1 General

manta2017 RG65 is a design by Andreas Hoffmann. The plan is available from his homepage:

http://rg-andy.blogspot.de/

I am very grateful for his permission to use and publish his design for 3D printing.

Recommended total displacement is 980 g with 600 g of ballast. This is easily achievable with 3D printed parts. My current boat has 950 g with 615 g of ballast.

The sail plan used for the 3D printed rig parts is from Andreas Hoffmann as well, it is the “A-SwingRigg 2013B” available at the “Downloads” page. Also the idea for rig bearings and lock is taken from his blog: http://rg-andy.blogspot.de/2013/01/riigg-lager.html

The sail servo is arm type, with approx. 45 mm effective arm length. Sheet arrangement is similar as explained here: http://rg-andy.blogspot.de/2014/07/schotfuhrung-swingrigg.html

Keel fin and rudder molds are included in the 3D print files package. These printed molds need to be sanded, polished and drilled to accept several bolts and alignment pins for achieving good compression before curing. Experience in carbon fiber molding is required to make these parts.

Another option is to use commercially available fin and rudder, for these a “universal” mast/keel box is included in the files package. It works best together with the “universal” midship.

Commercially available ballast bulbs can be used, I have used a 560 g DragonForce 65 bulb and a 615 g lead bulb with brass core. Both work very well. As the DF65 bulb center of gravity is far aft, the battery needs to be placed far forward in the bow to balance the boat. The “DF65 Keel Adapter” part is used to mount the DF65 bulb to the keel fin from the molds.

A distance from hull bottom to ballast bulb of 28 cm works well.

2 Printing

Recommended material is PLA. Main reason is that it shows no tendencies to buckle even in the large flat surfaces at the bow. Other materials have proven problematic here. Light colors are recommended because of PLA’s low resistance to heat.

Printing of the hull segments is done in single layer spiral vase mode. This mode produces best surface smoothness and light parts with just the right material thickness. I am printing with a 0.3 mm nozzle and 0.55 mm wall thickness. 0.2 mm layer height. Together with a good balance of printing speed and part cooling, I achieve very good layer adhesion. The higher the speed, the more cooling is needed. If
too much cooling is used with slow speed, the layer adhesion will decrease. Some testing to determine the highest possible temperature for your material while still achieving good surface quality is recommended to get best layer adhesion.

All other parts can be printed with 20% infill. The mastbox needs supports. Test the parts, especially the mastbox, for water tightness.

## 3 Post-printing

For joining the hull segments, these need to be deburred first. Typically the first few layers will have a slightly higher wall thickness and need to be scraped to the design thickness to fit the other parts.

The joints are designed to allow 2 mm overlap of the segments. To facilitate single layer vase printing, a 0.6 x 45° chamfer is applied. This chamfer needs to be added to the mating parts by scraping to achieve a perfect fit.

Scraping with a knife has proven to be very effective for these adjustments. It is recommended to also scrape the outside of the mating hull segment to achieve a flush fit already before gluing. Adjusting by sanding or similar after gluing is much more difficult.

*Figure 1: Hull segment joint*

*Figure 2: Scraping of hull joint*
The hatches need to be cut out after printing. This can be done before or after gluing the segments together. Cut by sharp knife or by heat, e.g. old soldering iron.

Before gluing the hull segments, fit and glue the mastbox to the midship segment. Typically, the gluing surfaces of the mastbox will be pretty rough and need to be sanded to achieve a smooth surface. Deburr and chamfer the corners to fit the midship in perfect alignment. Insert the M3 nut for the mast controller. Cut the hole for the mast in the midship before joining.

![Figure 3: Mastbox glued in](image)

As glue, dichlormethylene based solvent glue for gluing acryl glass has been used with great success. As it is very thin (low viscosity), the parts can be joined, aligned and fixed by tape, then glue can be poured in from the inside.

Other options are special cyanoacrylate based glues for PE and POM, usually with a primer pen.
After gluing the mastbox, fit the foredeck reinforcement. Most likely the fit to the mastbox has to be adjusted. Widen the holes with a 3 mm drill up to 1 mm depth. Add a groove to fit the midship – bow joint. When good fit is achieved, glue bow to midship, then glue the reinforcement.

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Figure 4: Fitting the foredeck reinforcement

Glue the bow bulkhead to the bow.

Glue the rudder post to the stern. Normally, good alignment is achieved by simply snapping the rudder post in its position. Drill and ream the 3 mm hole for the rudder shaft.

Fit the hatch ring to the hull opening. Most likely, the hull opening needs to be sanded a bit for good fit. Take care for a solid joint when gluing, this joint is stressed every time the hatch is closed or opened.

A 70 mm cardboard tube lid fits the hatch ring. Ream the sheet post hole to 4 mm to fit an aluminum tube. Bend the aluminum tube to the dimensions shown in Figure 6. Fit a 3 mm teflon tube (available in 3D printer stores) through the aluminum tube before bending. Cut the teflon tube to protrude 1 mm on both ends. Press a 4-5 mm diameter round object onto the teflon tube ends to achieve a smooth shape.
Figure 5: Hatch ring and lid

Figure 6: Sheet post tube
The rudder servo bracket acts as support for the sheet tube. Ream the half hole to 4 mm. Insert the sheet tube to the hatch ring, then clip in the rudder servo bracket and glue it in position. Take care for vertical alignment of the sheet post.

*Figure 7: Sheet post and rudder servo bracket*
4 RC gear installation

Effective servo arm length 45 mm is sufficient at 180° travel. Hyperion DH13 FMB or FTB is recommended for its high torque, light weight, HV capability and programmable travel.

