

Howard DGA-5 "IKE"

a *"Damned Good Airplane"*

User Guide for Version 3



Figure 1: 3D-printed Howard DGA-5 "IKE" using pre-foamed PLA.

Scale:	1 : 6.1
Length:	850 mm
Wingspan:	1000 mm
Wing airfoil:	NACA0012 → NACA0009
Tail airfoil:	NACA0003
Empty weight [LWPLA/PLA+]:	[530/650] g
Takeoff weight [LWPLA/PLA+]:	[880/1000] g
Wing area:	16 dm ²
Wing load [LWPLA/PLA+]:	[55/62.5] g/dm ²
Channels:	5

The user guide can be downloaded [HERE](#).

Print test parts can be downloaded [HERE](#).

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Content

Content	1
The original	2
What you get.....	3
3D print files.....	3
Decal sheets	8
What you need.....	9
3D printer specification.....	9
Required materials.....	9
Radio control components.....	10
Assembly	11
Step by step video guide	11
Noteworthy changes in assembly for version 3.....	11
Pre-flight setting & check.....	14
Change log.....	15

The original

The Howard DGA-5 “IKE” evolved from one of two almost identical prize-winning racers “MIKE” and “IKE” developed by Benny Howard in 1932 [1]. From 1932 to 1936 both planes won plenty of racing prices culminating in 1935 when Howard aircraft won the Bendix, Thomson, and Greve Trophy – a season of racing events that became unofficially known as “Benny Howard National Air Races” [2].



Figure 2: Harold Neumann with Miss Chevrolet in Miami, Florida. “Ike” (NR56Y) was sponsored by the Chevrolet Division of General Motors and was therefore also known as “Miss Chevrolet” [3].

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What you get

This is a thoroughly designed 3D printable scale version of the original Howard DGA-5 “IKE”. I spent considerable amount of time with prototype testing and continuous refinement to improve printability, surface quality, scale characteristics, flight characteristics, and rigidity.

This aircraft can be built

- with or without landing gear
- with or without flying wires
- completely in PLA+ or partly in LW-PLA

3D print files

The package includes a complete set of STL files, a set of [PrusaSlicer](#) project files, and the hereof generated gcode. PrusaSlicer is a powerful open-source software that can be used for free. The project files were created with version 2.7.1 and contain all detailed print settings required to optimally print each airplane part. Exemplary project files can be downloaded at [rc3dmarket.com](#).

Note: If you want to use a different slicer software, please make sure to check and reapply all part-dependent print settings provided in the PrusaSlicer project files. Otherwise, some parts may not print as desired.

STL	<p>STL stands for Standard Tessellation Language, a file format that describes the surface geometry of a three-dimensional object.</p> <p>The package includes STL files for all printable parts of the airplane including a bending template to form the spring steel wires of the landing gear.</p> <p>Moreover, for some parts modified STL files are provided for optional printing with active foaming Low-Weight-PLA.</p>
Project files	<p>Multiple STL files can be combined into a single project file (3mf) and “print job” (gcode). Specific slicer settings can be applied to e.g., increase the stability of a certain part area or improve the printability of an area with large overhang angle.</p> <p>The package includes 16 project files (6 are optional) with full access to all specific slicer settings used for each component. All project files can be easily modified with the graphical user interface of PrusaSlicer to comply with your 3D printer in terms of print volume, parameters, and print material.</p>
Gcode	<p>For each project file and each active foaming LW-PLA printable part corresponding gcode files are provided to minimize your preparation time. Please note that these gcode files were generated for the Prusa i3 MK3S. For many 3D printers and filaments, the gcode should just work fine. If you experience issues with the print quality, I recommend having a closer look at the slicer parameters to optimize the gcode for your printer.</p>

Figure 3 depicts an exploded view of the Howard DGA-5 “IKE”. Together with the following part list it provides an overview of all 3D printable parts. The color code of the index numbers visualizes to which project file and gcode the part belongs.

