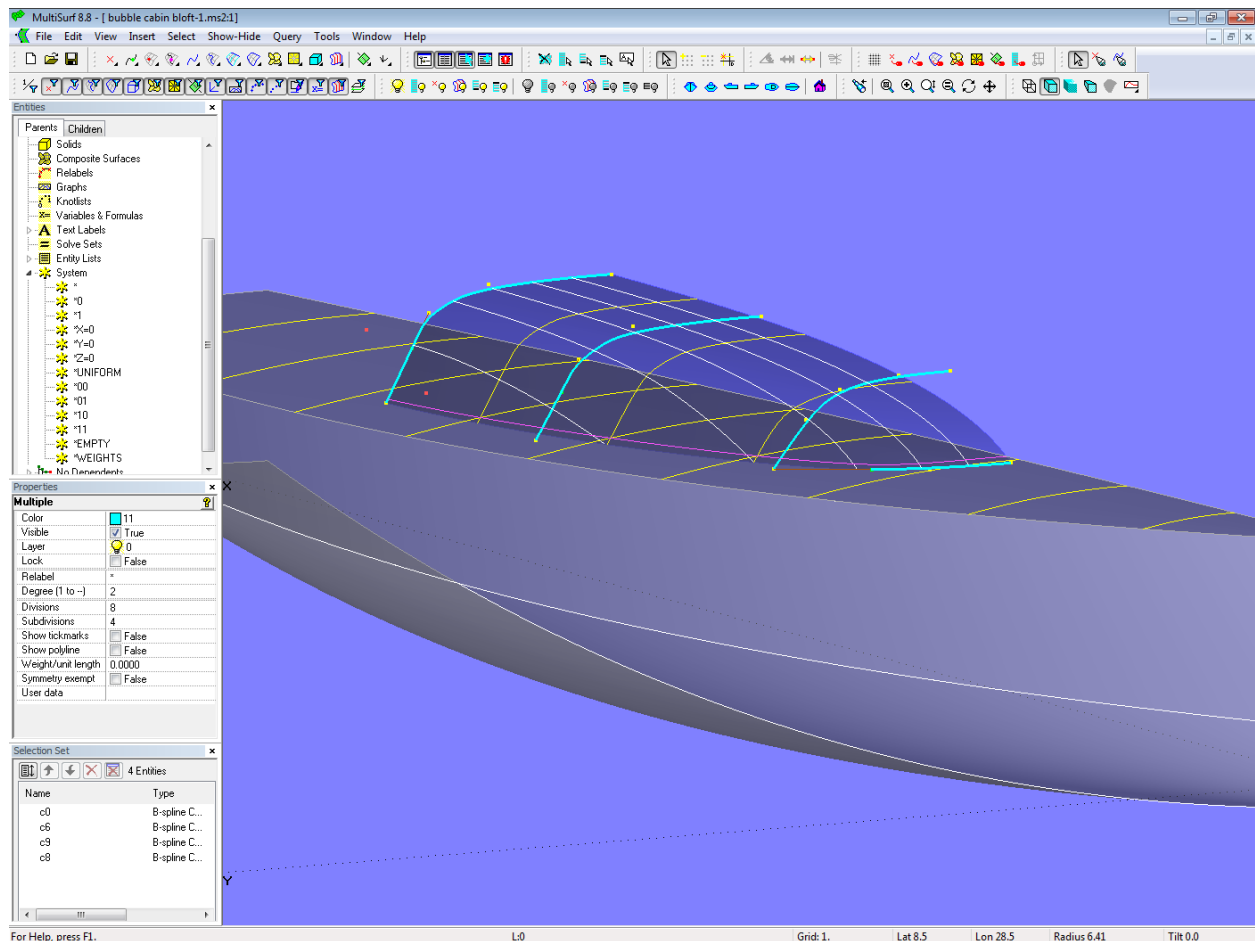
Model *trunk\_cabin-3.ms2* – basis surfaces for a cabin without being dependent in shape on deck surface

As can be seen by the Intersection Snakes, if the camber or sheer of the deck is modified, the construction now dips more or less deep into the deck. But otherwise the superstructure geometry remains unchanged. What will change, however, is the width of the deck at side and the cabin height above deck.

### 3 – The Freeform-Superstructure (Bubble Cabin)

#### B-spline Lofted Surface on Transverse Mcs

In the box-shaped design, there were separate surfaces for front, side and top. In model *bubble\_cabin\_bloft-1.ms2* these 3 elements are formed by a single surface of the type B-spline Lofted Surface. This kind of surface allows round, soft transitions between front, side and roof.

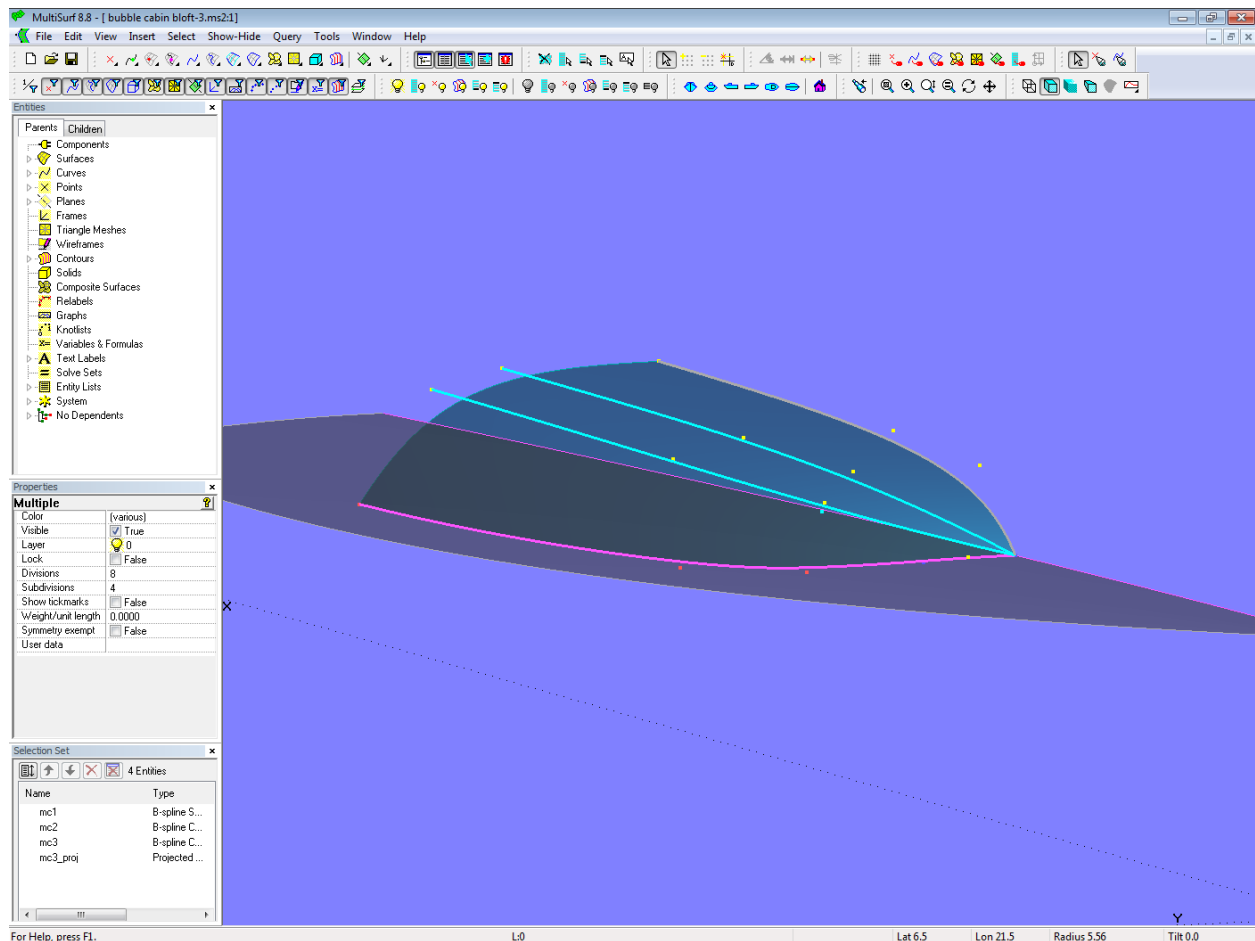


Model *bubble\_cabin\_bloft-1.ms2* – arrangement of transverse B-spline master curves

The support curves of the B-spline Lofted Surface are 4 B-spline Mcs, which run in transverse direction. The mc arrangement is similar to that for a hull rotated by 90 degrees.

## B-spline Lofted Surface on Longitudinal Mcs

In model *bubble\_cabin\_bloft-2.ms2* the support curves run in longitudinal direction. This makes it possible to place a mc as a snake on the deck, defining directly the shape of the cabin edge at deck level. So there is not need to trim the cabin at the deck.

