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# TBS DISCOVERY / DISCOVERY PRO ENDURANCE KIT

*High speed and endurance upgrade for the TBS DISCOVERY quadcopter platform*

*Revision 2014-09-10*

TBS DISCOVERY and TBS DISCOVERY PRO owners will enjoy the ability to add larger props and higher cell motors to get the endurance or long range juices going. Also great for higher speed setups. It will generally turn your quadcopter into a matured aerial filming or aerial surveillance platform.

Flights of up to 30 minutes are within reach. Extends the arms to allow up to 15-inch propellers. The length is customizable by cutting the carbon fiber tube to length, so you can even go symmetric if that's your thing.



## Features

- Real endurance and long range capability
- Up to 15-inch propellers supported
- Customizable carbon fiber arm length
- Low vibration and warping for great efficiency
- Specialized motors with self-locking propeller mount
- Up to 45 minutes flight duration possible
- Include all the great features of the original frame



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## Before we begin

Thank you for buying a TBS product! The TBS DISCOVERY is a new multirotor aircraft from Team BlackSheep (TBS) for hobbyist, semi-pro and pro aerial videographers. It features the best design practices available on the market to date, providing great flying stability and incredible FPV characteristics.

Please read this manual carefully before assembling and flying your TBS DISCOVERY quadrotor. Keep this manual for future reference regarding tuning and maintenance.

## Disclaimer

Our request to you; the aircraft may not be used to infringe on people's right to privacy. We have designed a toy with mind blowing capabilities. It is your responsibility to use it reasonably and according to your experience level. Use common sense. Fly safe. You are on your own. TBS has no liability for use of this aircraft.

- Locate an appropriate flying location
- Obtain the assistance of an experienced pilot
- Practice safe and responsible operation
- Always be aware of the rotating blades
- Prevent moisture
- Keep away from heat or excessive amounts of sunlight



# Specifications

The following specifications list our target for the TBS DISCOVERY ENDURANCE upgrade kit.

<b>Type:</b>	Asymmetric spider quadrotor
<b>Arms:</b>	Carbon fiber tubes, 83g, length 330mm, Ø16mm, thickness 1.2mm (ea.)
<b>Airframe:</b>	Reinforced black fiberglass (rear top RF transparent, bottom PDB)
<b>Battery:</b>	6S (22.2V nom.) 2500 to 4000mAh LiPo pack, XT60, max. 34 x 55 x 137mm
<b>Specific energy:</b>	more than 170Wh/gram (mAh x nom. voltage / batt. weight)
<b>Propellers:</b>	8 to 15-inch propellers (2xCW, 2xCCW)
<b>Motor:</b>	400kV LR motor, 300-350W, 16x19mm mount pattern
<b>Speed controllers:</b>	4S to 6S 30A 400Hz multirotor ESCs
<b>Receiver:</b>	6-channels or more, 8-channels recommended
<b>Flight controller:</b>	Quadcopter controller (DJI NAZA V2 recommended)
<b>Current sensor:</b>	50A on-board
<b>Camera gimbal:</b>	GoPro HD Hero1/2/3/3+ supported, 2-axis, roll and tilt stabilization (PRO)
<b>Gimbal controller:</b>	BaseCam 12V, tied to CORE to auto-switch profiles (PRO)
<b>Center of Gravity:</b>	15mm in front of Center of Thrust mark
<b>Duration:</b>	up to 20 to 30min single LiPo pack, up to 40min-50min dual LiPo packs
<b>Distance:</b>	up to 12km range (and return)
<b>Altitude:</b>	up to 1.5km / 5000ft
<b>All-up-weight:</b>	2500 to 3000g



## Required parts

Before upgrading your TBS DISCOVERY, be sure you have acquired the following parts, or similar grade. We provide an upgrade kit which has been proven to work and include everything, except propellers which is up to the builder to choose.