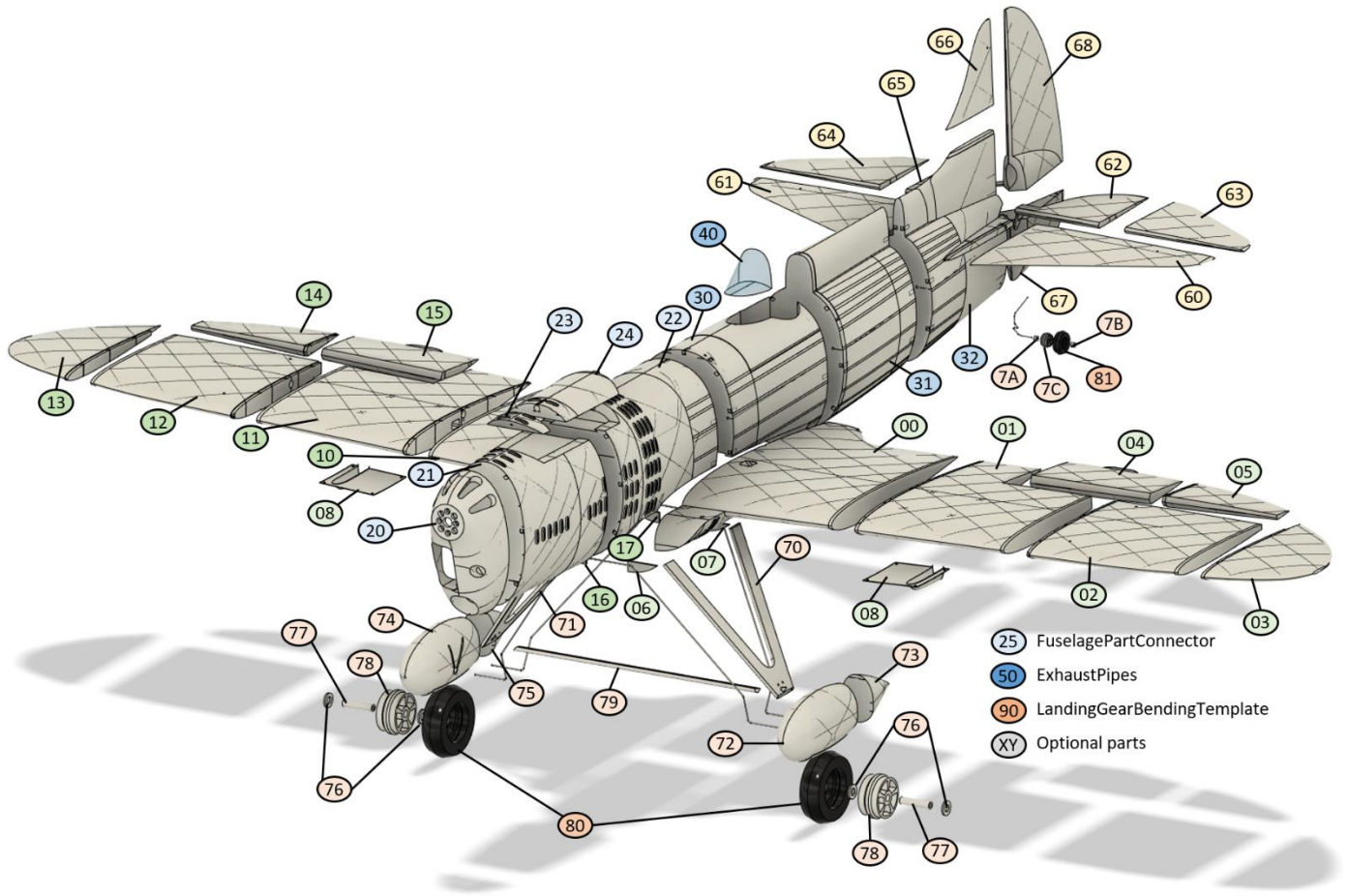
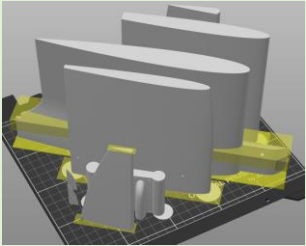
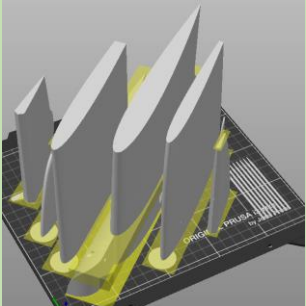
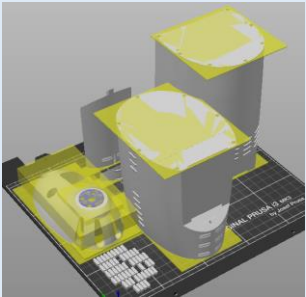
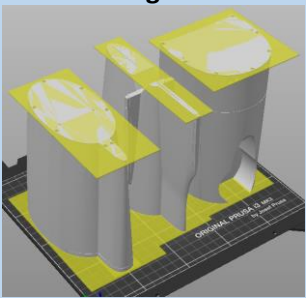
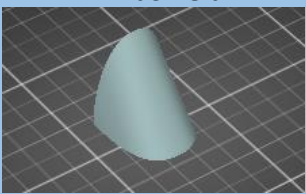

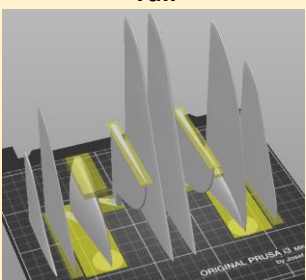


Figure 3: Exploded view with labeled plane parts.

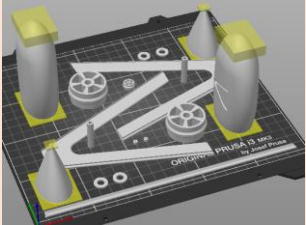
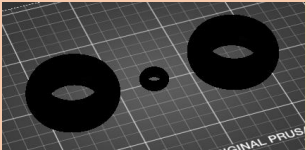