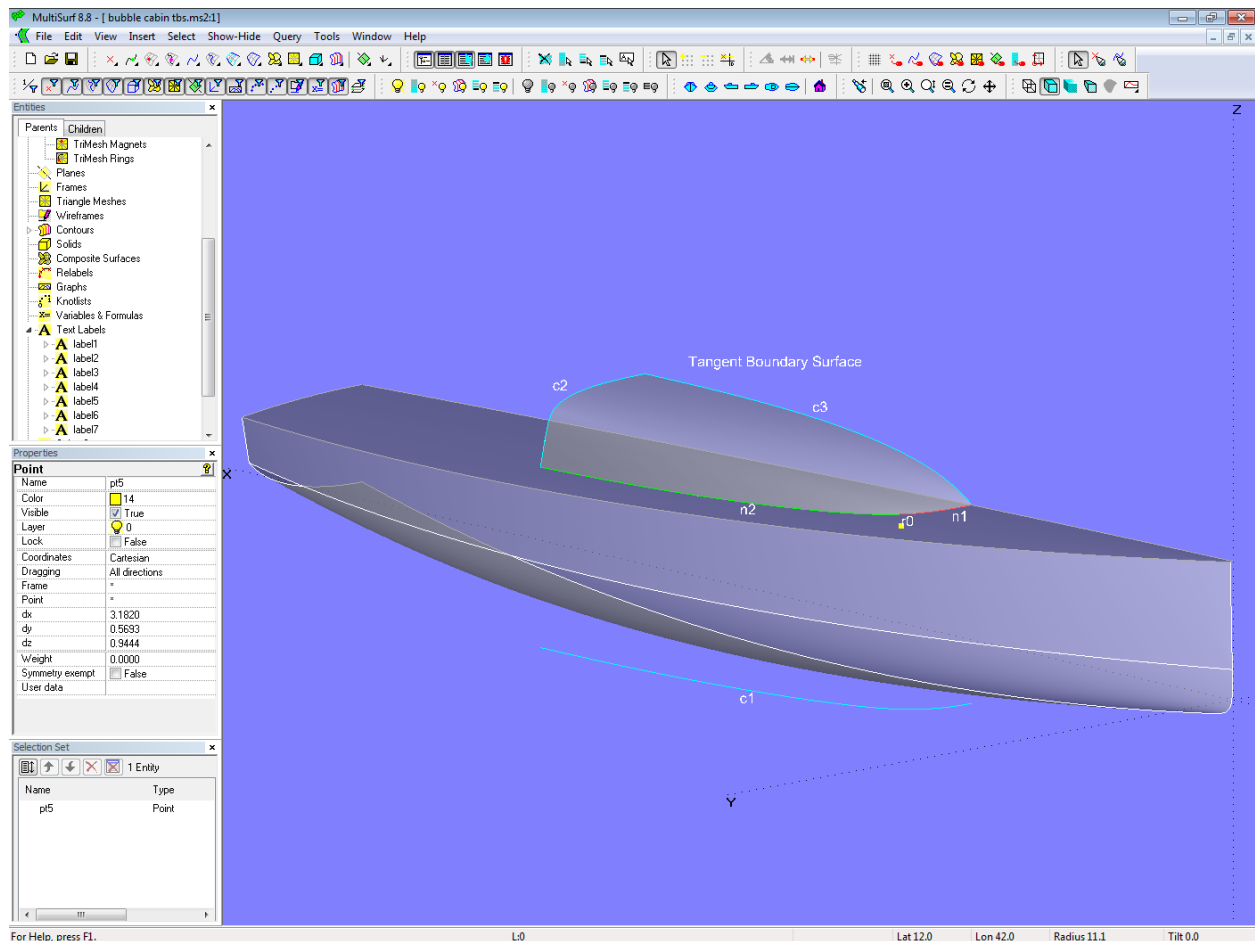


Model bubble\_cabin\_bloft-2.ms2 – arrangement of longitudinal master curves

## Tangent Boundary Surface

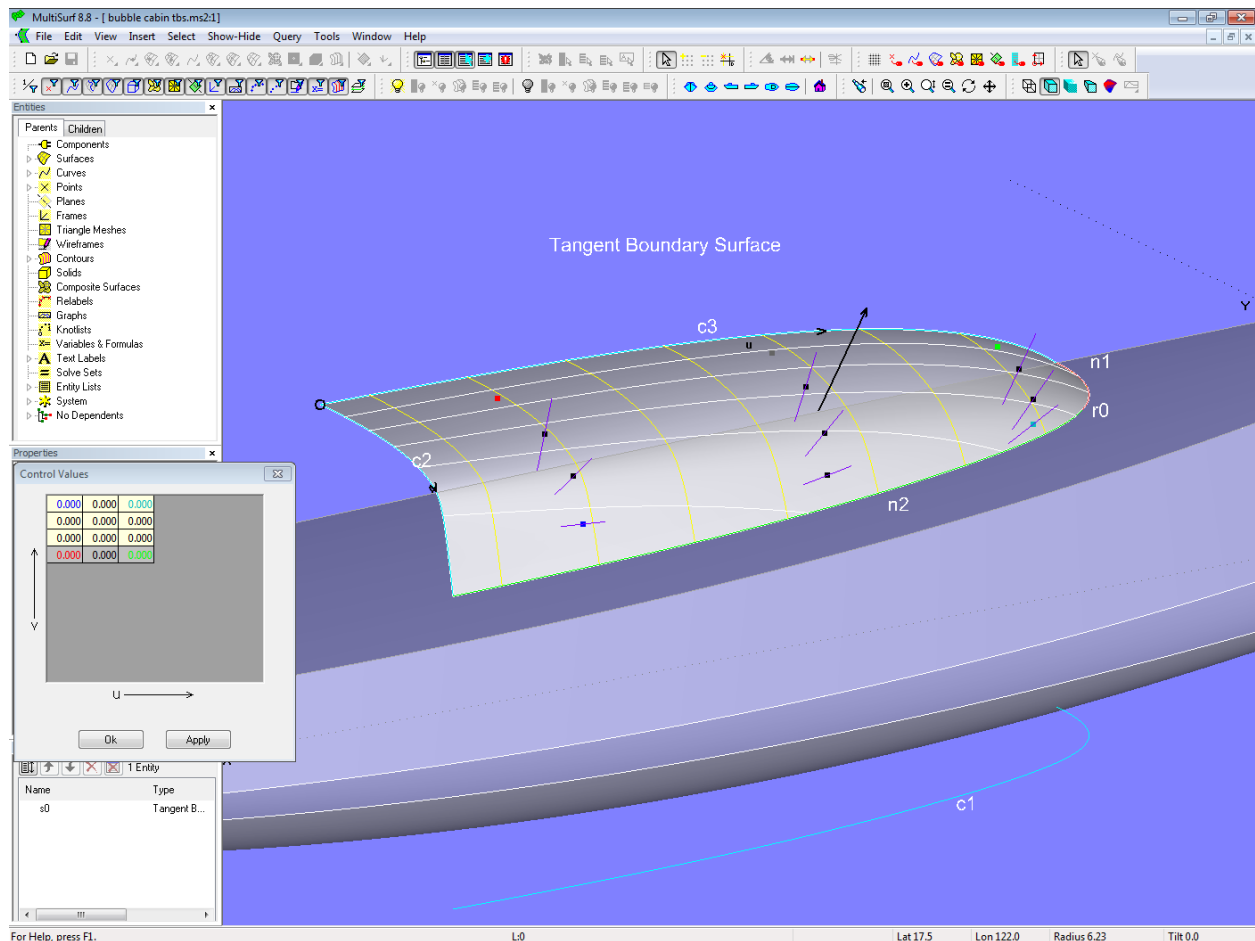
The ultimate bubble superstructure can be created using the Tangent Boundary Surface. On the one hand, the shape is defined by its 4 edge curves. On the other hand, the surface can be arbitrarily deformed by internal control points.

In the model *bubble\_cabin\_tbs.ms2* the shape of the lower edge is first created as curve **c1** and then projected onto the deck as Projected Snake **n0**. The Ring **r0** divides the Projected Snake **n0** into the Sub-Snakes **n1** and **n2**. The aft edge is defined by the B-spline Curve **c2**, and the profile on centerplane is given by the B-spline curve **c3**. Thus, all the 4 boundary curves of the Tangent Boundary Surface are determined.



*Model bubble cabin tbs.ms2 – bubble shape superstructure by Tangent Boundary Surface; arrangement of boundary curves*

If the shape of the cabin is not yet as desired, the surface can be modified further via internal control points (with a selectable number both in u- and v-direction of the surface).

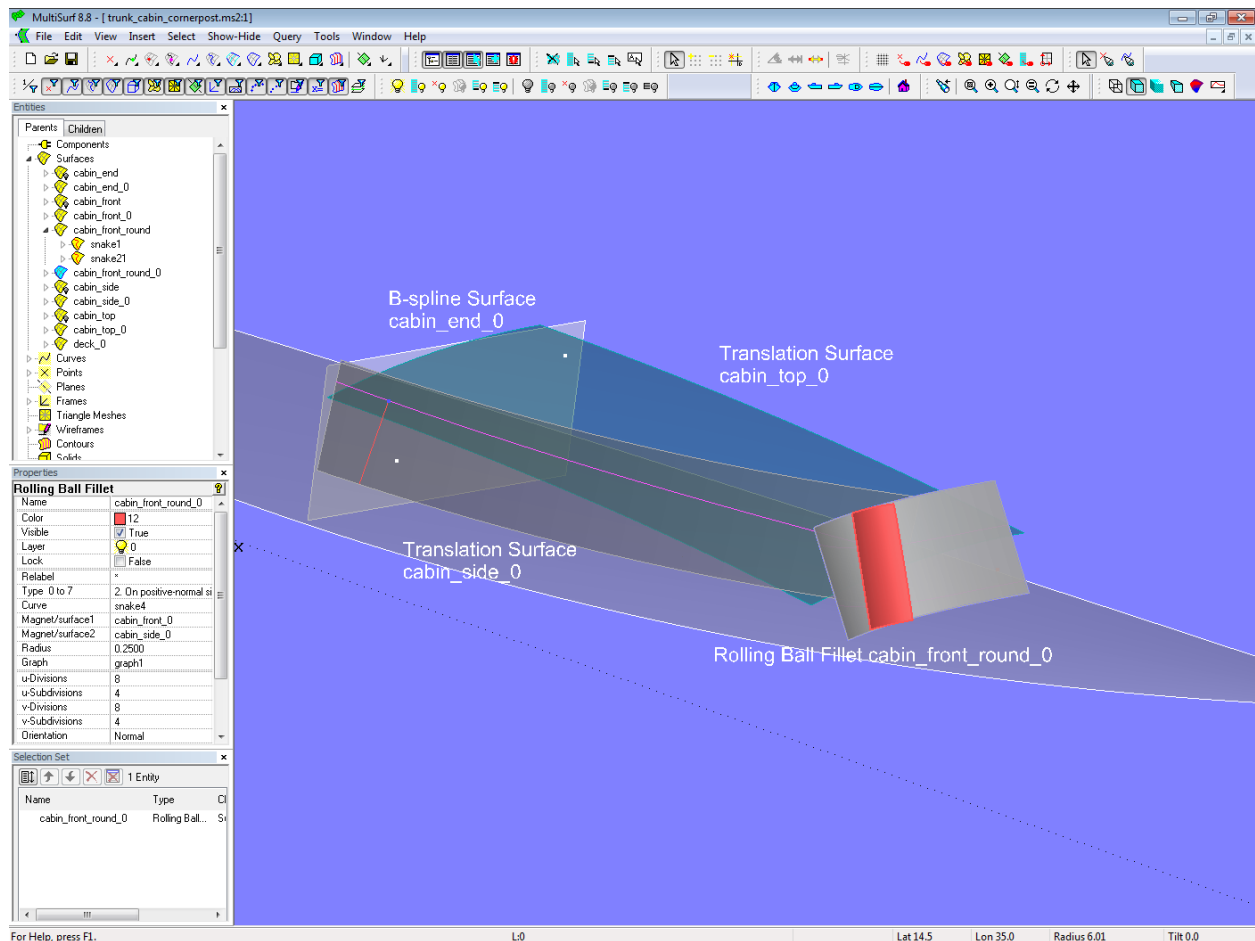


Model bubble cabin tbs.ms2 – the interior portion of the Tangent Boundary Surface can be formed by internal control points.

