

Appendix to the paper *3D printen van scheepsmodellen* SWZ-maritime 2012

This appendix contains additional material to the paper (which is in Dutch):

- An abstract in English.
- Links to relevant websites.
- Additional figures and photos, which could not be accommodated in the paper.

Abstract

The paper *3D printing of ship models* is aimed at methods for fast and low-cost fabrication of scale models of ship designs. After a survey of different fabrication technologies it is concluded that for Do-It-Yourself (DIY) printing the *Fused Deposition Modelling* (FDM), where a model is built up from tiny layers of plastic, is most appropriate. A driver in this conclusion is the emergence of low-cost FDM printers which are also available in the form of open-source hardware, such as the Dutch *Ultimaker*. The authors have access to appropriate software for the design of a ship hull as well as the internal arrangement, and this software was used to produce 3D printing files for the Ultimaker for two examples. These artefacts are presented and the experiences are discussed. One conclusion was that although the models were not always perfect (e.g. due to shrinkage strain), they might serve very well in the design process of a ship. Subsequently, the question of outsourcing is addressed, and a comparison is made between DIY and full-service outsourcing. Outsourcing brings more accurate model production technologies into reach of the common man, and examples of such are shown. The paper ends with an outlook into future developments.

Links

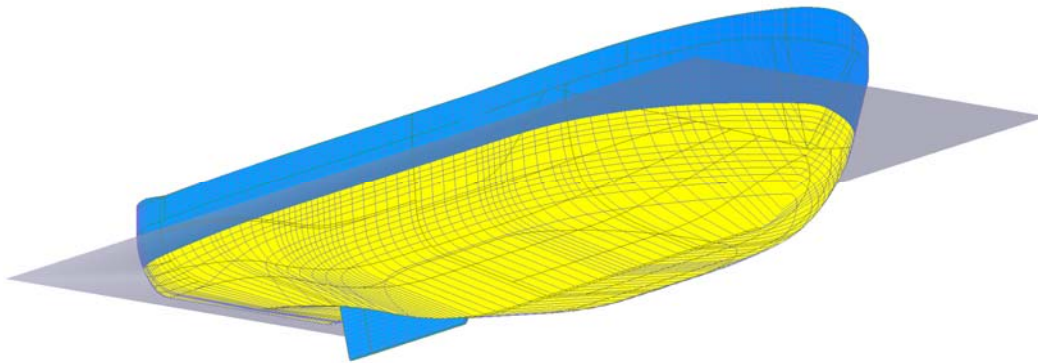
- The Reprap project: <http://nl.wikipedia.org/wiki/RepRap>
- Ultimaker 3D printer: <http://blog.ultimaker.com/>
- Personal Fabrication, in the Netherlands, in a FabLab: www.fablab.nl
- Fablab Utrecht: <http://www.protospace.nl/>
- PIAS hull shape design module Fairway, with a brand GUI: <http://www.sarc.nl/fairway/development>
- PIAS lay-out and compartment module *Newlay*: <http://www.sarc.nl/pias/development>
- Outsourcing of 3D prints, e.g. <http://www.shapeways.com/>
- A library of 3D models of a little of everything: <http://www.thingiverse.com/>
- 3D printing and modelmaking in full-service <http://www.3delft.nl/>
- Special report “*The third industrial revolution*” from *The Economist* of the 21st of April 2012:
<http://www.economist.com/node/21552901> Focussed on the subject ‘3D printing’ :
<http://www.economist.com/node/21552892>

Ship hull models

In about 1997 SARC launched the *Fairway* module. *Fairway* is specifically designed for all hull shape manipulations; design, fairing, shell plate layout, shell plate expansions, generation of 2D lines plan as well as 3D rendered views, conversion to general purpose CAD systems and to 3D print files. So, quite some models are readily available for 3D printing, and on these pages some examples will be shown.

Recently, *Fairway* has been equipped with a brand new Graphical User Interface (GUI), and all presented screenshots have been taken from *Fairway* with the new GUI.

Tug

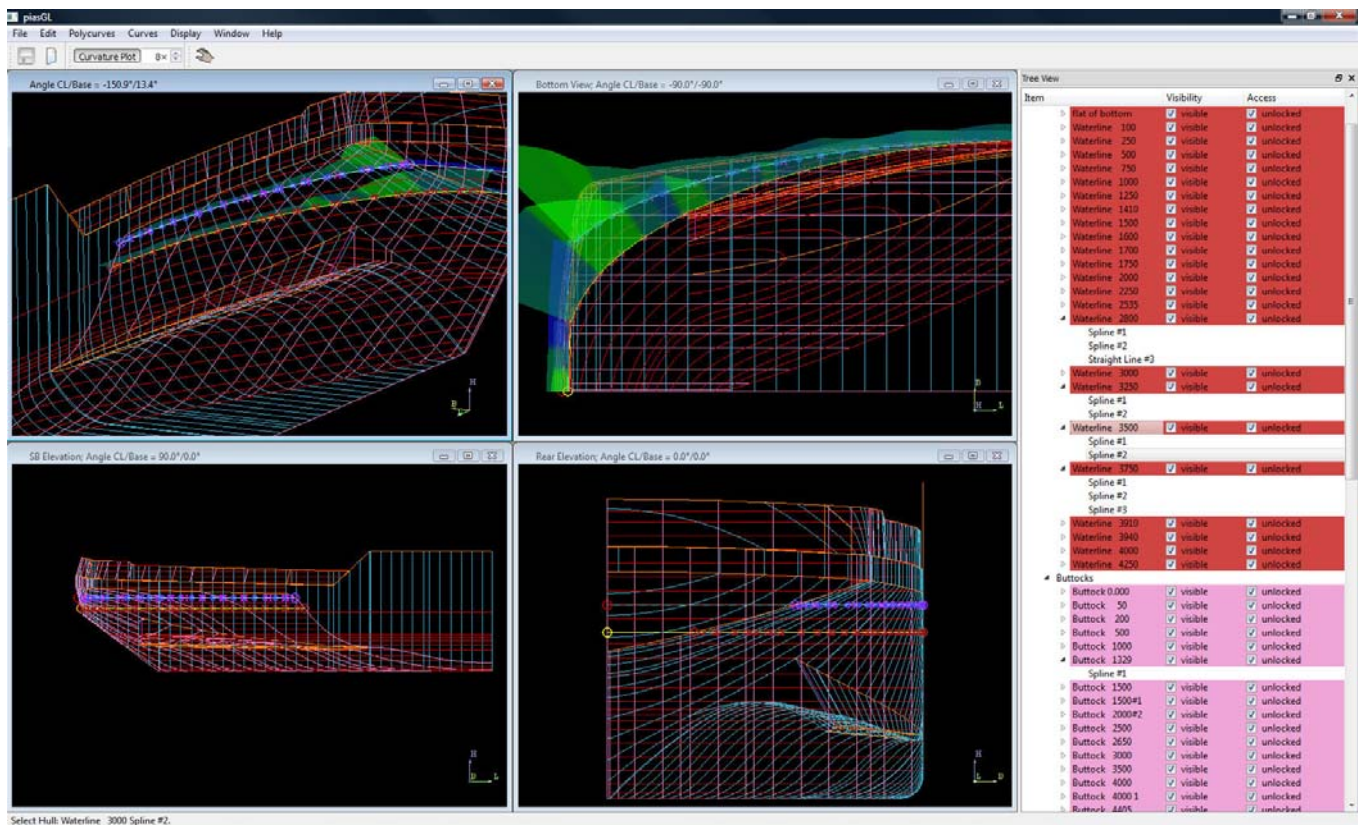


Computer model of a tug (courtesy Ankerbeer BV, Kolham, www.ankerbeer.nl).