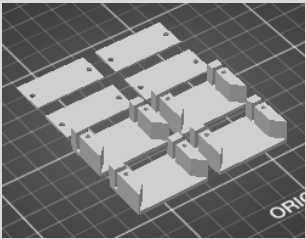
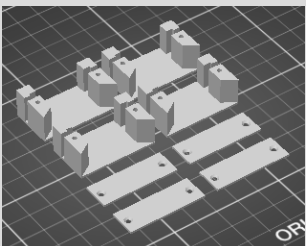
Project (.3mf/.gcode)	Part name (.stl)	Idx	Print weight	
WingLeft  time: 19h 1m	Wing1L	00	Pre-foamed	PLA+ (default)
	Wing2L	01	46 g	57 g
	Wing3L	02	27 g	34 g
	Wing4L	03	22 g	27 g
	Aileron1L	04	10 g	12 g
	Aileron2L	05	8 g	10 g
	LandingGearShimFrontL	06	4 g	5 g
	LandingGearShimBackL	07	< 1 g	< 1 g
	ServoCover (left+right)	08	< 1 g	< 1 g
WingRight  time: 18h 50min	Wing1R	10	Pre-foamed	PLA+ (default)
	Wing2R	11	46 g	57 g
	Wing3R	12	27 g	34 g
	Wing4R	13	22 g	27 g
	Aileron1R	14	10 g	12 g
	Aileron2R	15	8 g	10 g
	LandingGearShimFrontR	16	4 g	5 g
	LandingGearShimBackR	17	< 1 g	< 1 g
	SpacerFlyingWires	18	< 1 g	1 g

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<p>FuselagePart1</p>  <p>time: 14h 6m</p>	<p>Fuselage1 Fuselage2 Fuselage3 CanopyFront CanopyBack FuselagePartConnector (45pcs)</p>	<p>20 21 22 23 24 25</p>	<p>Pre-foamed 20 g 30 g 30 g 5 g 2 g < 1 g</p>	<p>PLA+ (default) 25 g 38 g 39 g 6 g 2 g 1 g</p>
<p>FuselagePart2</p>  <p>time: 10h 14m</p>	<p>Fuselage4 Fuselage5 Fuselage6</p>	<p>31 32 32</p>	<p>Pre-foamed 28 g 22 g 25 g</p>	<p>PLA+ (default) 35 g 28 g 31 g</p>
<p>WindShield</p>  <p>time: 0h 18m</p>	<p>WindShield</p>	<p>40</p>		<p>PLA (default) 1 g</p>
<p>ExhaustPipes</p>  <p>time: 0h 6m</p>	<p>ExhaustPipe (6pcs)</p>	<p>50</p>		<p>PLA (default) < 1 g</p>
<p>Tail</p>  <p>time: 9h 59m</p>	<p>HorizontalStabilizerL HorizontalStabilizerR ElevatorL1 ElevatorL2 ElevatorR1 ElevatorR2 VerticalStabilizer RudderBottom RudderTop</p>	<p>60 61 62 63 64 65 66 67 68</p>	<p>Pre-foamed 12 g 12 g 5 g 6 g 5 g 6 g 2 g 4 g 10 g</p>	<p>PLA+ (default) 15 g 15 g 6 g 7 g 6 g 7 g 3 g 6 g 13 g</p>

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<p>LandingGearParts</p>  <p>time: 6h 24m</p>	<p>LegL 70 LegR 71 WheelPantFrontL 72 WheelPantBackL 73 WheelPantFrontR 74 WheelPantBackR 75 WasherMainWheel (4pcs) 76 AxleMainWheel (2pcs) 77 RimMainWheel (2pcs) 78 Crossbar 79 WasherTailWheelL 7A WasherTailWheelR 7B RimTailWheel 7C</p>		<p>Pre-foamed 6 g 6 g 7 g 2 g 7 g 2 g < 1 g < 1 g 6 g < 1 g < 1 g < 1 g < 1 g < 1 g</p>	<p>PLA+ (default) 8 g 8 g 9 g 2 g 9 g 2 g < 1 g < 1 g 8 g < 1 g < 1 g < 1 g < 1 g</p>
<p>Tires</p>  <p>time: 1h 49m</p>	<p>TireMainWheel (2pcs) 80 TireTailWheel 81</p>		<p>TPU 18 g 1 g</p>	
<p>LandingGearBending Template</p>  <p>time: 2h 8m</p>	<p>LandingGearBendingTemplate 90</p>			<p>PLA (default) 24 g</p>
<p>Optional: ServoHolderDS843MG</p>  <p>time: 1h 12m</p>	<p>ServoHolderDS843MG (4pcs) A0</p>		<p>Pre-foamed 9 g</p>	<p>PLA+ (default) 11 g</p>
<p>Optional: ServoHolderDS939MG</p>  <p>time: 1h 16m</p>	<p>ServoHolderDS939MG (4pcs) B0</p>		<p>Pre-foamed 9 g</p>	<p>PLA+ (default) 11 g</p>