 <p>1x AerialMob Arm Extensions set</p>	 <p>1x TBS 4-6S ESC LR set</p>	 <p>1x TBS 400kv LR Self-locking Motor set</p>
 <p>2x 14 to 15x5-in CF propeller sets (2xCW, 2xCCW) recommended</p>	 <p>1x TBS 6S 4000mAh 10C LiPo battery</p>	<p><b>Other essentials:</b></p> <ul style="list-style-type: none"> <li>1x Medium strength (blue/purple) thread-lock</li> <li>1x Set of hex screw drivers</li> <li>1x Hobby hand-saw</li> </ul>



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## Endurance upgrade

It is finally here! The endurance upgrade kit for the TBS DISCOVERY quadcopter series. All the pieces for a 25 minutes flight time solution, for your convenience everything required is available from TBS.

The new TBS 400kV LR motor is the cornerstone in this kit. One of the reasons this motor is great for endurance is the weight. Without wires it weighs 75 grams. The pancake design ensures sufficient torque to carry a lot of batteries, or fly insane speeds and face-melting climb-outs. After all, performance should not be sacrificed too much for longer flight times. The propeller mount is self-tightening, compatible with all of the common carbon propellers. This makes it convenient to remove, and re-attach the propellers while travelling between locations. We also offer precision CF folding propellers for those who prefer quick setup time. The motor was developed by TBS in cooperation with T-Motors.

We recommend 14 to 15-inch propellers (14x4.8, 15x5 or 15x6.5) and 6S batteries on AerialMob extension arms. We have seen good filming results with the 14-inch propellers as they do not show in view when using GoPro Wide mode, they are also less prone to "jello" and provide a little higher stability on windy days.

A TBS 6S 4000mAh battery will fit in the trunk and can keep you aloft for up to 25 minutes (landing at 20V loaded). These are specially made with lower discharge rate to ensure a high energy-to-weight ratio while still fit neatly. Expected hovering current consumption to be around 9A and full forward around 14A. With a second battery strapped to the bottom of the copter, you can go out up to 12km (and back), or cruise for up to 40 minutes. With GoPro gimbal and FPV equipment on board, obviously.

TBS carries two brands of carbon propellers. We have the T-Motor Carbon Fiber propellers which provide the maximum efficiency and stiffness, and the RCTimer Carbon Fiber propellers are for the budget-minded, or prop-slinging pilot.

The new TBS 30A Super-lightweight 6S ESCs is a perfect match for the TBS Long Range 400kV motors on a 2.5kg or lighter setups. Rated for 30A but should be exposed to airflow as they do heat up significantly under load.



## Choosing the right endurance setup

The following list recommendations are based on TBS DISCOVERY and TBS DISCOVERY PRO base setups and you might already have most of the suggested equipment if you are upgrading an existing platform.

### TBS DISCOVERY / TBS DISCOVERY PRO setup for short range endurance flights

- Expected flight time: 20-30 min
- Approximate cost: US\$ 2'850 - US\$ 3'250
- Experience level: Beginner to Expert
- Ideal for: Parks, R/C clubs, front lawns

<b>R/C transmitter/receiver:</b>	Graupner MX-12 2.4GHz radio with bundled receiver (GR-6) or Futaba 8FG / 7C 2.4GHz radio with included receiver (R6208SB / R617FS)
<b>Quadrotor equipment:</b>	1x AerialMob carbon fiber arm set 4x TBS 4S-6S 30A speed controllers 4x TBS 400kV LR brushless motors (2x CW, 2x CCW) 4x T-motor CF 15x5-inch propellers 1x DJI NAZA V2 flight controller (optional GPS add-on)
<b>Battery:</b>	1x TBS 6S (22.2V nom.) 4000mAh 10C LiPo pack
<b>Battery charger:</b>	Graupner Ultramat 14S (premium) or TBS B6AC 80W (budget)
<b>FPV transmitter:</b>	TBS ROOKIE BOSCAM 5.8GHz 200mW video transmitter
<b>FPV receiver:</b>	TBS RC508 5.8GHz video receiver or Dominator 5.8GHz module
<b>FPV pilot camera:</b>	TBS 59 or TBS 69 FPV camera
<b>FPV goggles:</b>	FatShark Dominator video glasses
<b>HD camera:</b>	GoPro HD Hero 3/3+ Black edition
<b>Ground station accessories:</b>	TBS Ground Station TBS 3S 5000mAh Ground Station LiPo Camera Tripod to mount your gear (e.g. Cullmann Primax 150)