3D print of the tug's demimodel

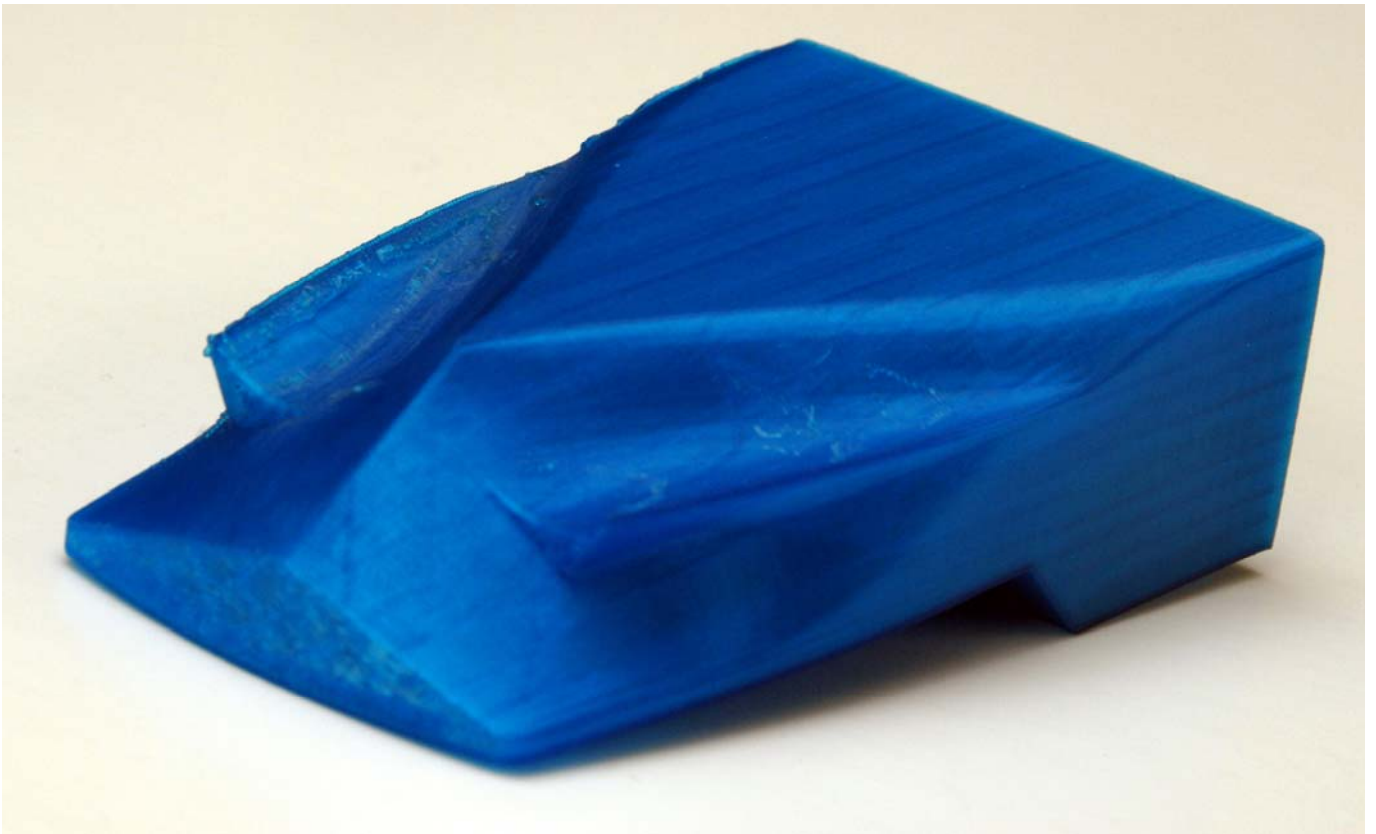
Inland waterway tanker



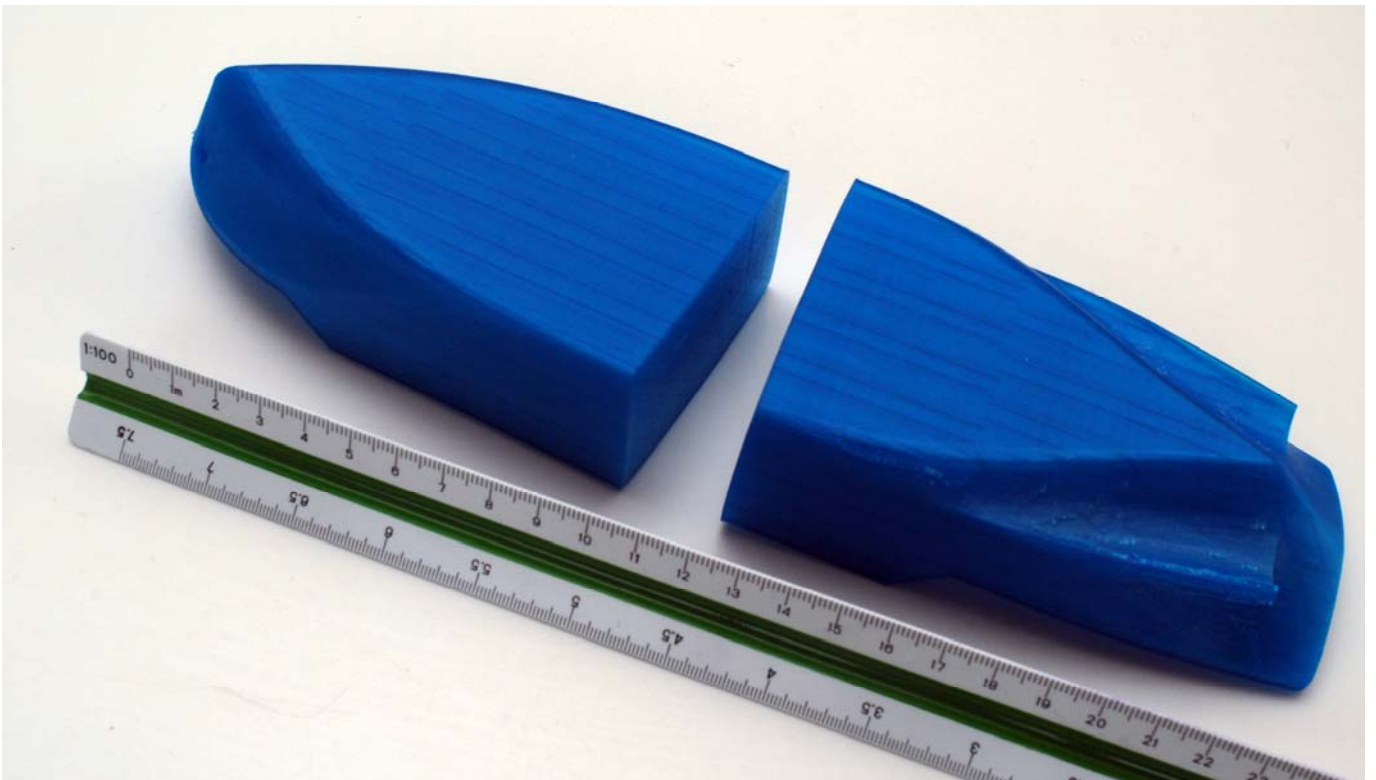
Screenshot of the *Fairway* GUI of the aft body of an inland waterway tanker.