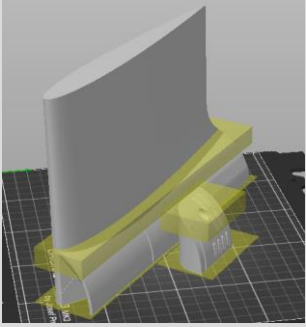
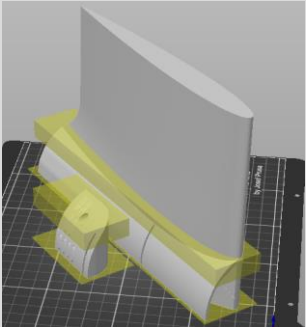
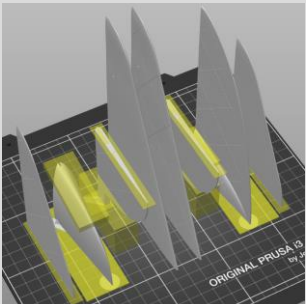
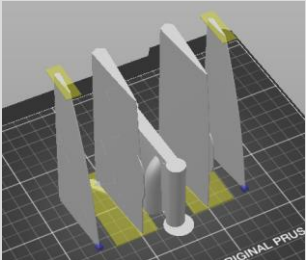
<p>Alternative: WingL1FrontBack</p>  <p>time: 7h 37m</p>	<p>WingL1Front WingL1Back</p>	<p>010 011</p>	<p>Pre-foamed 4 g 43 g</p>	<p>PLA+ (default) 5 g 54 g</p>
<p>Alternative: WingR1FrontBack</p>  <p>time: 7h 37m</p>	<p>WingR1Front WingR1Back</p>	<p>100 101</p>	<p>Pre-foamed 4 g 43 g</p>	<p>PLA+ (default) 5 g 54 g</p>
<p>Alternative: Tail LW-PLA</p>  <p>Print each active foaming LW-PLA part separately!</p>	<p>HorizontalStabilizerL HorizontalStabilizerR ElevatorL1 ElevatorL2 ElevatorR1 ElevatorR2 RudderBottom RudderTop</p>	<p>600 610 620 630 640 650 670 680</p>	<p>Active foaming 8 g 8 g 4 g 4 g 4 g 4 g 4 g 7 g</p>	
<p>Alternative: Ailerons & Servo Cover</p>  <p>Print each active foaming LW-PLA part separately!</p>	<p>Aileron1L Aileron2L Aileron1R Aileron2R ServoCover (left + right)</p>	<p>040 050 140 150 080</p>	<p>Active foaming 5 g 3 g 5 g 3 g 2 g</p>	



Figure 4: All printed parts at a glance.



Figure 5: Assembled plane printed with pre-foamed PLA.

Left: 478g without landing gear and flying wires. Right: 554g with landing gear and flying wires.

Decal sheets

The set includes PDF files (600dpi, letter and A4 format) to print decals for the Howard DGA-5 "IKE". The original plane used black aircraft registration letters in the first years which were later partly replaced by golden letters. Unfortunately, gold is a special color that can only be approximated by the RGB or CMYK color space. Therefore, black registration letters are provided as an alternative.

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Thank you!

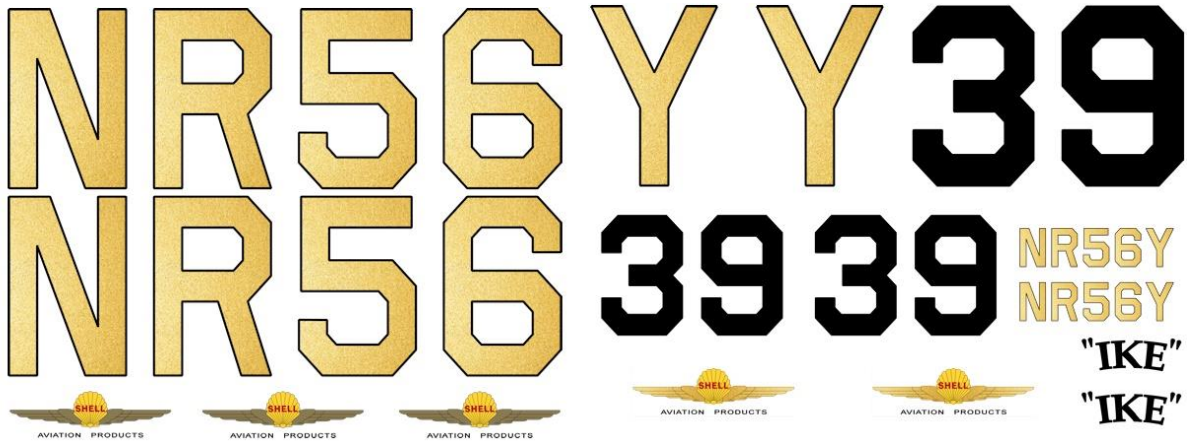


Figure 5: Decal sheets with golden registration letters.



Figure 6: Decal sheets with black registration letters.

What you need

3D printer specification

All STL files have been successfully tested with my Prusa i3 MK3S.

- 3D print volume** Minimum requirement for single STL file (ensures printability of all plane parts):
 $X \geq 190\text{mm}$; $Y \geq 180\text{mm}$; $Z \geq 171\text{mm}$
 Optional files (STL, project, gcode) are provided to print the most inner wing parts with such small printer bed sizes (see optional print parts below).
 Minimum requirement for other gcode: $X \geq 240\text{mm}$; $Y \geq 200\text{mm}$; $Z \geq 171\text{mm}$
- Nozzle diameter** 0.4mm
- Filament support** PLA, TPU

Required materials

Most plane parts are printable except for a few components such as steel wires or nylon screws. For the parts printed with white PLA I recommend using either PLA+ (Premium PLA) or pre-foamed PLA.

[Overture PLA Professional](#) (PLA+) is my first insider tip. It has a much higher tensile strength compared to standard PLA and a higher glass transition temperature. Structure details and surface finish are excellent.