## 4 – Somewhat more complex superstructures

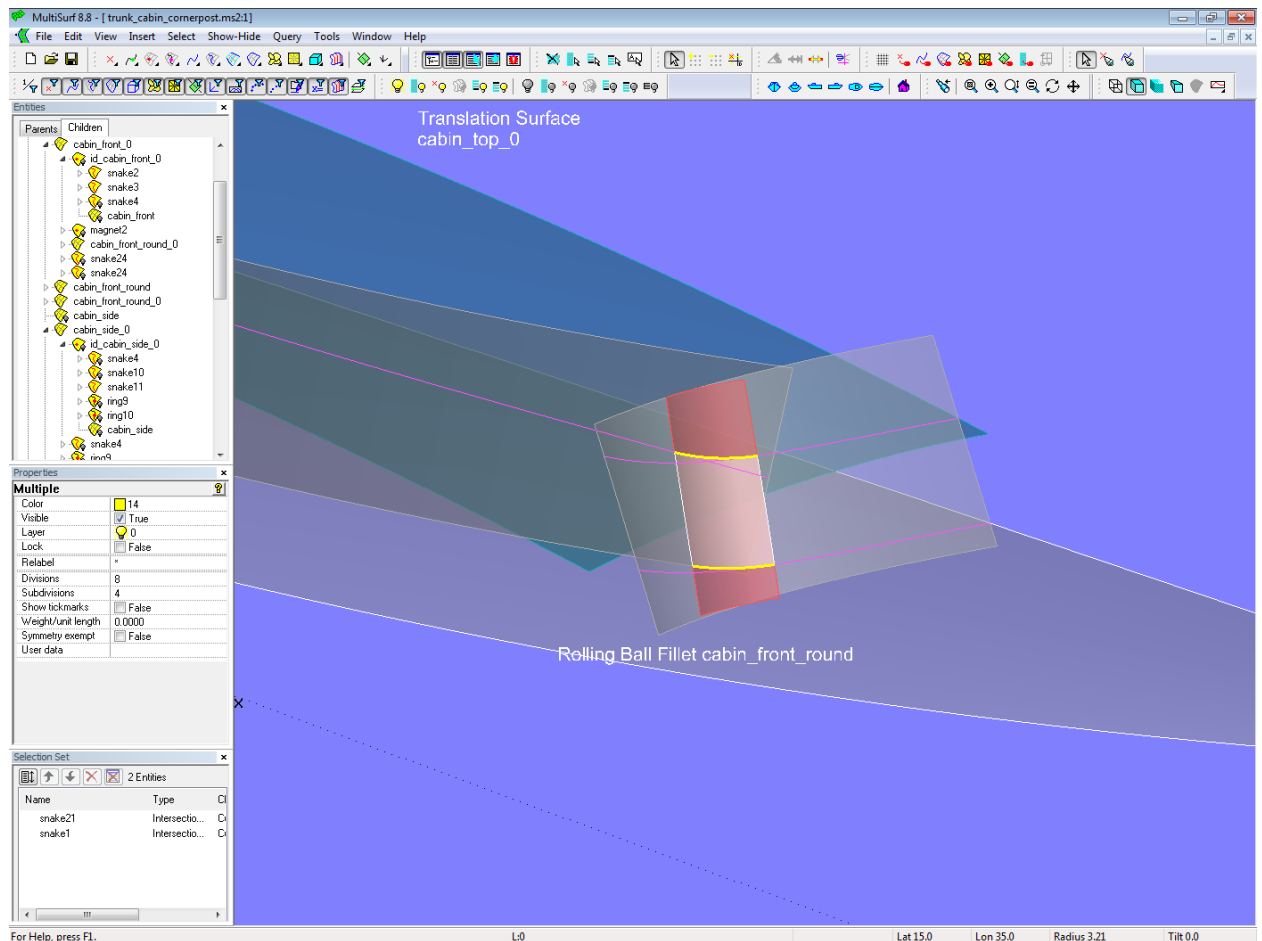
### Rounded front

A box-shaped design as in the *trunk\_cabin* models can have rounded corners. Model *trunk\_cabin\_cornerpost.ms2* shows how to do something like that. The basic construction is the same, separate basis surfaces for side, front, etc. Between front and side the surface [cabin\\_front\\_round](#) of the type Rolling Ball Fillet is added. As the name implies, this surface can be thought of as a sphere that rolls between the two surfaces, sweeping a rounding which extends between the path of all the contact points on the one surface and the path of all contact points on the other surface.



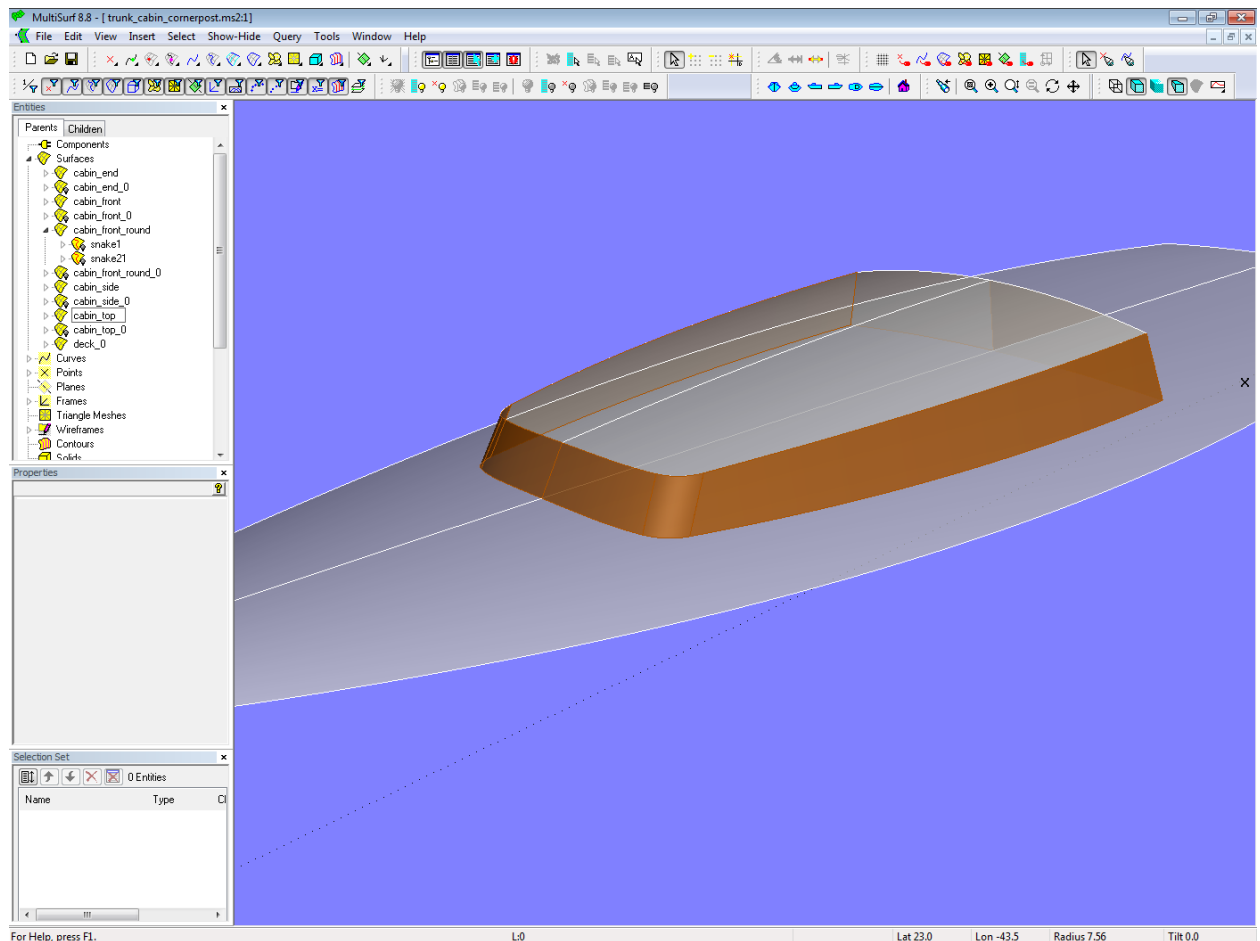
Model trunk\_cabin\_cornerpost.ms2 – basis surface for the rounding between cabin front and side

As with the other surfaces, the rounding is intersected with the adjacent surfaces (Intersection Snakes) and then the desired portion of the surface is generated as a SubSurface or Trimmed Surface.