Fore ship of this tanker, including anchor pockets



Aft ship of the same tanker, including propellor tunnels

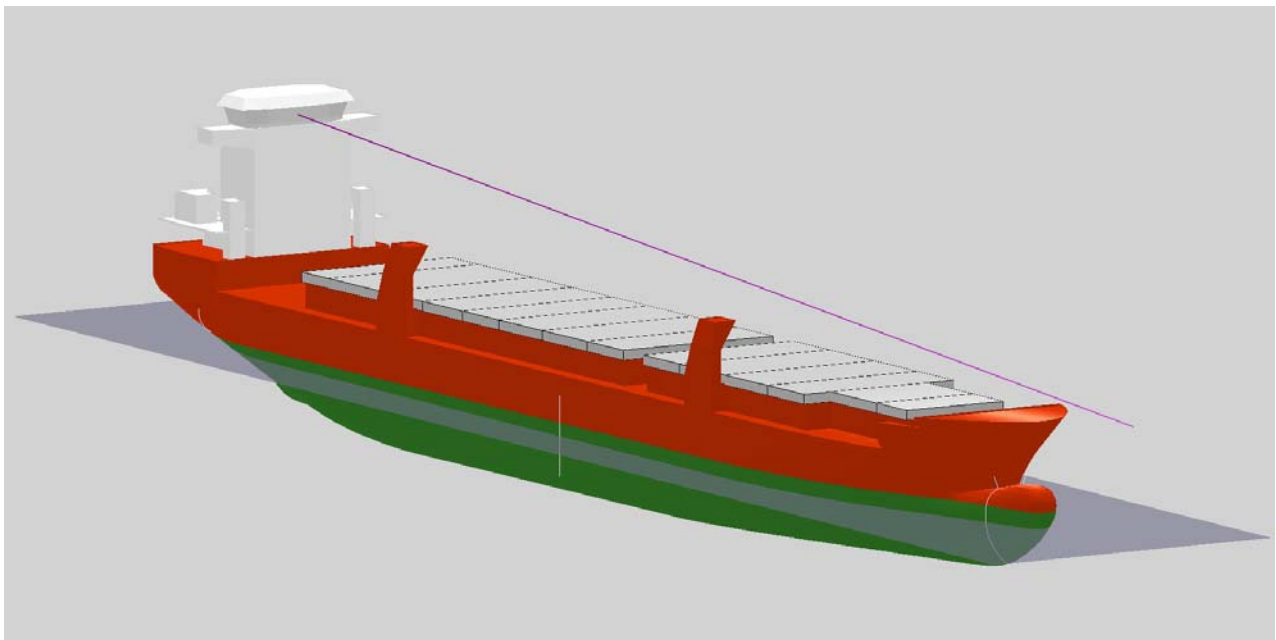


Fore ship and aft ship combined. The long parallel mid body is omitted.

M.s. Kent Sunrise



The vessel



The *Fairway* computer representation.

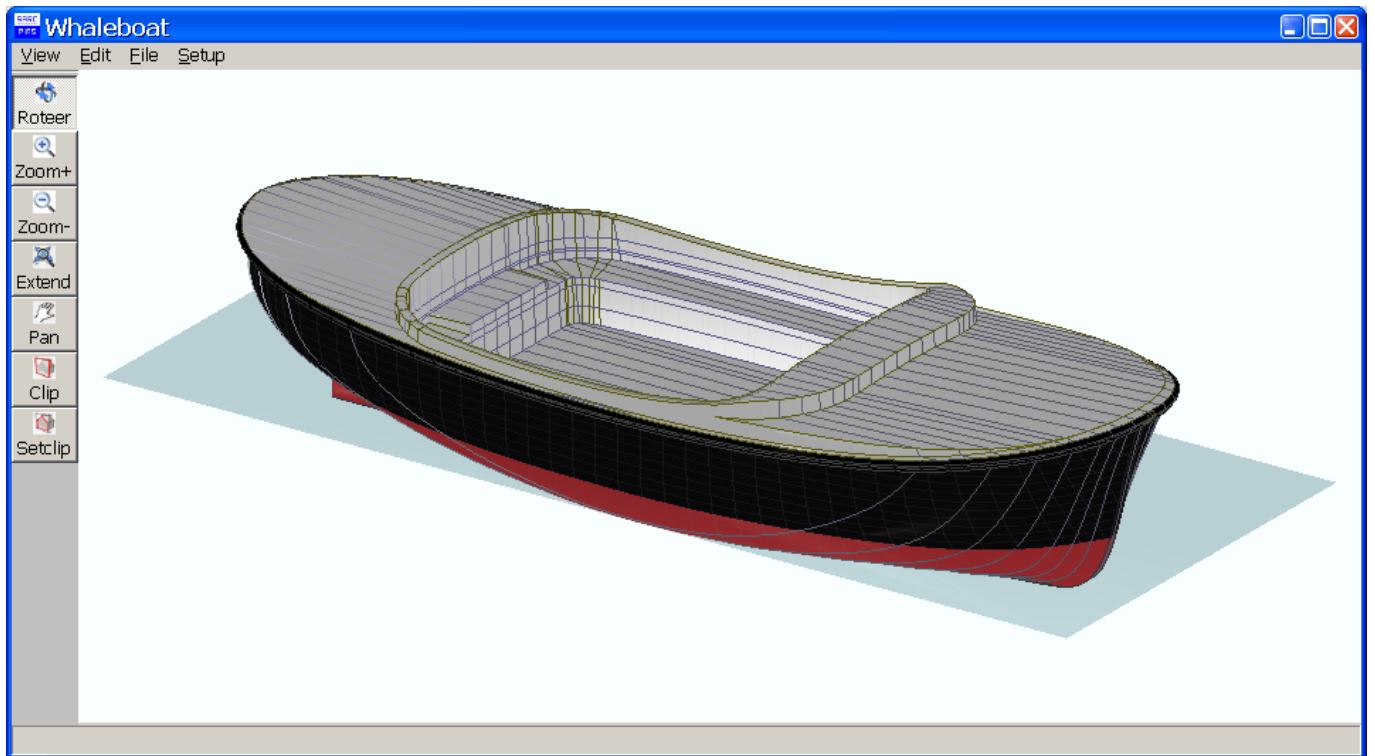


Printed scale model of the *Kent Sunrise*, seen from port side.