[Overture Air PLA](#) (pre-foamed PLA) is my second insider tip. Compared to PLA+ it weighs approximately 20% less. This pre-foamed PLA can be printed with almost same slicer settings as used for standard PLA. Thanks to lower

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nozzle temperatures, stringing can be handled much better compared to active foaming LW-PLA. Printing of multiple parts at the same time is possible. Also, stiffness of the printed parts is notably better compared to LW-PLA. The following filament print setting modifications are typically sufficient to successfully print Overture Air:

- Nozzle temperature: ~205°C (high enough for good layer adhesion, low enough to minimize stringing)
- Retraction length (direct extruder): ~3mm (effectively reduces stringing)
- Retraction speed (direct extruder): ~30mm/s (lower is better to avoid negative side effects)
- Deretraction extra length: 0.08mm (to improve z seam)

Let me emphasize that the recommendation above is based on my personal experience. I do not get anything from Overture.

Filament	White PLA for majority of print parts: ~665g for PLA (e.g., Overture PLA Professional White) or ~530g for pre-foamed PLA (e.g., Overture Air PLA White) Black PLA for exhaust pipes: ~2g (or paint white PLA printout with black color) Transparent PLA for the wind shield: ~2g (e.g., Fillamentum PLA Crystal Clear Iceland Blue) Black TPU for tires: ~15g, (e.g., 3DFILS eFil TPU 90A) Optionally, white active-foaming LW-PLA for horizontal stabilizers, rudders, ailerons, and wing servo covers: ~61g (e.g., colorFabb LW-PLA NATURAL)
Spring steel wires	∅ 1.0mm, 2pcs of length ~800mm (servo linkage rods) ∅ 1.0mm, 1pc of length ~70mm (tail landing gear) ∅ 1.5mm, 1pc of length ~930mm (main landing gear)
Linkage stopper	2pcs for servo linkage rods e.g., Hobbyking Brass Linkage Stopper For 1mm Pushrods
Screw-in nuts	2pcs M4x10 (outer ∅ ≤8.0mm, sometimes used for furniture)
Self-tapping screws	8pcs M2.3x6 for wing servo cover 8pcs M2.3x6 for servo holder (optional)
Nylon screws	2pcs M4x20mm
CA hinge sheet	1pc e.g., Hobbyking CA Hinge Sheet 180mmx140mmx0.3mm
Elastic cord	∅ 1.0mm, grey or white ("flying wires", I use grey color)
Carbon fiber rod	Optional: ∅ 2.0mm, 1pc of length 250mm. Recommended if LW-PLA is used for the horizontal stabilizers.
Carbon fiber pipe	Optional: Outer ∅ 6.0mm, inner ∅ 4.0mm, 1pc of length 700mm. Intended as reinforcement of the wing to support cunning aerobatic figures.
CA glue	Medium viscosity e.g., Hobbyking Super Glue CA (50g / 1.7oz) Medium
CA accelerator	Optional: E.g., Hobbyking Insta-Set CA Accelerator 2. Oz
Double-sided tape	Strong sticky tape to fix the receiver (and optionally the servos) to the airplane e.g., Hobbyking Double Sided Tape (Clear) 25mm x 1m
Decal sheet	2pcs A4 or letter format (e.g., inkjet waterslide decal paper)
Clear spray coating	~200ml, for decal sheets (e.g., acrylic clear finish)

Radio control components

There is a large variety of products available which fulfill the requirements to provide enough power and precise control for the Howard DGA-5 "IKE". The following set is what I am currently using and can recommend. It provides a maximum thrust to weight ratio of 1.2 to 1.4 (according to ecalc.ch) and a mixed flight time of more than 7 minutes.

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Motor	Hobbyking PROPDRIVE v2 2836 1200KV (max. Ø 32mm)
ESC	Hobbyking Turnigy Plush-32 30A (2~4S) Brushless Speed Controller W/BEC
Battery	Hacker TopFuel LiPo 25C ECO-X 1800mAh 3S MTAG
Propeller	Hobbyking Meister Airscrew Propeller 9x6inch
Servos (4pc)	Hobbyking Corona DS-843MG
RC control	5 channel TX/RX

Assembly

Step by step video guide

This video guide is based on version 1 of this 3D printable Howard DGA-5 “IKE”. Some parts of version 3 look slightly different. Relevant changes are explained in the following subchapters.

[Howard DGA-5 “IKE” – step by step video guide](#)

Chapters:

- 00:15 > [Right wing](#)
- 04:02 > [Left wing](#)
- 05:18 > [Combine wings](#)
- 06:49 > [Servo cover](#)
- 07:43 > [Fuselage](#)
- 16:59 > [Tail](#)
- 24:04 > [Landing gear](#)
- 31:24 > [Decals](#)
- 33:56 > [Radio control](#)
- 39:06 > [Flying wires](#)
- 41:26 > [Final check](#)

Noteworthy changes in assembly for version 3

Partly applied selective brim instead of continuous brim to reduce the post-processing effort of the printed parts before assembly. The connection of the wing parts has changed to avoid additional post-processing steps in case of an elephant foot of the printed components. The landing gear crossbar is printed as one part.