Model trunk\_cabin\_cornerpost.ms2 – final rounding between intersection with deck and cabin top (SubSurface)

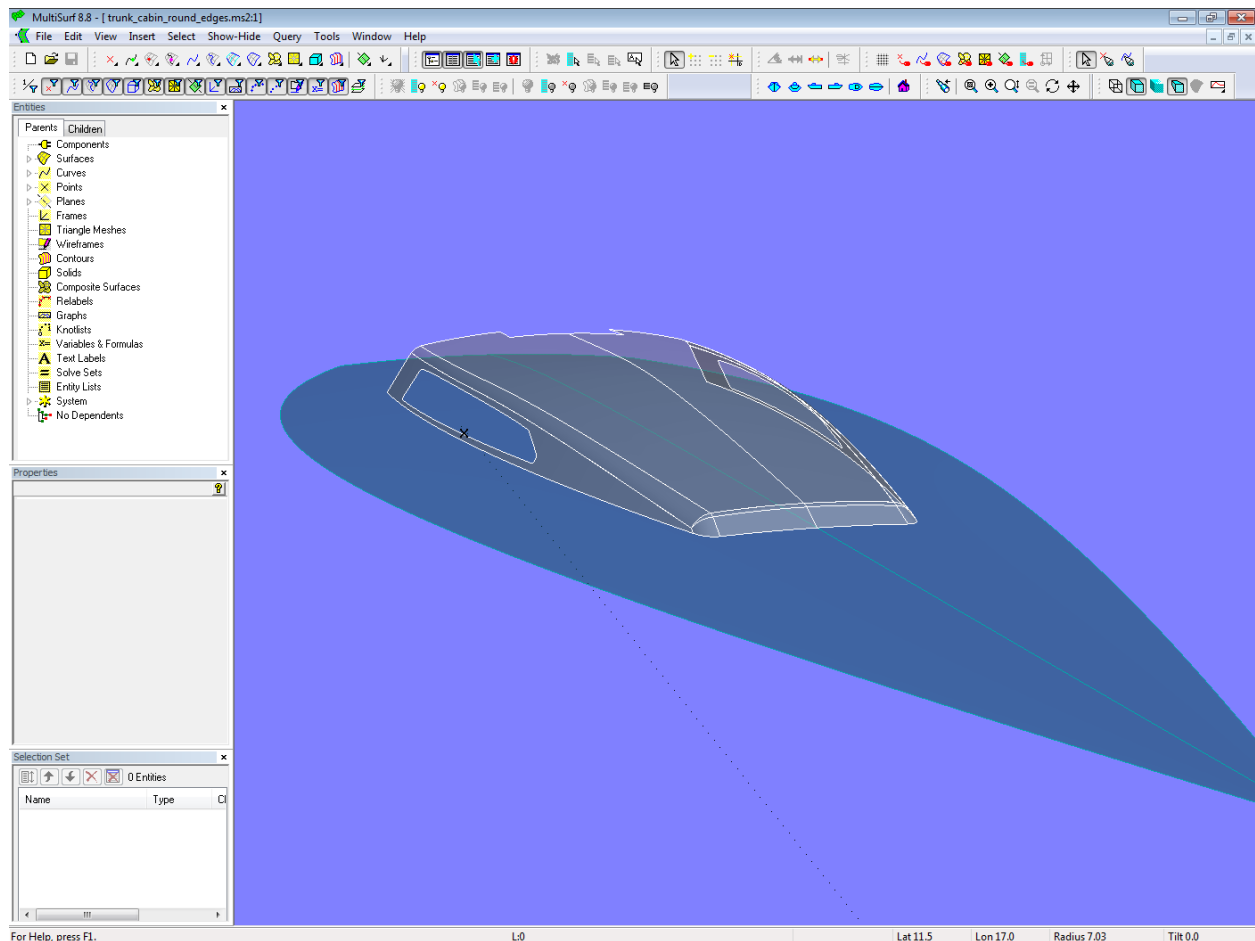




*Model trunk\_cabin\_cornerpost.ms2 – finished cabin surfaces*

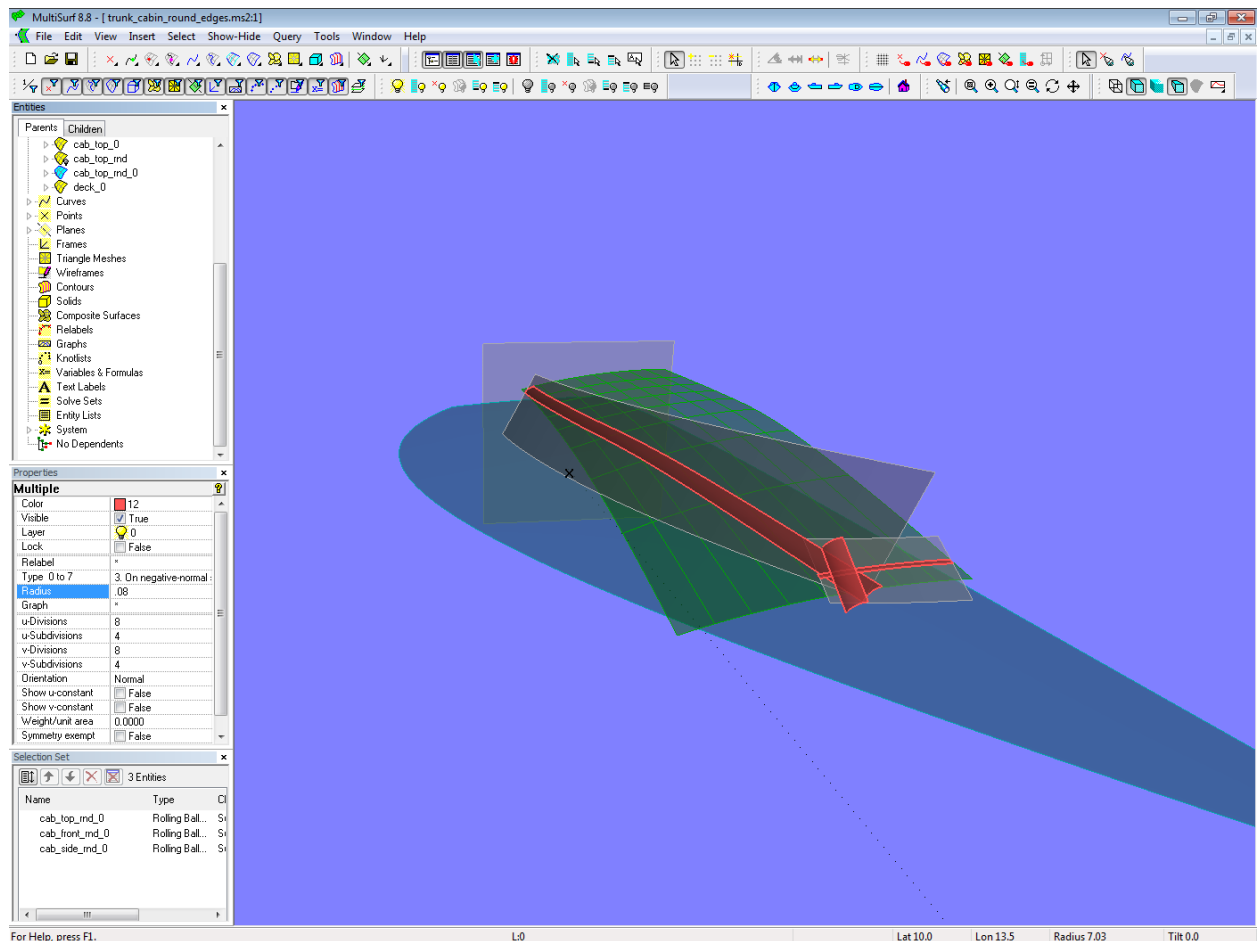
## Rounded edges

With the Rolling Ball Fillet, the edges along the cabin faces can also be rounded off. Model *trunk\_cabin\_round\_edges.ms2* shows an example.



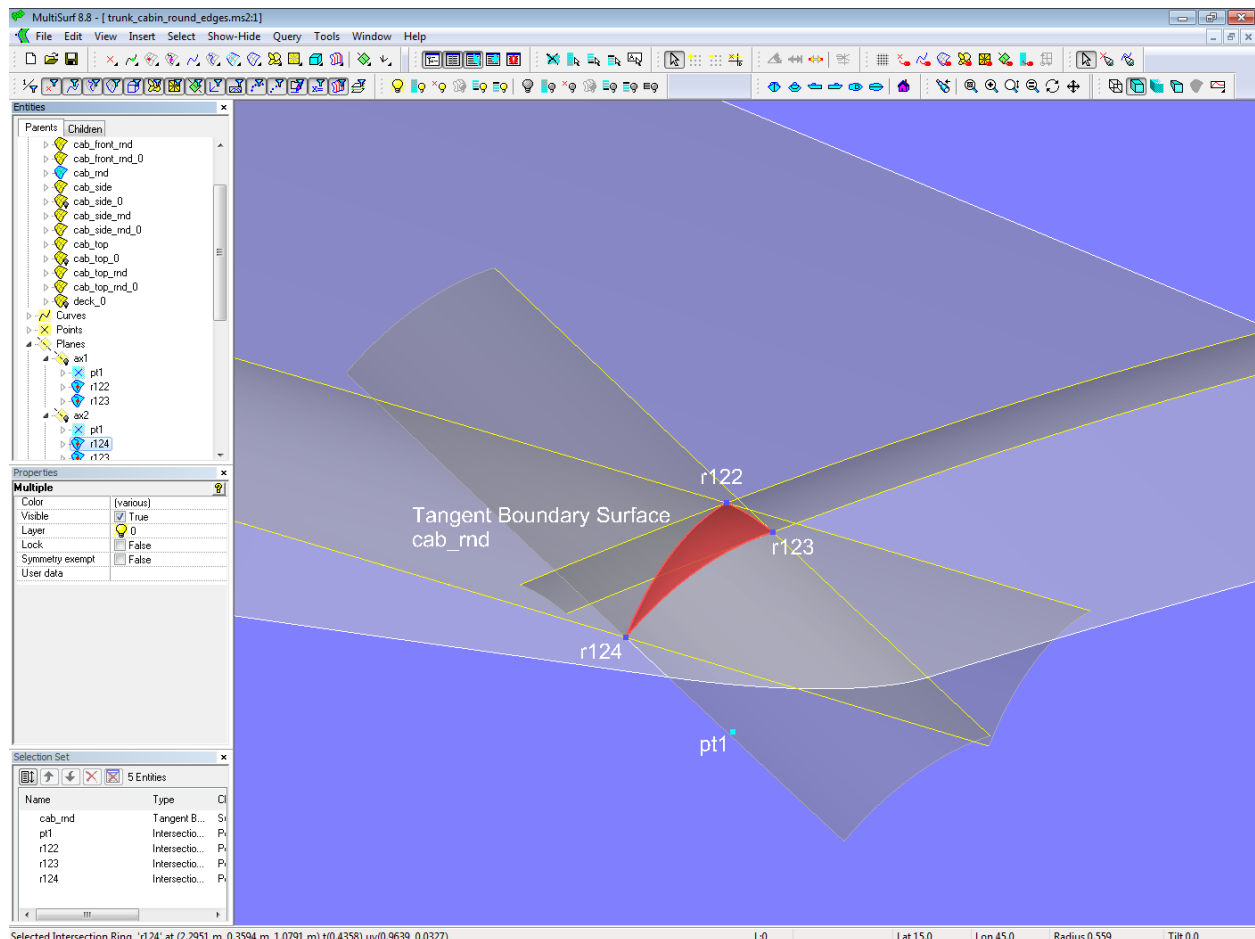
Model trunk\_cabin\_round\_edges.ms2 – rounding of cabin edges using Rolling Ball Fillets