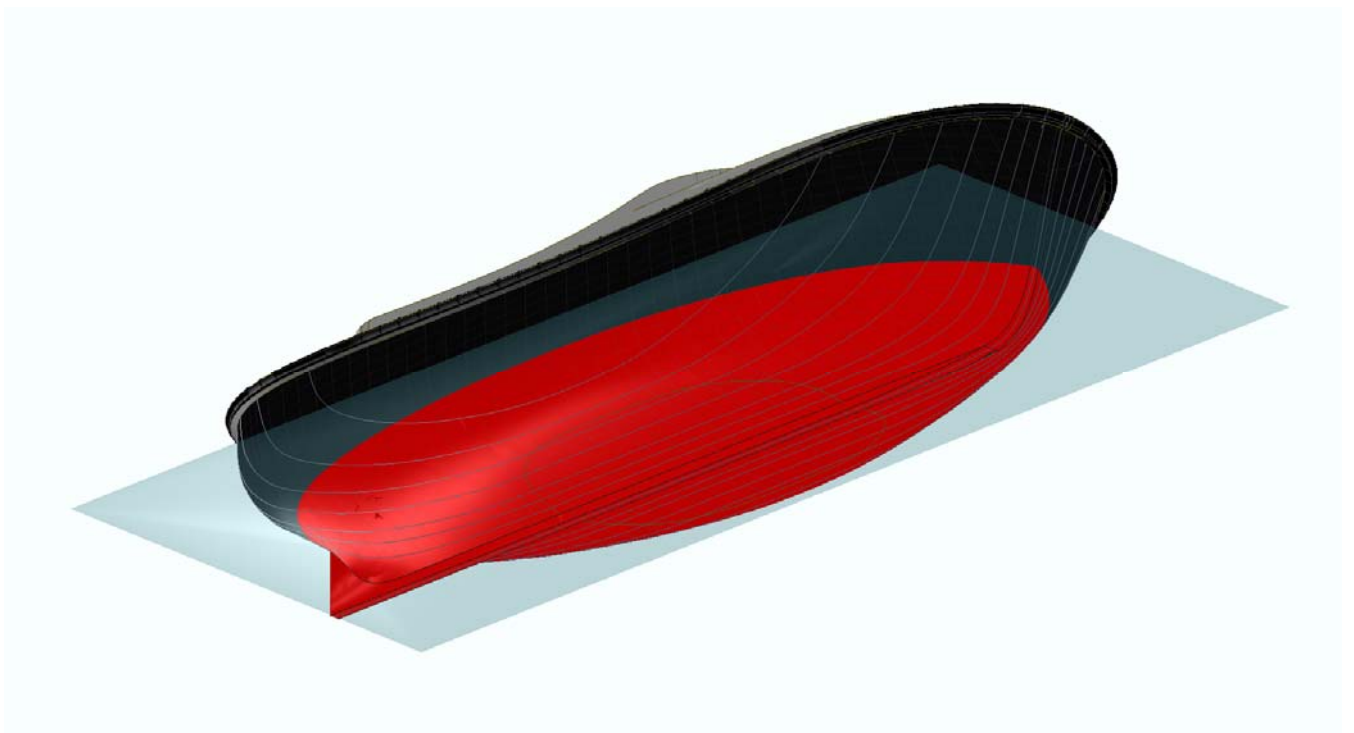


Two demi models, printed separately and glued together.

Motor launch



Rendered view.



View on bottom.



The motor launch printed; two demi models glued together



Top view of the launch.



Shrink strain! Caused by shrinkage after cooling down of the molten material.



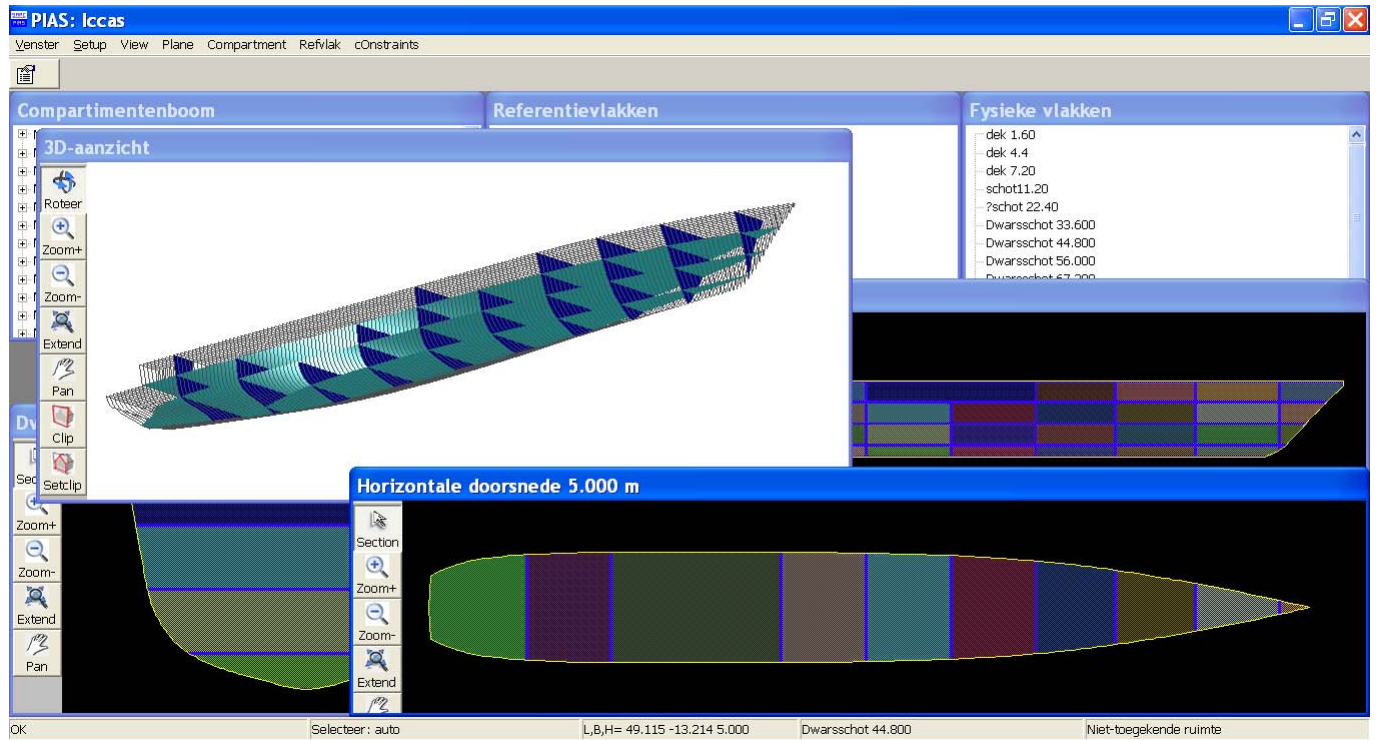
Post-processed computer model of the launch, as will be 3D printed with the Selective Laser Sintering (SLS).



