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MARITIME SOFTWARE AND SERVICES

Surface export from PIAS/Fairway: closing the gap with LEANURBS

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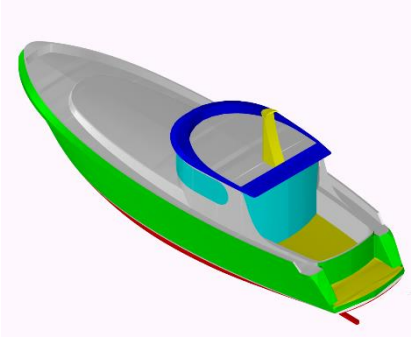
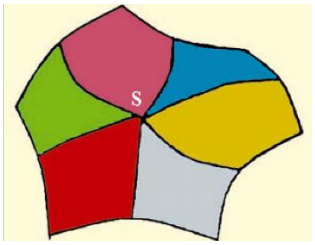
Conventional B-spline or NURBS surfaces are not particularly suitable for ship hullform design. We will not elaborate on that in this paper, after all this subject has been duly documented, e.g. in 1997, 2003 and 2013. The PIAS suite offers an attractive alternative with her Fairway hullform design and fairing module. However, although the NURBS surface method is not very suitable for the hull design process as such, it is widely used for interfacing. So, when a hull design is to be used downstream, e.g. for engineering, CFD analyses or visualization, the Fairway hullform has to be converted to a set of NURBS surfaces. That forces the user of PIAS/Fairway into a kind of Catch-22 situation, because in first instance the nuisance of the NURBS is circumvented when designing the hull, but it still is haunting us when transferring the data to other software.