## TBS DISCOVERY / TBS DISCOVERY PRO setup for long range endurance flights

- Expected flight time: 35-45 min
- Cost range: US\$ 3'000 - US\$ 3'500
- Experience level: Expert
- Ideal for: Long, wide open fields, plains, coastlines and valleys or urban flying

<b>R/C transmitter/receiver:</b>	Futaba 8FG / 7C or Graupner MX-12 radio + EzUHF 433MHz transmitter module and SRH-771 UHF antenna + EzUHF Lite 8-channel 433MHz receiver
<b>Quadrotor electronics:</b>	1x AerialMob carbon fiber arm set 4x TBS 4S-6S 30A speed controllers 4x TBS 400kV LR brushless motors 4x T-motor CF 15x5-inch propellers 1x DJI NAZA V2 flight controller (optional GPS add-on)
<b>Batteries:</b>	2x TBS 6S (22.2V nom.) 4000mAh 10C LiPo pack, Y-adaptor
<b>Battery charger:</b>	Graupner Ultramat 14S (premium) or TBS B6AC 80W (budget)
<b>FPV transmitter:</b>	Lawmate 2.4GHz 500mW Video Tx (stock or tuned)
<b>FPV receiver:</b>	Lawmate 2.4GHz Video Rx (stock or tuned) with 11dBi Yagi
<b>FPV pilot camera:</b>	TBS 59 or TBS 69 FPV camera
<b>FPV goggles:</b>	FatShark Dominator video glasses
<b>HD camera:</b>	GoPro HD Hero 3/3+ Black edition
<b>Ground station accessories:</b>	TBS Ground Station TBS 3S 5000mAh Ground Station Lipo Camera Tripod to mount your gear (e.g. Cullmann Primax 150)



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# Installation

## Preparation

Remove the current drive train setup (propellers, motors, ESCs) from the DJI arms, remove the arms and clean the ESCs solder pads. If you are going to reuse the motors, clean the top of bearings with a cotton-bud.

It is imperative to remove as much excessive weight from the platform as manageable before upgrading to the endurance kit. Every gram will have a direct effect on the final flight time - e.g. 200 grams can easily mean 8 minutes less flight time. Consider shortening wires, thinner gauge wires, removing bullet connectors, NAZA PMU, redundant screws, titanium screws, using PPM, lighter PVC heat-shrink, removing plastic casings and similar type of nuances.

## Arm length

Begin by finding the right cut point for the carbon fiber tubes (if needed). This depends on the size of the propellers used, see the guide below for suggested lengths. Longer arms are supported (17-inch has been tested) but you have to supply the carbon fiber tubes yourself (Ø16, 1.2mm thickness).

Propeller	Tube length (four pieces)
8-inch	241.30mm / 9.5-inch
9-inch	254mm / 10-inch
10-inch	266.70mm / 10.5-inch
11-inch	279.40mm / 11-inch
12-inch	292.10 mm / 11.5-inch
13-inch	304.80mm / 12-inch
14-inch	317.50mm / 12.5-inch
15-inch	330mm / 13-inch ( <i>stock</i> )

Measure from the end of the tube where there is a guide hole. This hole is used to mount the frame clamp later on and keeps one end aligned - it should not be cut away.

Use a small hand-saw or other fine cutting tool to cut the tube to length. Apply gentle pressure and slow strokes to avoid fraying the carbon fiber. Note that this is carbon fiber and the small fiber dust particles produced can have an impact on your health if inhaled - always cut in a ventilated area with a mask.