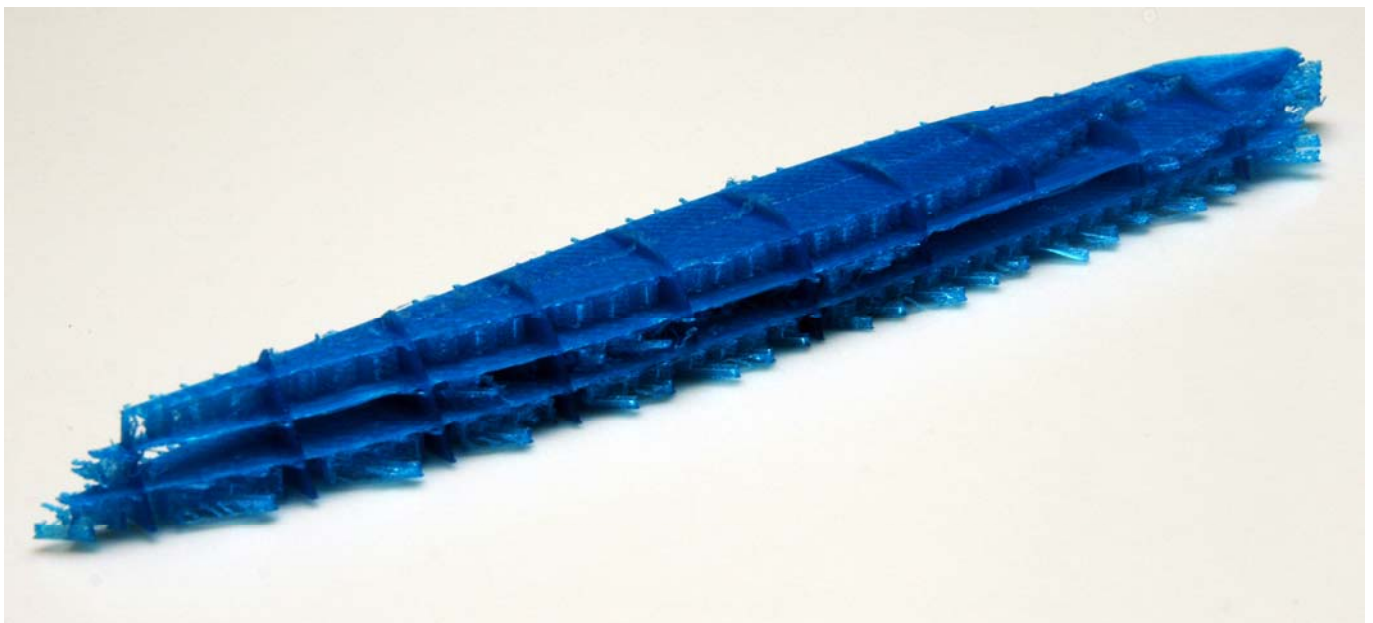
Scale model of the launch, printed with the SLS technology.

Internal subdivision model

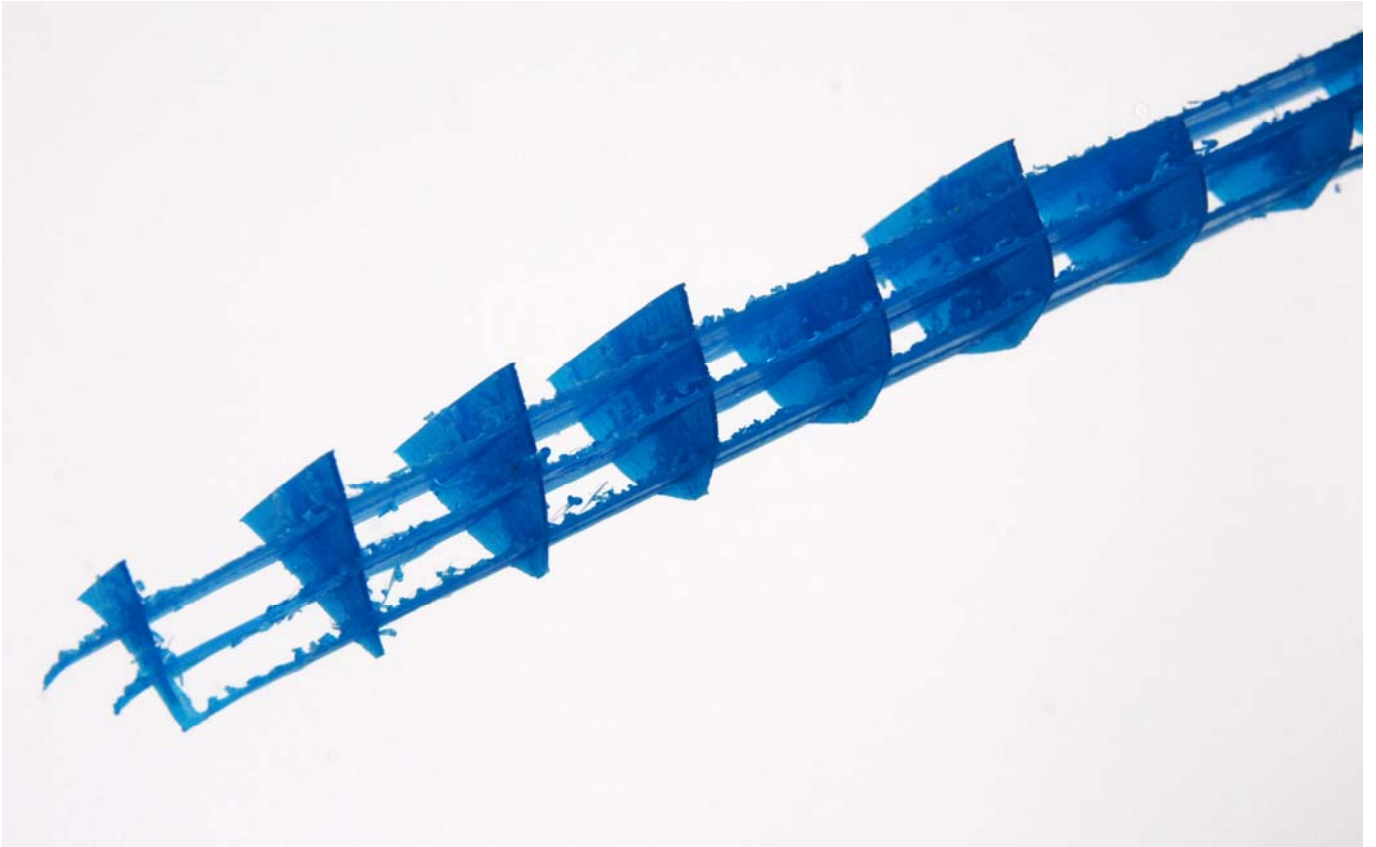
A new PIAS module is *Newlay*, aimed at the integral design and representation of bulkheads, decks and compartments. *Newlay* will replace PIAS' present compartmentation module. Below a screenshot of *Newlay*, showing a (rather elementary) internal layout, which is converted into an STL file and 3D printed.