Since version 2.1 there is the option to insert a carbon fiber pipe into the center area of the wing. Doing so, further increases the stability of the wing and ensures sufficient durability for all cunning aerobatic figures. Please make sure to check if the pipe fits into the prepared hole in the wing parts before gluing them together. Insert the carbon pipe latest when you glue both wing halves together.

Since version 2 the rudders, stabilizers, ailerons, and wing servo covers of the airplane are optionally available for printing with active foaming LW-PLA. The design of these parts has been modified to minimize extra travel moves of the nozzle during the print process and to partly compensate for the reduced stiffness of the foamed PLA. At one side of the print (bottom side except for the rudder) the rib structure becomes more visible along the surface. As shown in Figure 7, this visual effect can be easily minimized by sanding the area of the rib structure.

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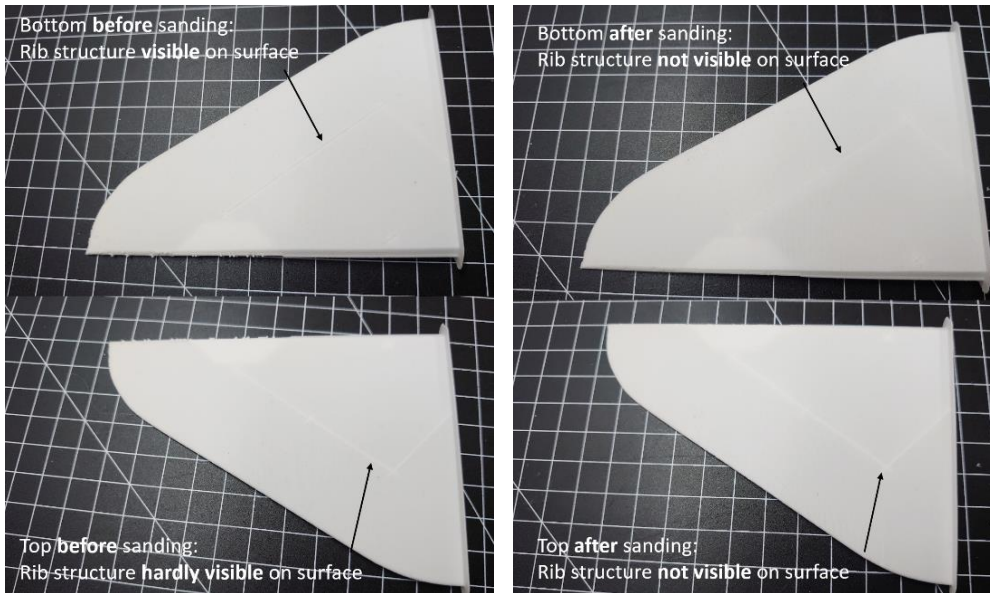


Figure 7: ElevatorL2 before (left) and after (right) sanding.

The active foaming LW-PLA horizontal stabilizers and fuselage part 6 have tubes to optionally insert a 2mm carbon fiber rod to improve rigidity and simplify the assembly as can be seen in Figure 8.

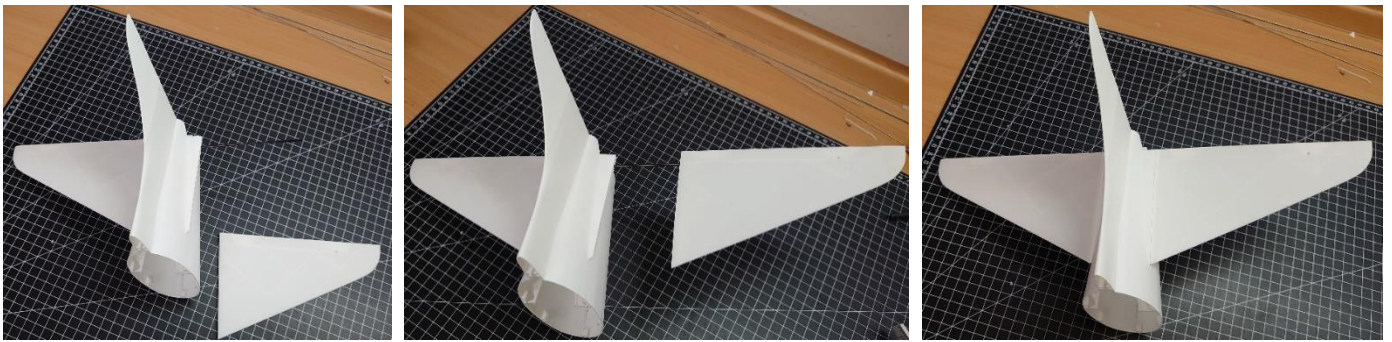


Figure 8: Optional 2mm carbon fiber rod

The main landing gear has been weight-optimized with version 2. This is mainly realized by reducing the diameter of the spring steel wires from 2.0mm to 1.5mm. To ensure robustness, the crossbar became slightly thicker. Overall weight reduction is approx. 13g resulting in a total weight of 68g.

Also the tail wheel became more light weight by reducing the diameter of the spring steel wire from 1.5mm to 1.0mm and optimizing the weight of rim and tire. Despite these optimizations the landing gear remains robust.