Three roundings are added to the cabin basis surfaces: the Rolling Ball Fillet [cab\\_top\\_rnd\\_0](#) between [cab\\_top\\_0](#) and [cab\\_front\\_0](#), the Rolling Ball Fillet [cab\\_front\\_rnd\\_0](#) between [cab\\_side\\_0](#) and front, and the Rolling Ball Fillet [cab\\_side\\_rnd\\_0](#) between roof and side. All fillets have the same radius.



*Model trunk\_cabin\_round\_edges.ms2 – the basis rounding surfaces meet at the front.*

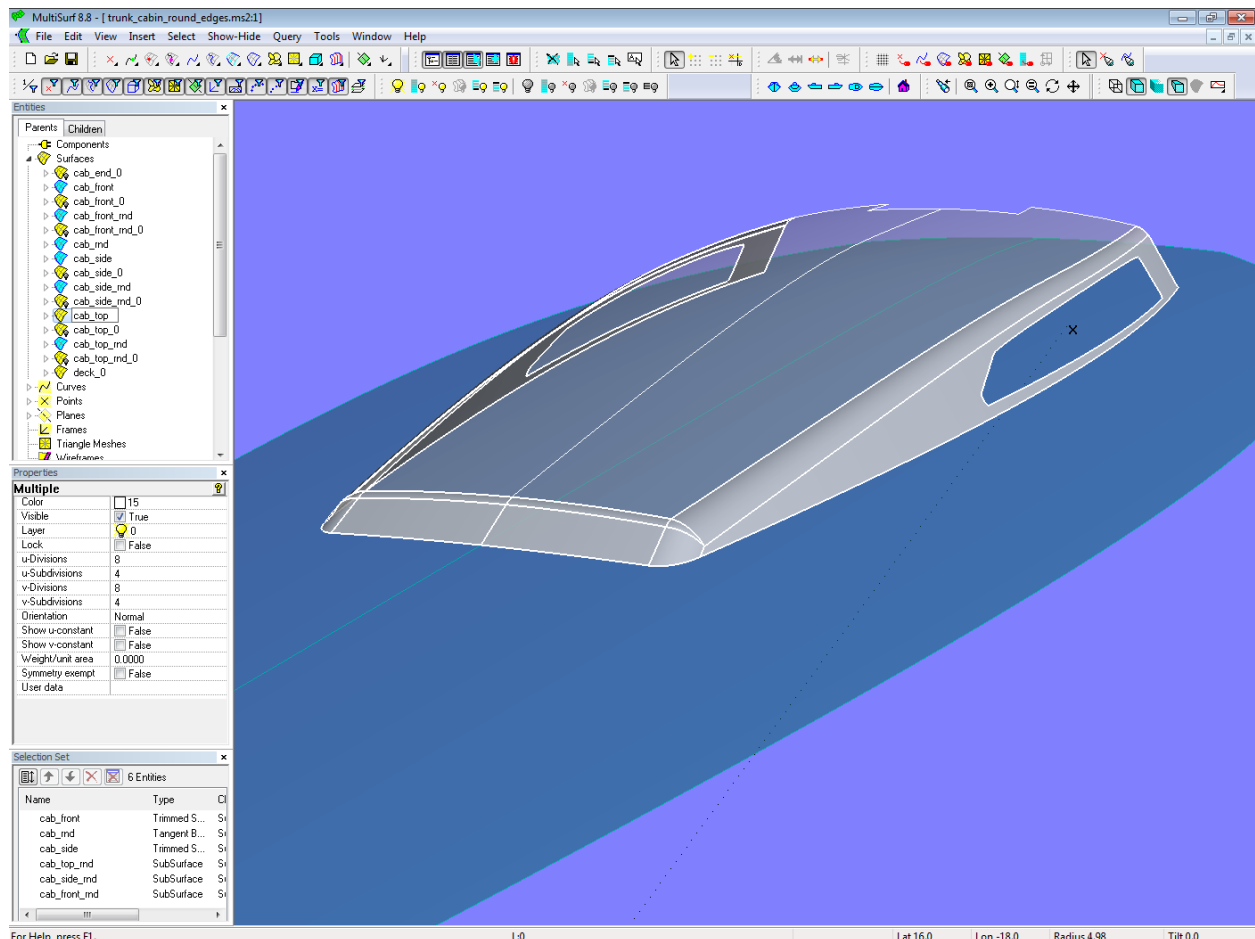
The fillets meet in the corner between roof, side and front.



Model trunk\_cabin\_round\_edges.ms2 – spherical triangle between the rounding surfaces in the corner of side, roof and front

The sphere, which rolls along the intersection of side and roof of the cabin knocks against the front wall (r123), thus its rounding surface ends before the front. When the sphere travels along the intersection of roof and front, it hits against the side (r124), thus its rounding surface stops before the side. When the sphere moves along the intersection of side and front, it hits the roof (r122), its rounding ends in front of the roof. Therefore a gap arises between the 3 rounding surfaces. This gap is closed by a part of the surface of the sphere (center point pt1) fixed in the corner; the rounding here is a spherical triangle.

In the model trunk\_cabin\_round\_edges.ms2 this triangle is produced by the Tangent Boundary Surface cab\_md.



Model trunk\_cabin\_round\_edges.ms2

## Front with flat windows

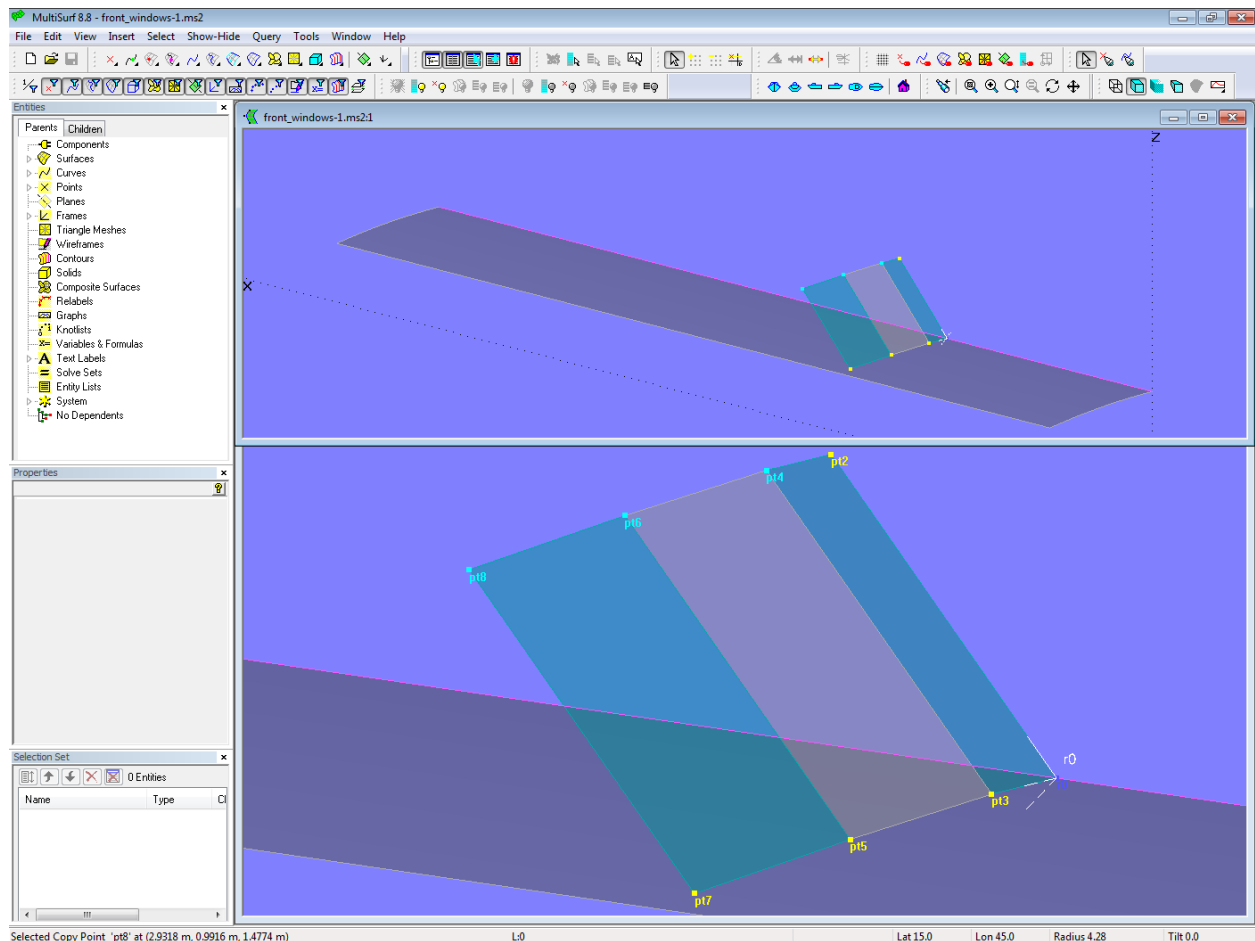
The model *front\_windows-1.ms2* shows the easiest way to create surfaces for front windows. The restrictions are flatness and rectangular shape.