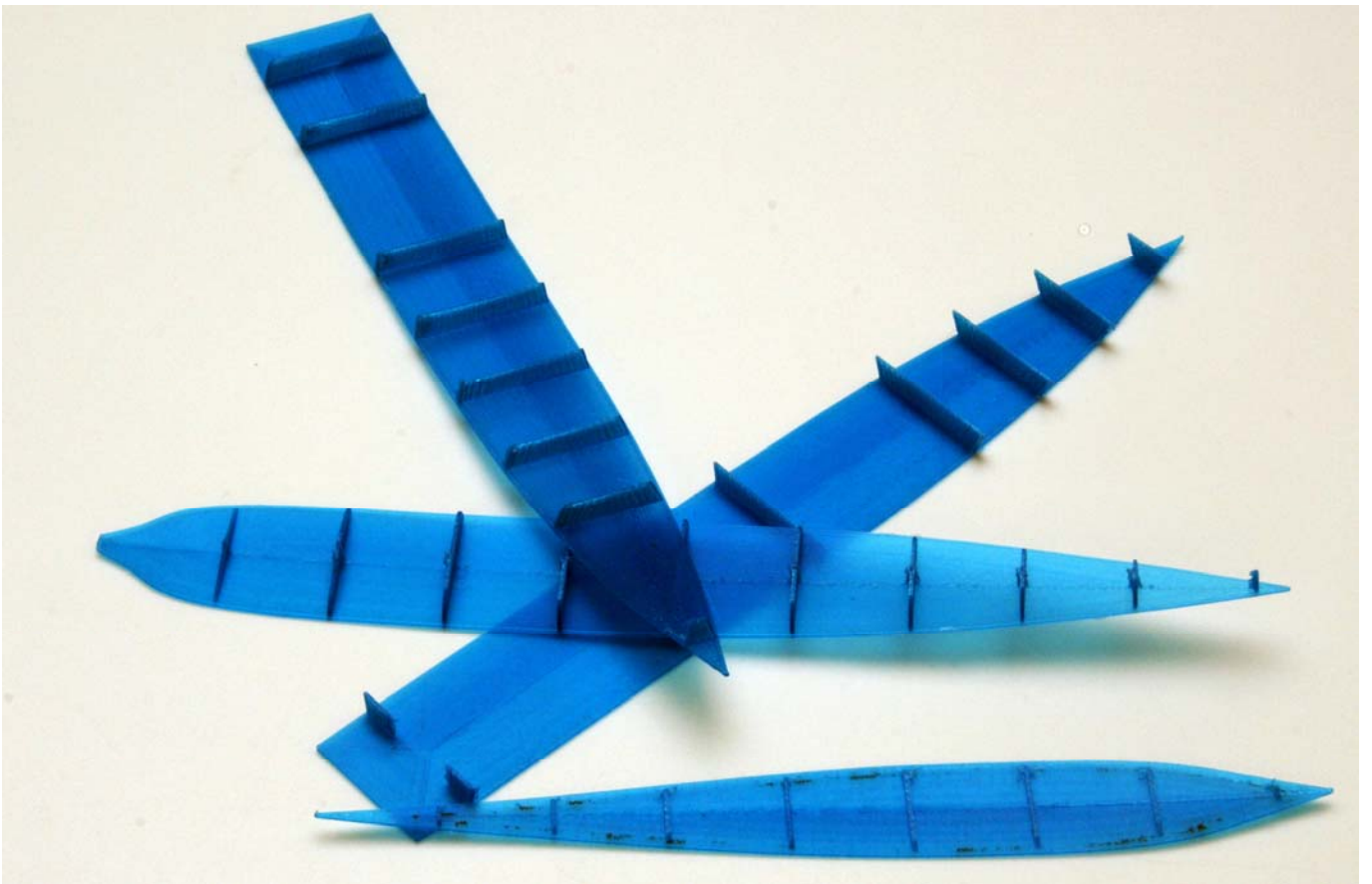
Newlay screenshot of the bulkhead and deck layout.



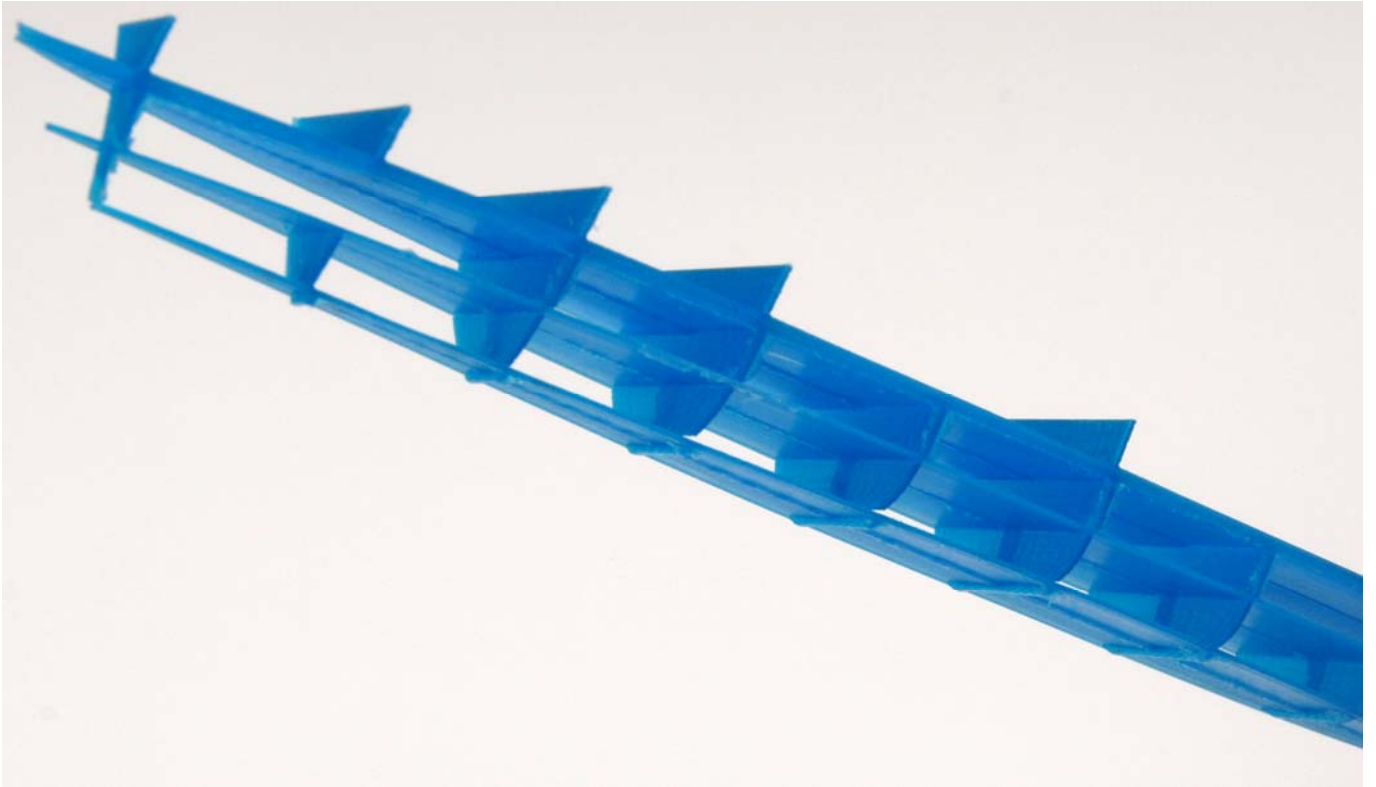
Layout model, printed in one. In order to prevent the decks from sagging, the print program has added so-called 'fluff' support, which can be scratched away later on.