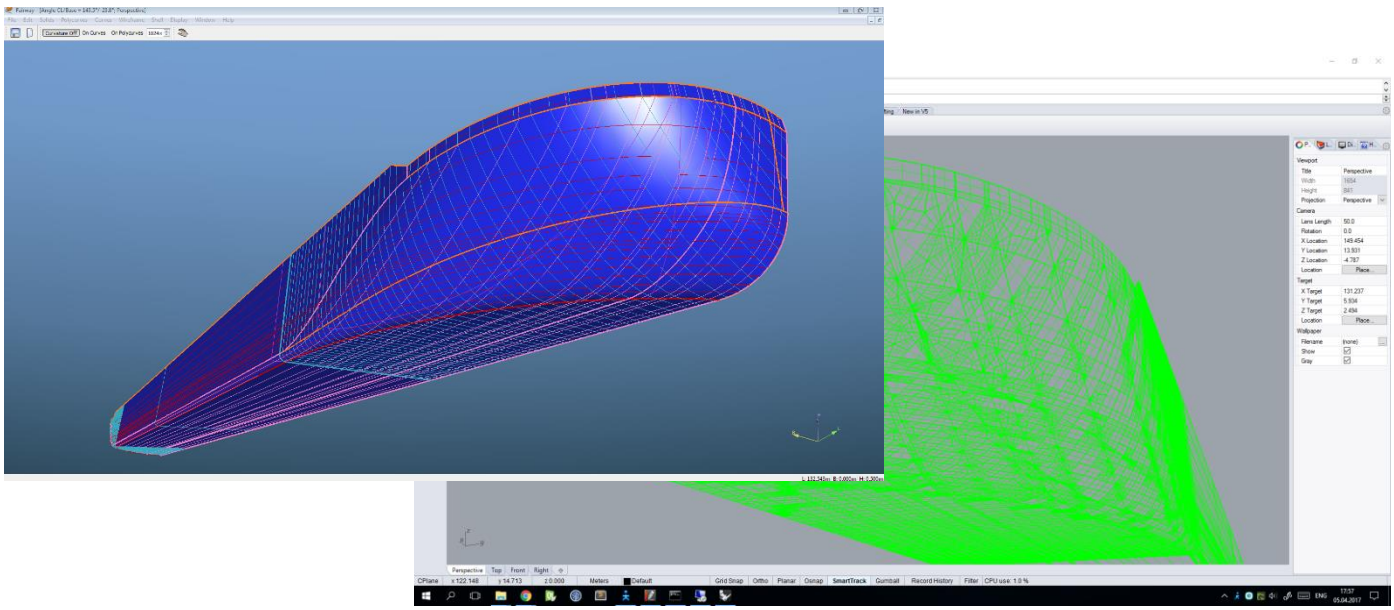


This background does not imply that conversion to NURBS as such is difficult to achieve. It has been available for twenty years in Fairway's option "export surfaces to IGES", which converts Fairway's surface patches to NURBS, and puts them in an IGES file[1]. One of the drawbacks of the NURBS is that it only accommodates four-sided surfaces, so a non-four-sided surface is split into sub-surfaces. Such as in the picture at the right, where the six-sided surface is split into six four-sided surfaces. As such, this conventional export from Fairway to NURBS (in IGES format) works fine, as demonstrated by motor yacht picture, which was generated in 1999.



Unfortunately, this conventional export has two drawbacks:

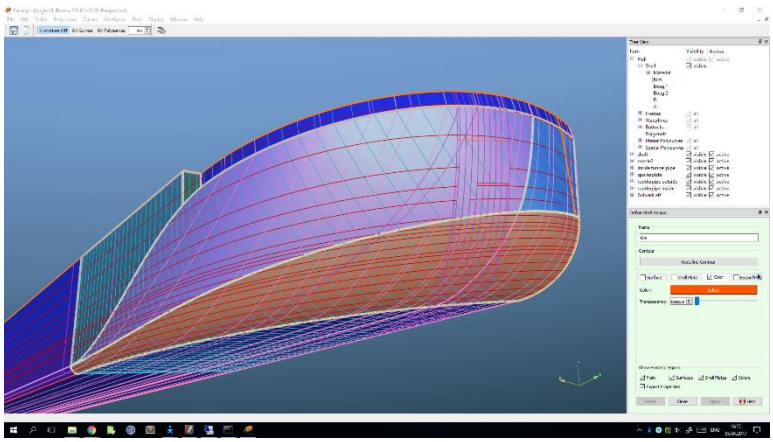
- The high number of resulting NURBS surfaces, because each and every surface patch from Fairway is converted to a single NURBS surface, even exaggerated by the subdivision of each N-sided Fairway patch into N NURBS surfaces. An example is presented below, where on the left a Fairway hull is shown, and on the right its NURBS export, visualized in Rhino. A close inspection reveals the hundreds small NURBS surfaces, that in their combination constitute the hull form. As such, a high number of NURBS surfaces is not prohibitive — after all the IGES standard does not specify a maximum allowed number of surfaces — but some receiving systems tend to have problems with the magnitude.



[1] As IGES entity 128: Rational B-spline surface.

- Gaps, which are inevitable when NURBS patches are created independent from their neighbours. By using small tolerances, the gaps can be made rather small, and that's what Fairway does, demonstrated by the apparently gap-free picture of the motor yacht. However, although tiny, gaps may still hamper postprocessing. We have seen examples of IGES export files with gaps as small as 0.1 mm, which appeared to be unprocessable by subsequent CFD software. It was assumed that some tolerance parameter might play a role in that CFD package, but nobody knew at the time.

So, even when defending ourselves that these phenomena are not caused by PIAS/Fairway, they are still hampering the smooth transition of data in the ship design process. So we decided to design a more advanced Fairway -> NURBS conversion method.