Starting point is the XYZRing **r0** on the deck centerline. From it depends the point **pt2** on centerplane; it controls the inclination of the inner window. Together with point **pt1** they determine the 3-point Frame **F0**, to which all further points then refer.

The half width of the window determines the point **pt3**. For the window to be rectangular, the CopyPoint **pt4** is created. With **r0**, **pt2**, **pt3** and **pt4** the B-spline Surface **window1\_0** is determined. (A flat rectangular surface can be created with a minimum of 4 points and a B-spline Surface, one point being a Copy Point of the other 3 points.)

The adjacent window **window2\_0** is also a B-spline Surface with 4 Cps; **pt5** is defined in polar coordinates, so the radius is the width of the window, and the latitude is the angle to the inner window.

The outer window **window3\_0** is defined in an analogous manner. If the bending angle is to be as large as for the neighboring surface **window2\_0**, the value for latitude for the point **pt7** must be the double of the value for **pt5**.

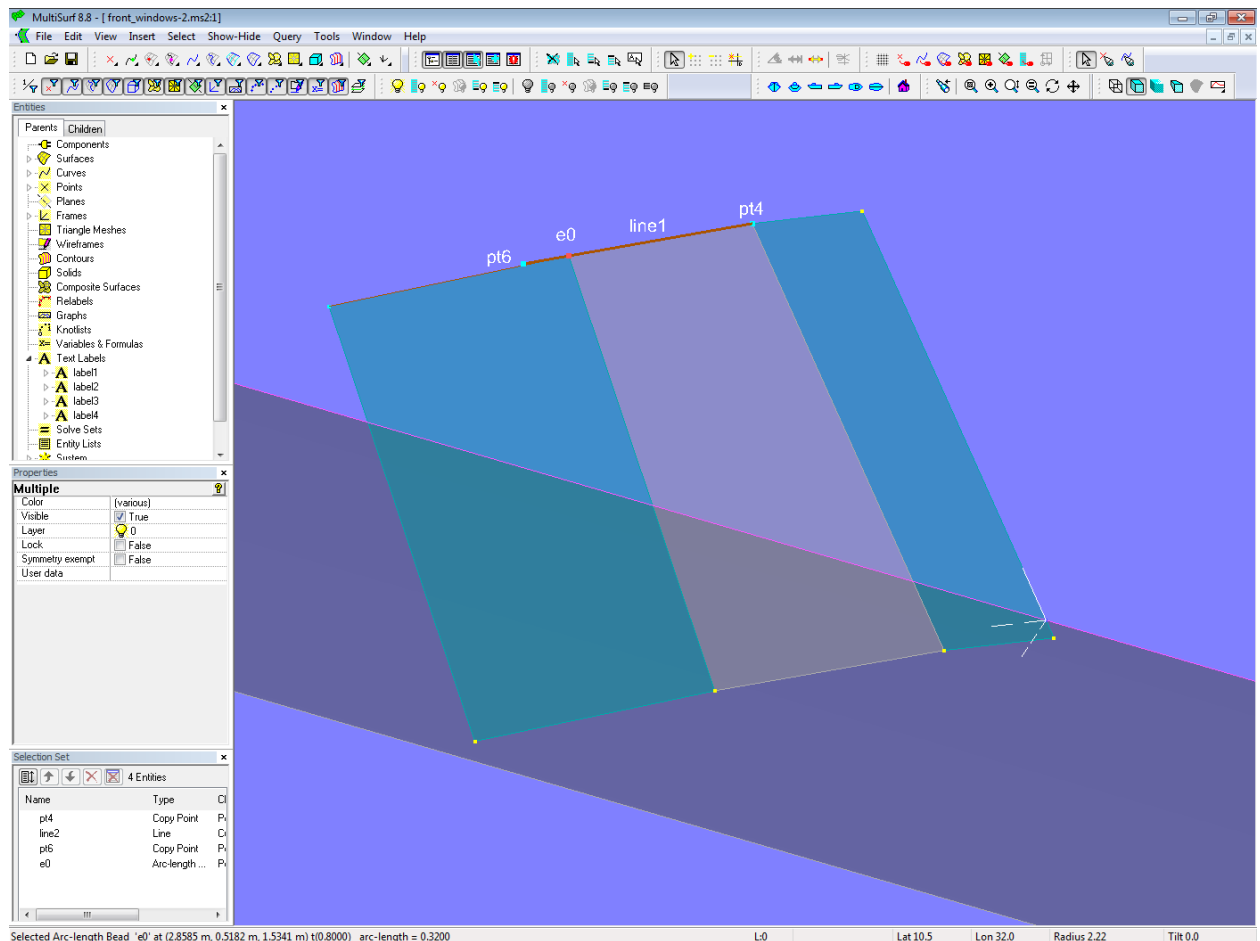


Model front\_windows-1.ms2 – arrangement of control points for 3 planar rectangular surfaces (front windows)

If the window surfaces are not to be rectangular, but have a different width at the upper edge than at the lower edge, the method shown in the model *front\_windows-2.ms2* can be used.

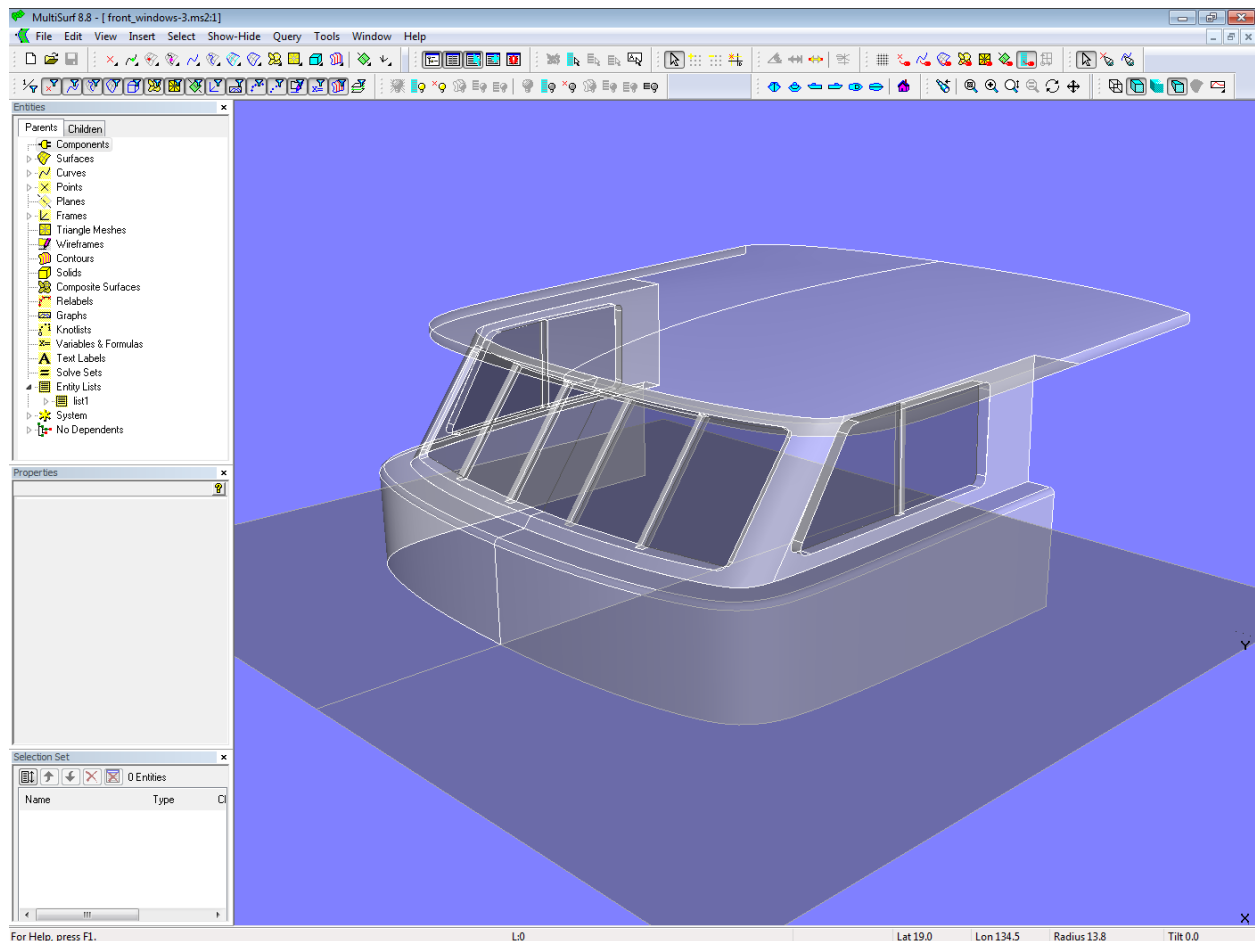
A Line (*line1*) is spanned between the points *pt4* and *pt6*, and the Arc-length Bead *e0* is set on it. For the B-spline Surface *window2\_0*, the bead is then used instead point *pt6*. The window surface is still planar (ensured by Copy Point *pt6*), but you can now control the desired upper width by *e0*.