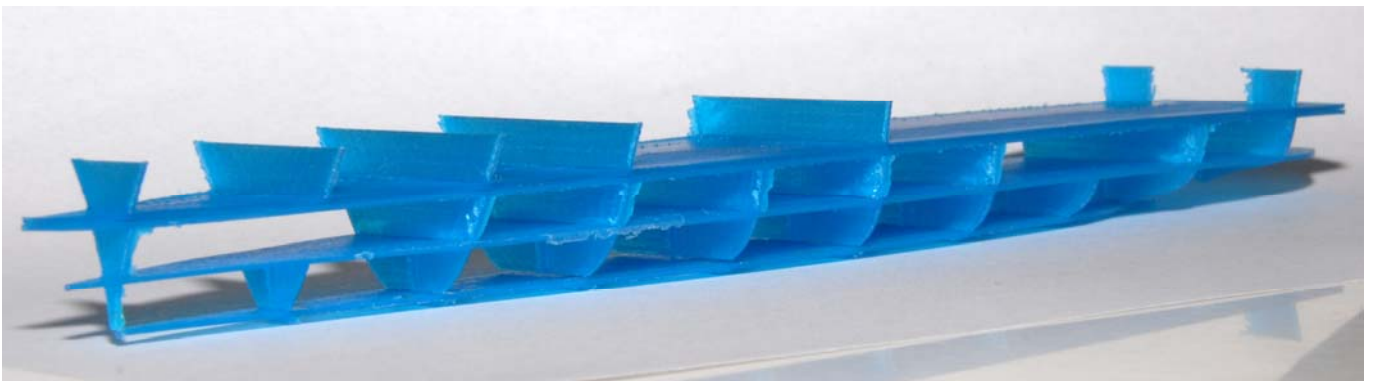
layout model of previous picture, after scratching away the fluff support material.



The same layout model, printed as four distinct decks including the perpendicular transverse bulkheads.

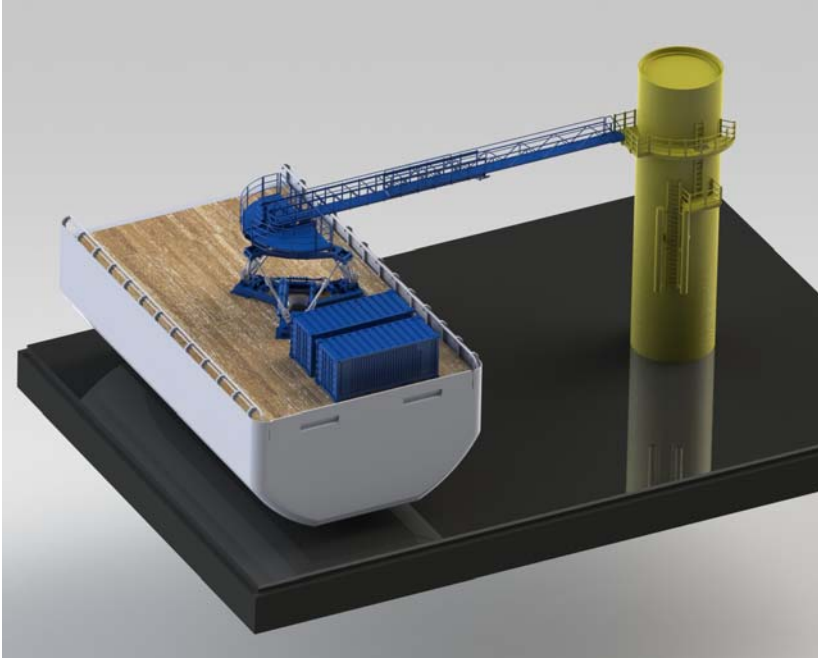


The four decks glued together.



Idem.

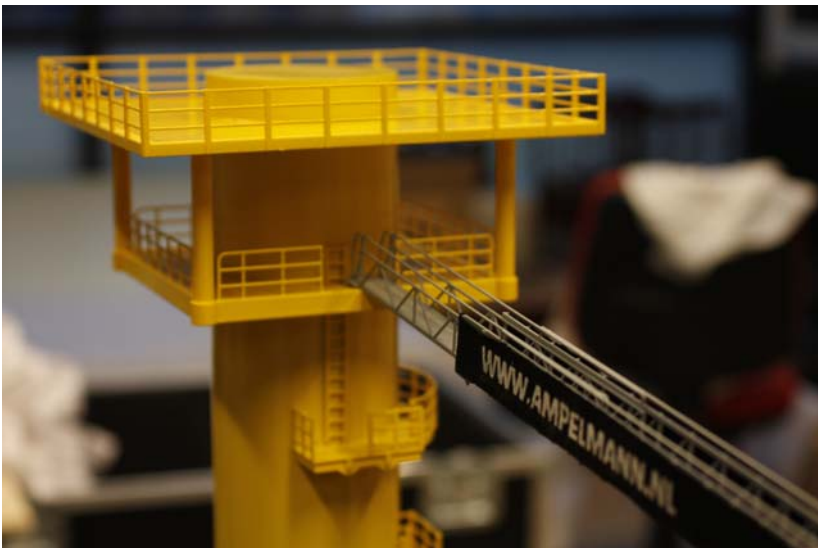
The Ampelmann platform



Computer model.