Figure 9: Weight-optimized landing gear and tail wheel

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Since version 2 connectors can be used to simplify the step of exactly aligning and gluing both wing halves together. The assembly process is comparable to the fuselage parts. Figure 10 (left) depicts WingL1 and WingR1 with connectors inserted in WingR1. Please note that this change only applies to the central wing parts. Fuselage1 now offers the possibility to fix the motor cables with a cable tie as shown in Figure 10 (right).



Figure 10: Connectors are available to simplify the alignment of left- and right-wing halves (left). Motor cables can be fixed to the fuselage (right).

Another useful modification is the extension of the battery compartment. Version 2 provides more degrees of freedom in the choice of battery type and size which is especially useful in combination with active foaming LW-PLA printed tail parts to adjust the center of gravity. Also, the required manual cut-out has been simplified.



Figure 11: Extended battery compartment to adjust center of gravity.

In version 3, the size of the battery compartment has been increased to support additional batteries. Maximum supported dimensions are 140mm x 38mm x 28.5mm.

Pre-flight setting & check

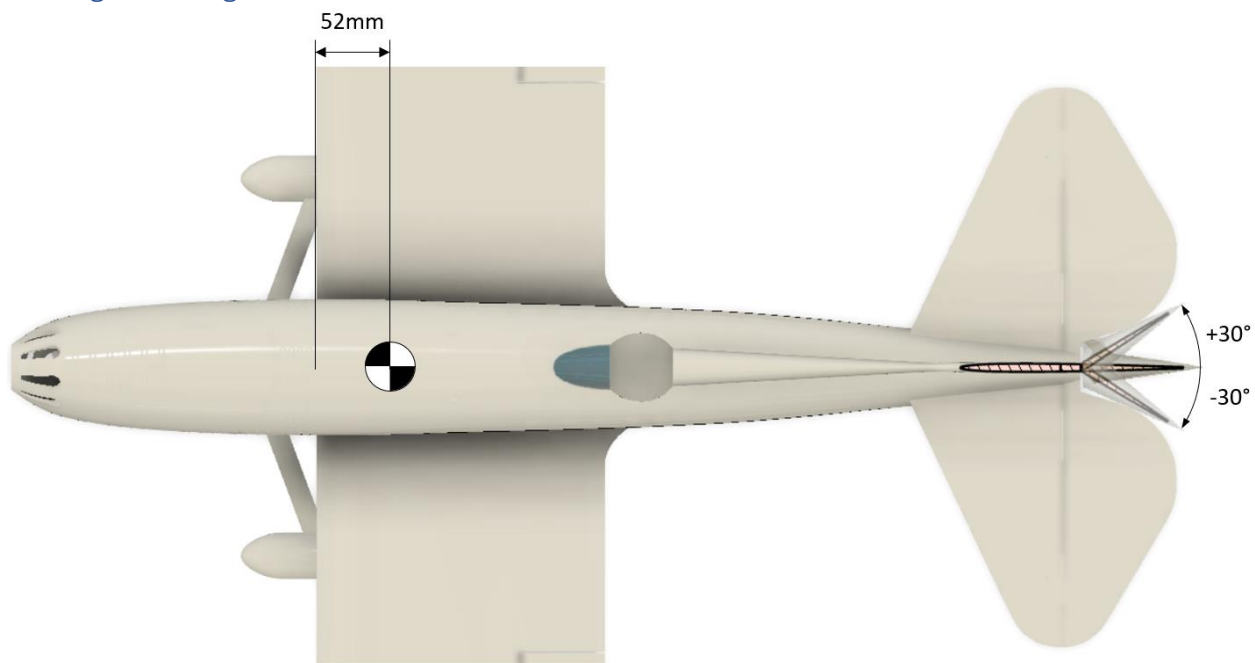


Figure 12: Center of gravity (CG) and rudder deflection angles

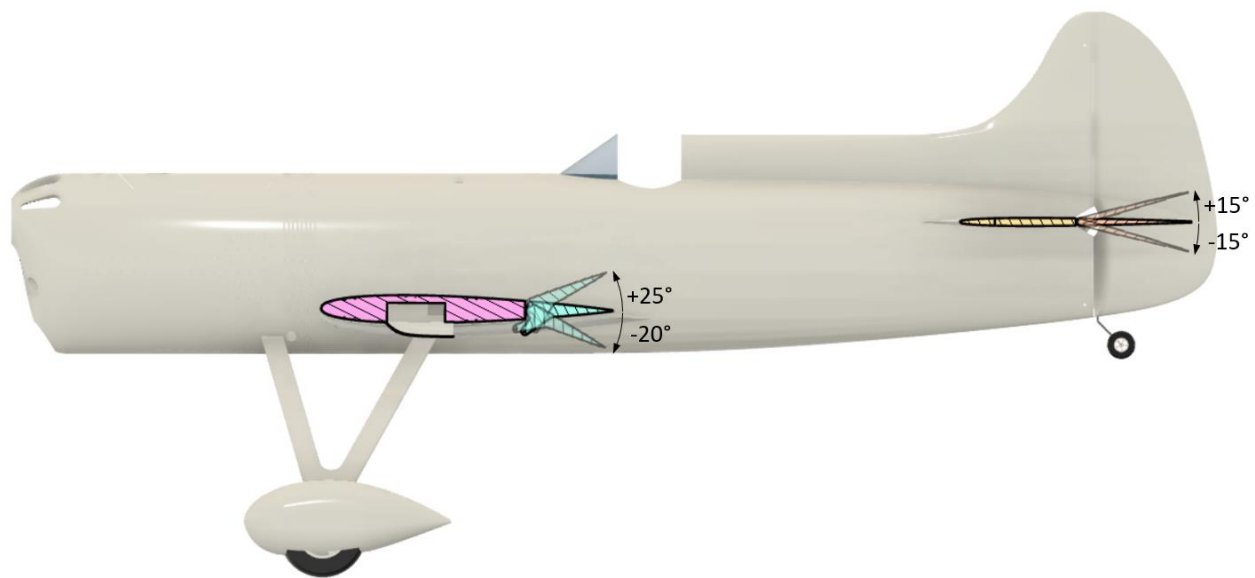


Figure 13: Aileron and elevator deflection angles

Change log

Version 3

- Optimized inner structures to improve compatibility of the STL files with freely available slicer versions such as Ultimaker Cura 5.3.1 or PrusaSlicer 2.7.1. It is possible to rescale and print this airplane with other nozzle diameters. Correct downscaling of the original 3D print size to 60% could be confirmed with Ultimaker Cura and PrusaSlicer. Upscaling should be only limited by the print volume of your printer.

Parameter	Original 3D-print size	Smaller	Larger
Nozzle Ø:	0.4 mm (100%)	0.3 mm (75%)	0.5 mm (125%)
Scale:	1 : 6.5	1 : 8.13	1 : 4,88
Wingspan:	1000 mm	750 mm	1250 mm
Length:	850 mm	638 mm	1063 mm

- Moved from Ultimaker Cura to PrusaSlicer due to notably improved print quality of PrusaSlicer with my Prusa i3 MK3S. Latest slicer versions include a feature called "Arachne" which causes surface quality degradation for several parts of this model. Unfortunately, Ultimaker Cura does not allow to switch off this feature completely. On the other hand, PrusaSlicer allows to deactivate this option which I've used for all print parts except for the canopy. In summary, I recommend using PrusaSlicer 2.7.1 (tested) or later together with the newly created project files and optimized print settings.
- Increased battery compartment to support batteries with larger form factor.
- Optimized connection of wing parts. It now features an improved 3mm continuously overlapping outer perimeter to simplify alignment and gluing of the parts which also results in an improved surface finish.
- Added carbon tube support for horizontal stabilizer in PLA.
- Modified rib structure of tail and aileron parts to improve rigidity and print quality.
- Improved tires by replacing internal structure with gyroid infill.