The outer window surface can be defined in the same way.



Model *front\_windows-2.ms2* – arrangement of control points for variable width of upper edge

Model *front\_windows-3.ms2* shows an application of the method explained in the foregoing.

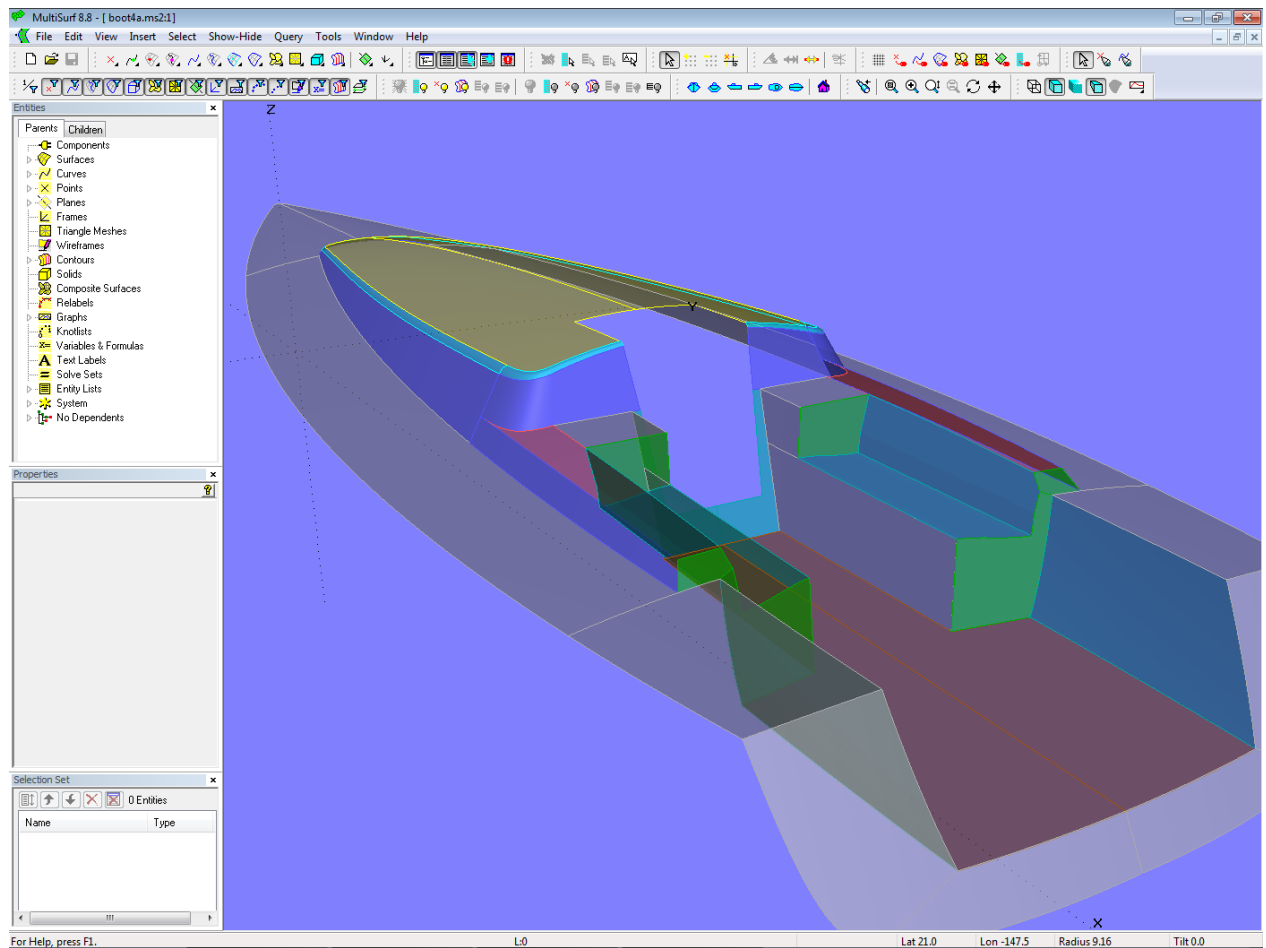


Model front\_windows-3.ms2

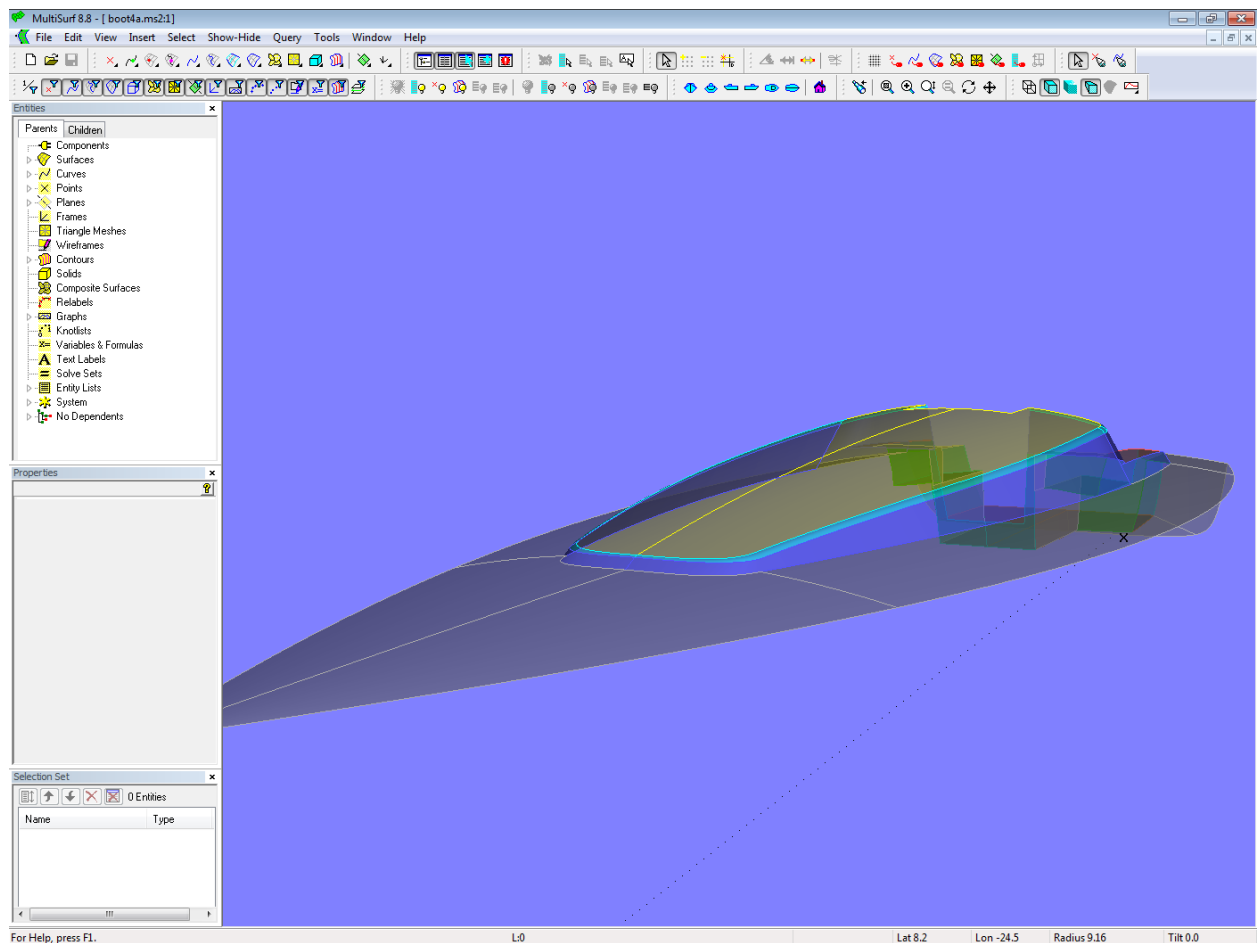
## 5 – Complex Superstructures

Complex superstructures are a combination of simple elements, the modeling of which has been shown in the preceding sections. Here are some examples.