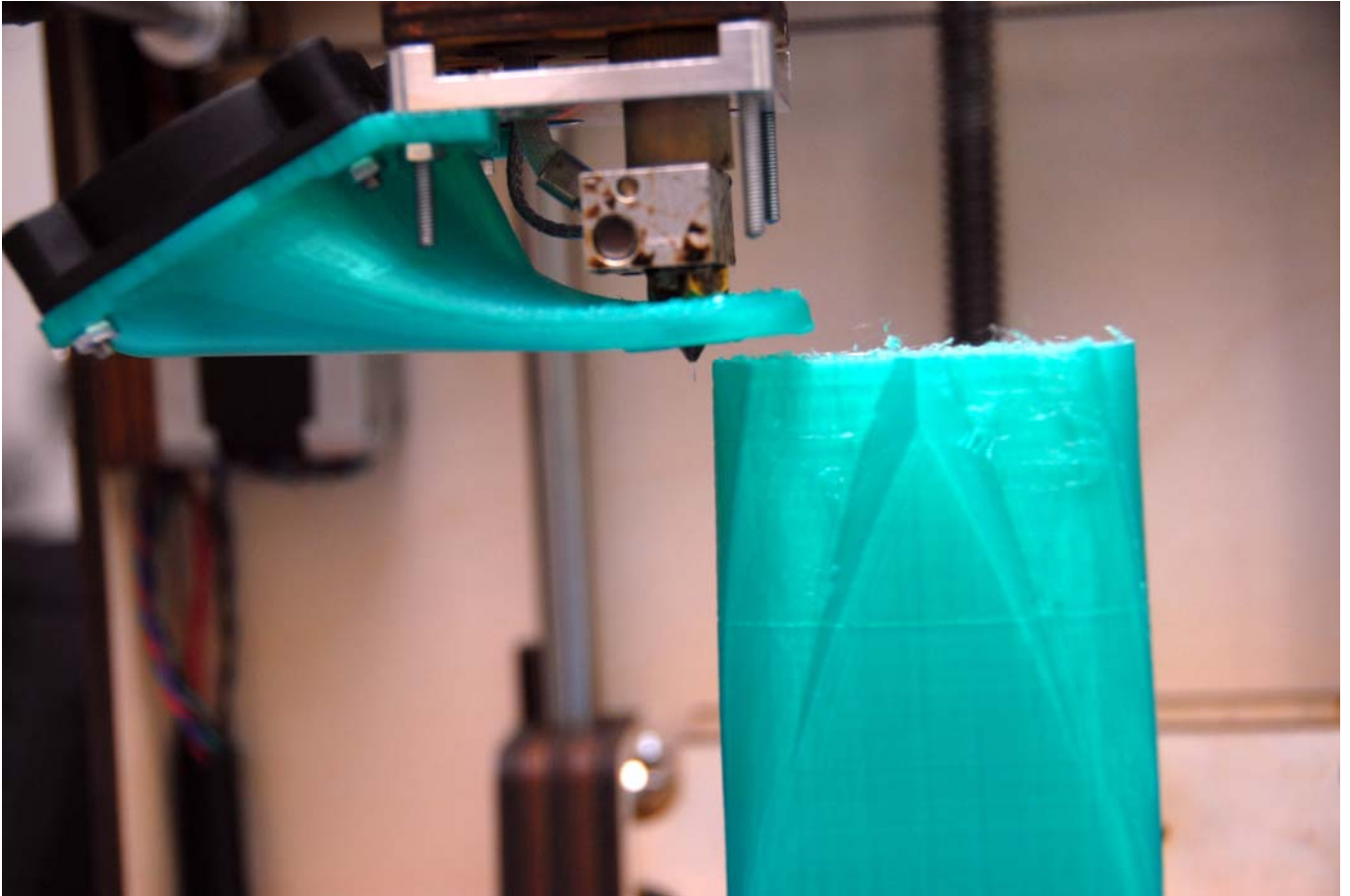


Working scale model.

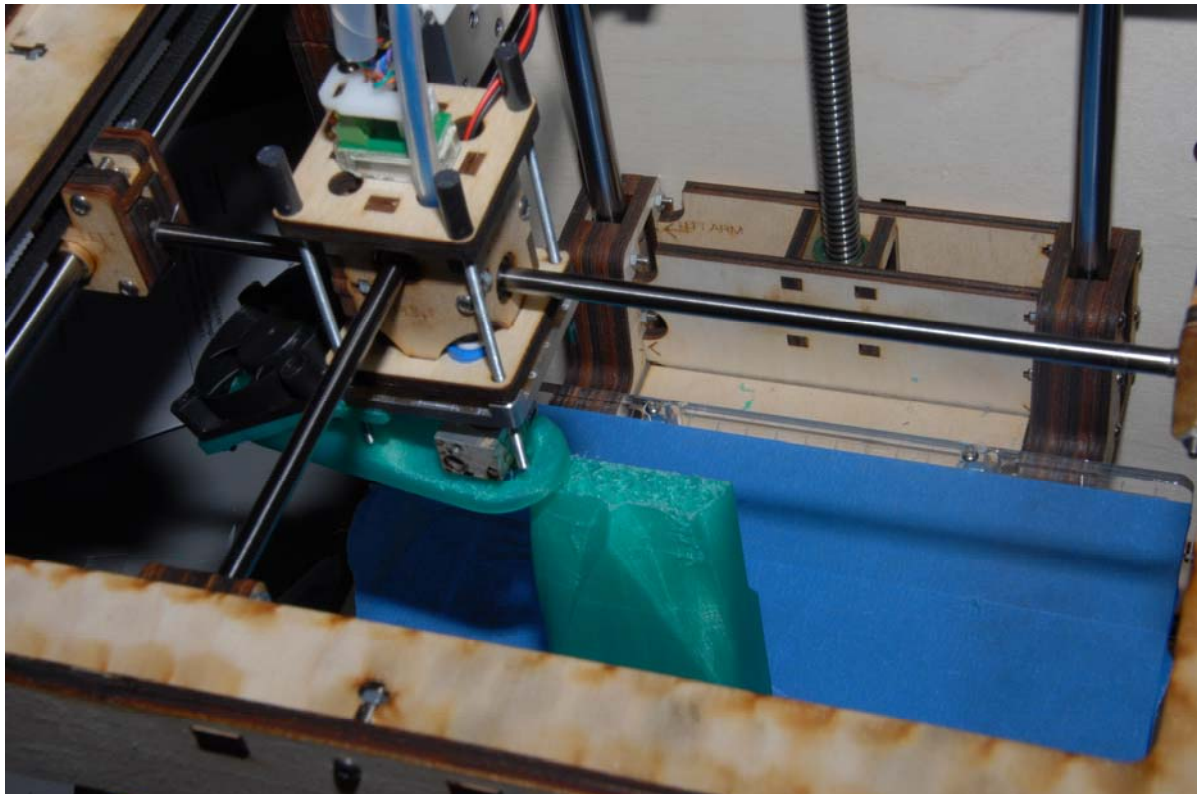


Detail of scale model.

The Ultimaker in action



The Ultimaker in action: printing the aft ship of an inland waterway tanker.



Here it is clearly visible that the printing head can move along two axes. The platform is stuck with blue painters tape, which improves the sticking of the first printed layer. That platform lowers down a little bit after each printed layer, thus forming the 3D artefact.