- Optimized print parameters with respect to print time and quality.
- Partly replaced continuous brim by selective brim to reduce assembly time.
- Merged landing gear crossbar halves. By default, the crossbar will be printed in PLA. Nonetheless, I recommend printing it with white TPU to improve stability and add some suspension in case of hard landings.
- Fixed a small issue with the wing servo covers.
- Changed filament recommendation for the wind shield from PETG to PLA. The [Fillamentum PLA Crystal Clear Iceland Blue](#) is easier to print and looks amazing.
- Added filament recommendation to use Overture Air instead of PLA+ to reduce the weight of the printed parts by ~20%.

Version 2.2

Minor modifications based on customer feedback.

- Increased engine side pull from 3 degrees to 4 degrees. This change improves the take-off behavior.
- Slightly increased the wheel opening of the landing gear wheel pants.

Version 2.1

- Added carbon fiber pipe support for wing reinforcement to have an additional robustness margin for cutting flight maneuvers. Normal aerobatic figures with limited g-force such as a larger looping, turn or roll do not require such additional reinforcement.
- Increased fuselage louver openings for improved scale impression – looks even greater!
- Reinforced landing gear wheel pants and crossbar.

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- Reinforced internal structure of main wheels.
- Fuselage bottom seam part optimization for print quality improvement

Version 2.1 weighs 35g more compared to version 2 at the benefit of reinforced structures where needed. This additional weight has marginal impact on the center of gravity.

Version 2

- Support of active foaming LW-PLA printing for weight-critical components with a total print weight reduction of approx. 50g.
 - Stabilizers, rudders, ailerons, and wing servo covers can be optionally printed with active foaming LW-PLA. Note that the weight reduction of the tail parts allows to additionally save motor and/or battery weight of up to 70g due to leverage with respect to center of gravity.
 - The active foaming LW-PLA horizontal stabilizers and their connection to the fuselage feature tubes to optionally insert a 2mm carbon fiber rod. The rod is intended as alternative for the tail flying wires.
 - Provision of modified STL files, gcode for each part and Cura project files with all required active foaming LW-PLA print settings.
- Extension of the compartment for the battery (and the ESC).
 - Provides more degrees of freedom in the choice of battery type and size, especially in combination with active foaming LW-PLA printed parts. Maximum supported dimensions are 140mm x 38mm x 28.5mm.
 - Simplified the required cut out of the battery compartment.
- Weight reduction of the landing gear by approx. 13g.
 - Mainly realized by reducing the diameter of the spring steel wires. The crossbar is now a slightly thicker to ensure robustness.
- Improvement of all wing part connections resulting in increased stability and print quality.
 - Added connectors to central wing parts to simplify the step of exactly aligning and gluing together both wing halves.
- Further optimization of general and part specific print parameters
- Several smaller improvements