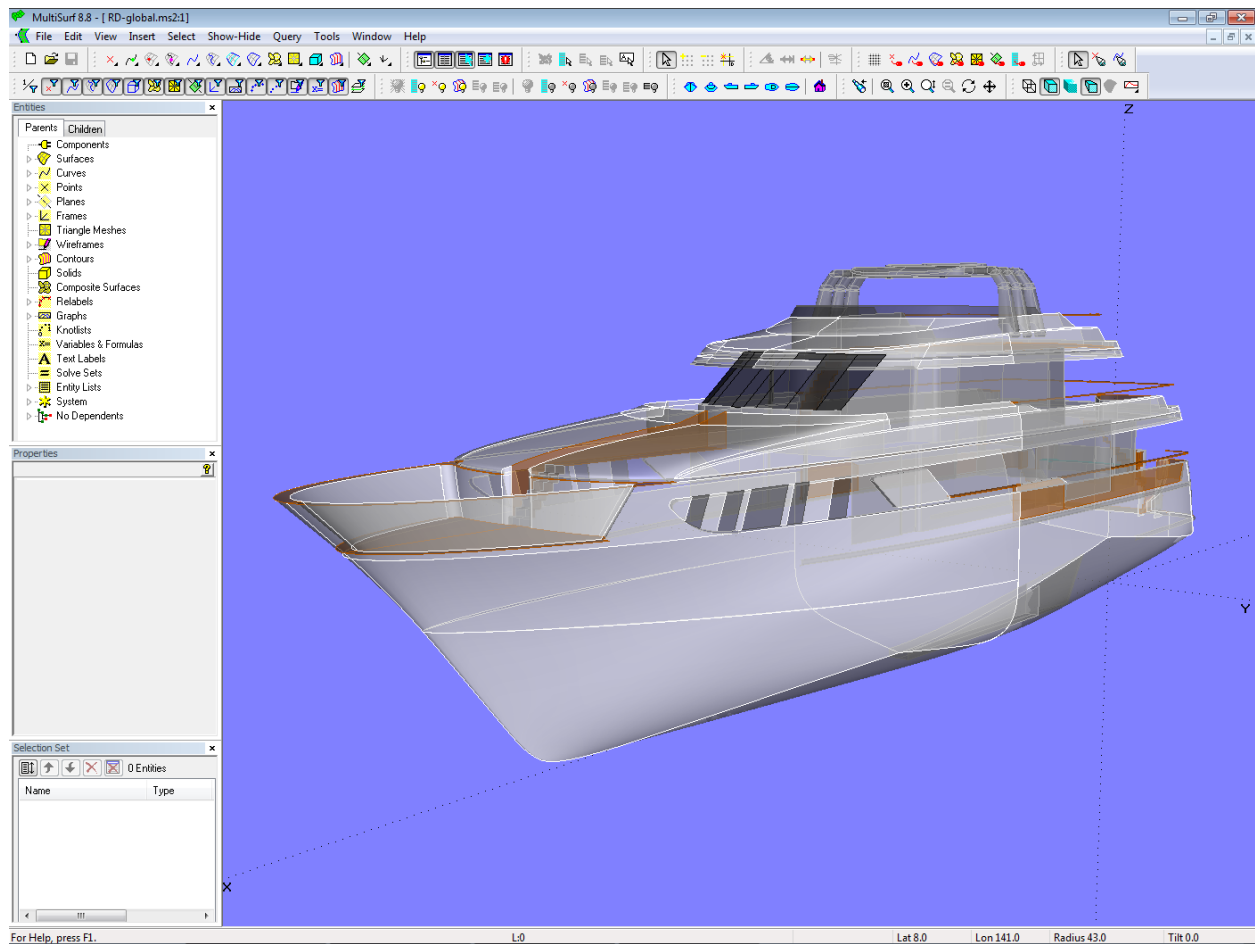




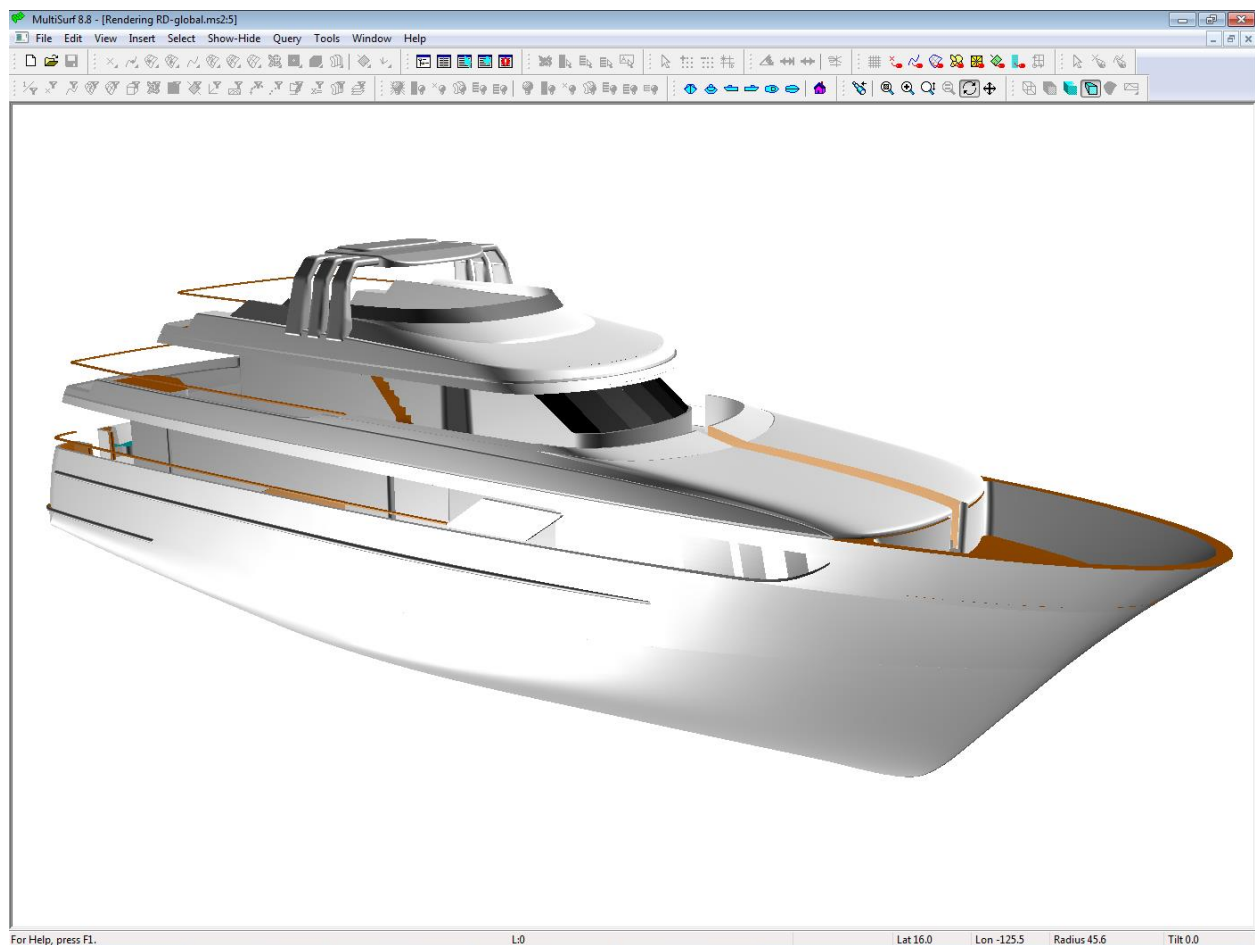
Model design-4.ms2 - 10 m sailboat – superstructure and cockpit



Model design-4.ms2 - 10 m sailboat - superstructure



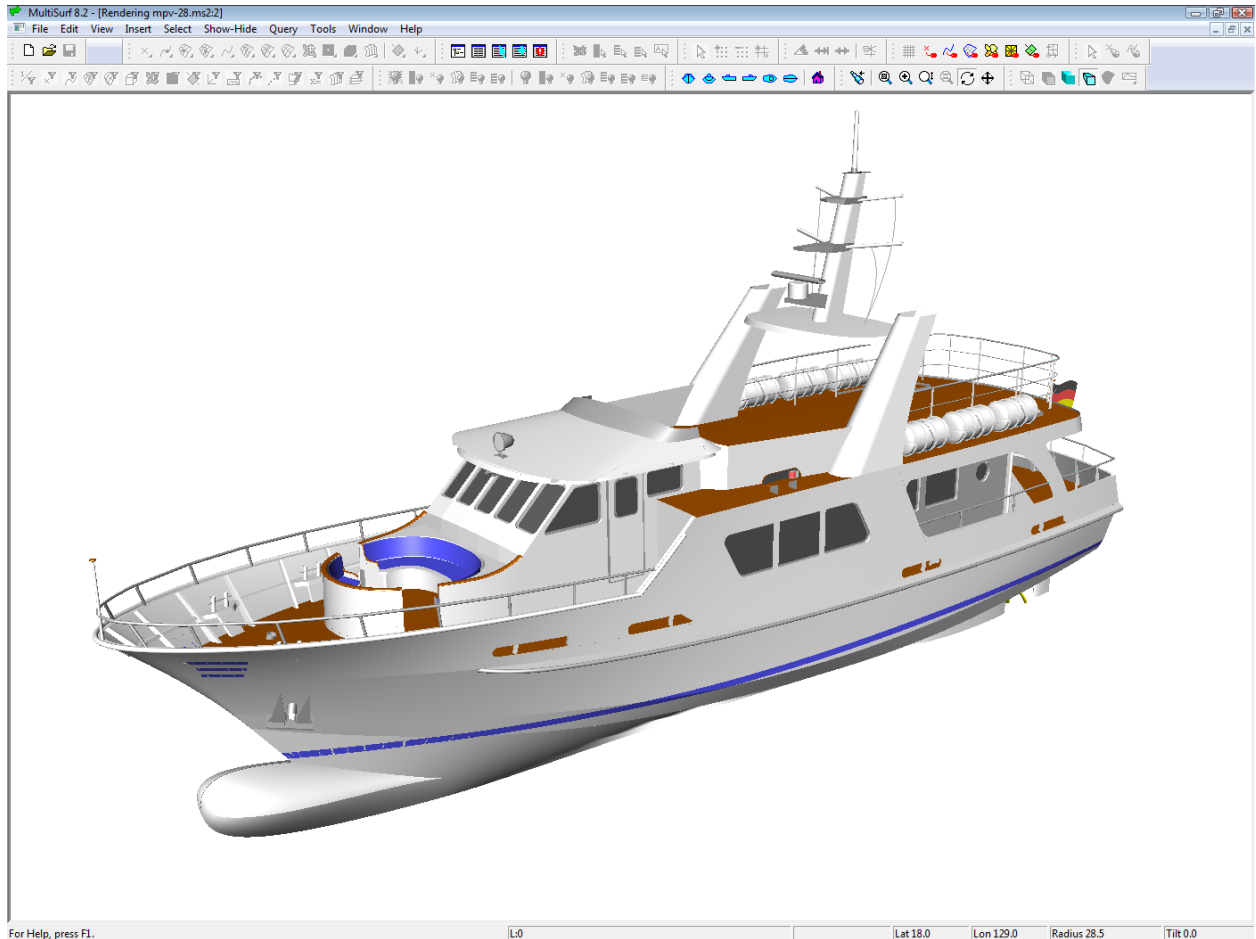
120 ft motor yacht (Russel Dowland design)



120 ft motor yacht (Russel Dowland design)



10 m sailing yacht (Juliane Hempel design)



27 m passenger vessel (CL Shipdesign)

## **MultiSurf** - Relational 3D Surface Design Software



11.5 m classic motorboat (CL Shipdesign)

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