The sail servo mounts have to be deburred to achieve good fit. The rear servo mount needs to be adjusted to fit the mastbox and hull, the front mount needs a groove to clear the hull joint. Find suitable self tapping screws for joining the mounts. Do not overtighten, PLA cracks easily. The rear mount’s screw is angled to allow tightening through the front deck opening.
Fit the upper sail servo mounts to the sail servo, join the parts together and glue to mastbox and hull. The servo just clears the hull; use a small diameter servo horn to fit the arm. Make sure no screw or corner protrudes, otherwise the sheet are prone to bind.

![Figure 10: Sail servo installation. Pictured arm is too long and needs to be shortened.](image)

Route the main sheet through the sheet post tube, through the servo arm, then tie to the rudder servo bracket. Program the servo for 180° travel.
Important: Take care for a reliable sheet arrangement. If the sheet binds and the servo is stressed for more than a few seconds, it will fry its electronics.

Rudder linkage installation is straightforward, I use a 1.5 mm steel rod.

Receiver and battery (2S 850 mAh LiFe, 48 g) are attached to the keelbox with velcro.

To fit in the standard keel box, a 8 x 45° chamfer needs to be added to the keel fin upper rear corner. I chose not to add this chamfer to the mold to not overcomplicate the fabric cutting. Adding the chamfer by sanding is easier.
5 Rig

5.1 Swingrig

The mastbox is designed for swing and conventional rigs. For swingrig, use the front mast position.

Ream the front hole in the mastbox to 5.5 mm and press in the iglidur J 0405 bearing. Make sure a 4 mm shaft will rotate freely within the rake adjustment range. If it binds, ream the bearing.

Ream the hole in the swingrig mastcontroller to 8 mm and press in the iglidur J 0608 bearing. Cut excess length. Sand the sides of the mastcontroller to fit the groove in the deck.

File a 120° point to a 4 mm stainless steel rod and glue it in a 6 x 4 mm carbon tube. Assemble and test the bearing arrangement. Fit the mast lock ring and glue to the mast foot tube.

See Andy Hoffmann’s blog for the mast lock principle.

http://rg-andy.blogspot.de/2013/01/rigg-lager.html

![Diagram of Mast Foot](image-url)
Wrap both ends of the swingrig cross with carbon roving, soak with thin CA. This is required to keep the ends from splitting. Ream the holes to fit mast and booms to 6 and 5 mm respectively.

Redrill the cunningham hole after gluing the main boom.

Glue the swingrig cross to the mast foot so that it clears the mastcontroller. Observe correct lock position.

I am using Skyshark 3, 5 or 7PT conical tubes (available in 1016 mm length) as mast. Cut the mast foot to extend 5 cm past the swingrig cross. Wrap with paper to achieve a good press fit of the mast, then glue.

The manta2017 is well balanced with Andy Hoffmann’s “A-SwingRigg 2013B”. Build the rig according to your liking. Several small parts like boom bands, clips etc. can be 3D printed as well.

Important: After sailing, ease rig tension to remove stress from the swingrig cross. PLA doesn’t like constant stress.
5.2 Conventional rig

The rear mast position is used for conventional rigs. All eyelet positions are designed to fit the DF65 rigs. Use a 7 x 5 mm carbon tube as foot.

Ream the rear hole in the mastbox to 5 mm. It accepts a 5 mm carbon rod, glue in the lower end of the mast foot tube. The upper end of the mast tube fits the DF mastcontroller.

Add a reinforcement to the stern to mount an eyelet for the backstay.

The distance of main sheet attachment to mast is approx. 100 mm for the DF rigs. Unfortunately, this is right above the hatch. Therefore, a “DF style” bridle has to be used.

![Figure 14: Mainsheet bridle DF style (Early prototype)](image-url)
6  Final touches

Figure 15: Almost done, only deck patches missing.

Figure 16: Here we go. I used spinnaker tape this time.
Make sure to firmly apply the deck patches. The deck surface is rough from 3D printing, so the patches won’t adhere as well as on a painted surface. A “massage” by fingernails works well for improving adhesion.

Add a bumper of 5 mm thick soft material. I use self adhesive rubber foam cut and sanded to shape. The hull should be 648 mm long without bumper.

No need to sand and paint the hull, the roughness from 3D printing does not slow the boat down.

7 Weight

The printed parts allow to reach a surprisingly competitive weight. The manta2017 is designed for 980 g displacement with 600 g ballast. The recommended RC gear is optimized for weight, allowing to easily reach the target weight even with slightly heavier ballast.

Component weights:

<table>
<thead>
<tr>
<th>Component</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hull with all internal parts glued in</td>
<td>126 g</td>
</tr>
<tr>
<td>Keel fin</td>
<td>21 g</td>
</tr>
<tr>
<td>Ballast</td>
<td>615 g</td>
</tr>
<tr>
<td>Rudder</td>
<td>10 g</td>
</tr>
<tr>
<td>Lid</td>
<td>5 g</td>
</tr>
<tr>
<td>Receiver</td>
<td>11 g</td>
</tr>
<tr>
<td>Rudder servo</td>
<td>10 g</td>
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<tr>
<td>Sail servo incl arm</td>
<td>31 g</td>
</tr>
<tr>
<td>Battery</td>
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<td>A rig</td>
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<tr>
<td>Rudder linkage</td>
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<tr>
<td>Deck patches</td>
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<tr>
<td>Total</td>
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