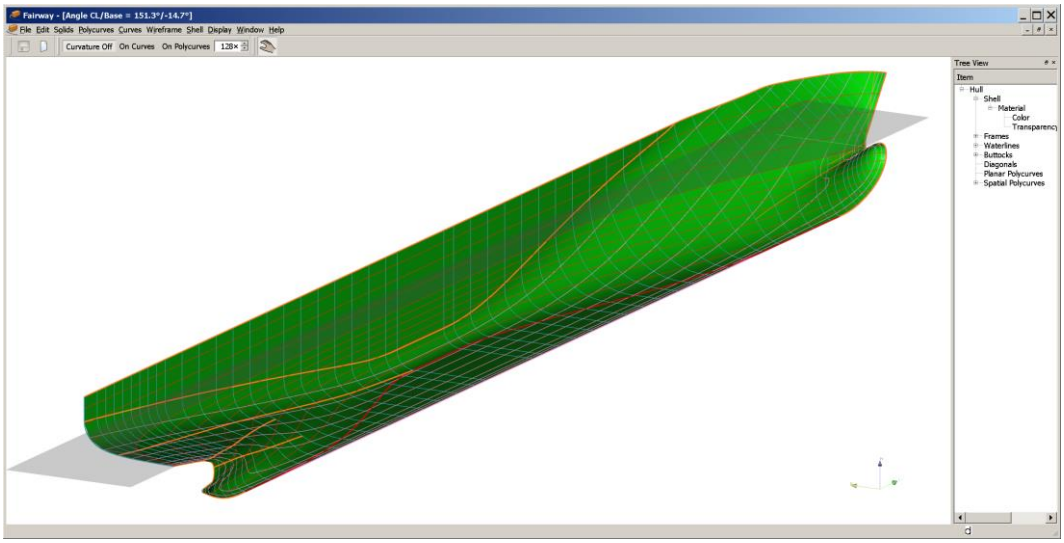


The first step is identifying larger, four-sided areas, which is essential because its four-sidedness is an intrinsic requirement of the NURBS. For the time being this requires human effort, although this is minimized by the special GUI facilities available to 'draw' the boundaries on the ship hull, as depicted in the picture at the right. The next step is to convert these surfaces to NURBS. In this paper the mathematical nitty-gritty will be omitted, the interested reader is redirected to a special conference paper on this subject. Anyway, the result is that by some neat mathematical processing, a patchwork of NURBS surface is created with the following properties:

- Guaranteed gap-free along common boundaries between adjacent surfaces[2].
- The number of vertices of the resulting NURBS surfaces is determined automatically, and is the minimal required to achieve this gap-freeness, as well as accurate representation of the original Fairway surface.

Although the NURBS surfaces are gap-free, they are not mutually connected. So they are not quite suitable for subsequent design modification[3]. However, that is not considered to be a disadvantage, because where Fairway is the master of the hull form shape, modifications can better — and more convenient — be made in Fairway.

This method, which is unprecedented as far as we are aware, is baptized LEANURBS (an acronym for **L**owest **E**ffective **A**mount of **NURBS**). Its implementation in Fairway is demonstrated by the following sequence of screen dumps[4], from which the first shows the ship hull in Fairway:

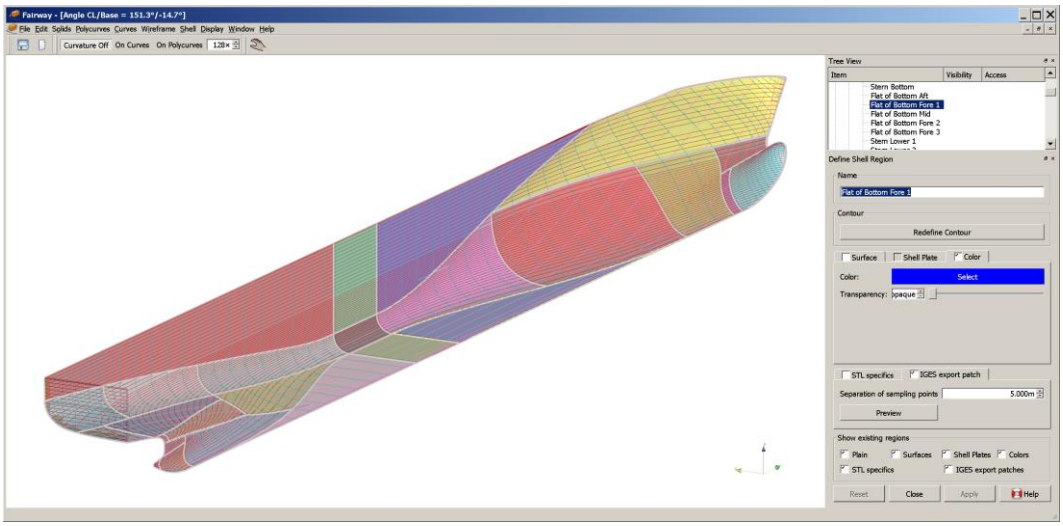


Subsequently, the hull is subdivided into four-sided regions. 41 for this example:

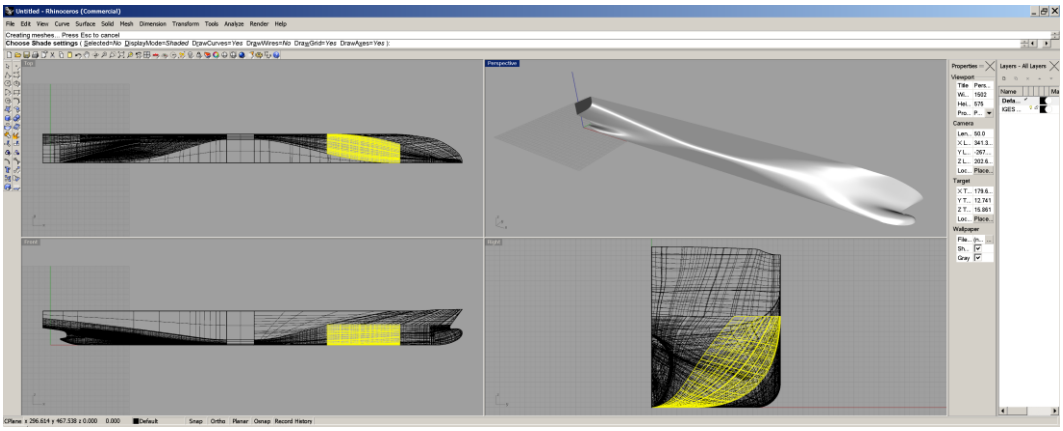
[2] For completeness we have to relax this statement to the extent that in the IGES file the surface coordinates are listed with finite precision, which is (for 64-bit reals) 16 significant digits, So, a gap of max. abt. 10^{-10} mm may arise, however, this is not caused by the algorithm, but by finite computer (im-)precision instead, and is inevitable with common digital computers.

[3] Because when changing the boundary of one surface, the adjacent one will not change.

[4] With the ship hull as published in Moktar, el, A.; Shigunov, V.; Zorn, T. (2012) Duisburg Test Case: Post-Panamax Container Ship for Benchmarking, J. Ship Technology Research 59/3, pp.50–64.



For which an IGES file is generated, which shows in Rhino as:



From today, this LEANURBS feature is available for users with a license to the ‘export to NURBS faces’ function (function code 10.300.50).

Finally, the issue of identifying four-sided surfaces on the ship hull will be addressed. In the introduction of this document it was postulated that this is a manual action. Currently, this is indeed the fact. We admit that this task requires human attention, which is regrettable, however, the four-sideness is an intrinsic and harsh requirement of the NURBS surface (a method that we have never endorsed). Anyway, in the GUI of Fairway quite some effort has been put to make that task as convenient as possible. Moreover, additional support may be on the brink. A graduate student (mathematics) has devoted her Msc thesis to the subject of automatic subdivision of the ship hull into larger, four-sided regions. In the near future the proposed methods will be evaluated, and, where helpful, be included in Fairway.