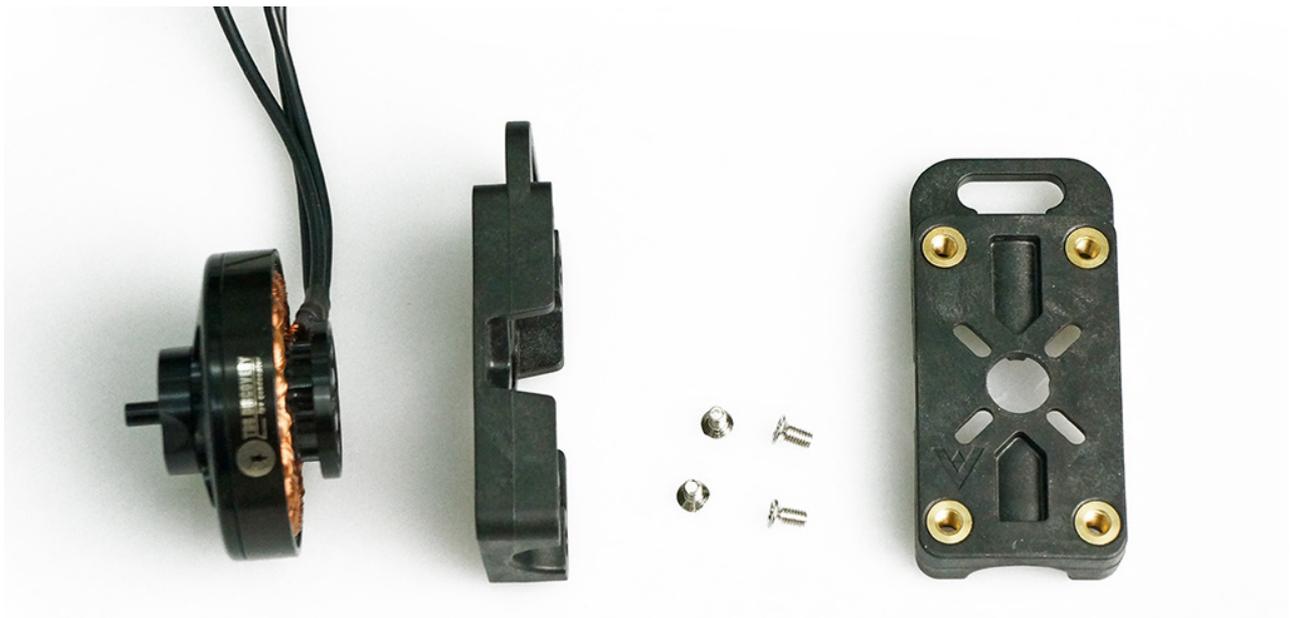


## Motor mount

If you are going to use your current setup or motors with short motor wires, it is necessary to extend the motor wires to reach at least the length of the tubes, plus 20%. Wire gauge should be 18 to 20 AWG. Heatshrink to protect against short-circuit.

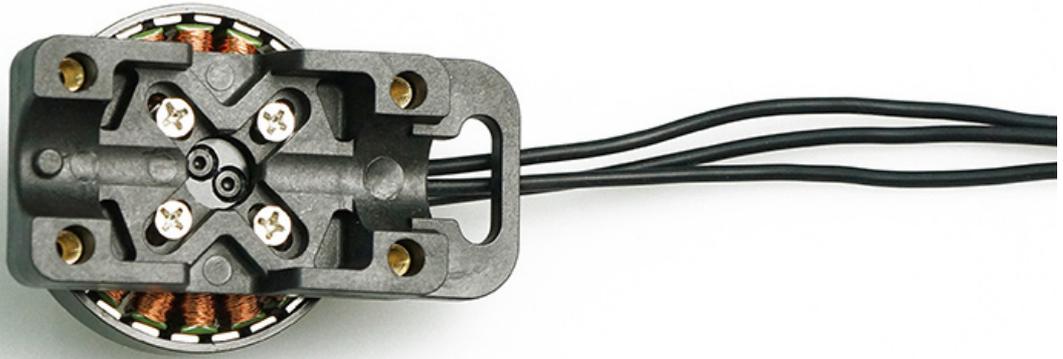


The motors arrive in two turning directions (clockwise, CW; counterclockwise, CCW). The white dot marks motors that are turning counter-clockwise, to be positioned on the arms for motor M1 and M3. Prepare the motor mount part; top motor mount, boom support part and M3x8mm screw.

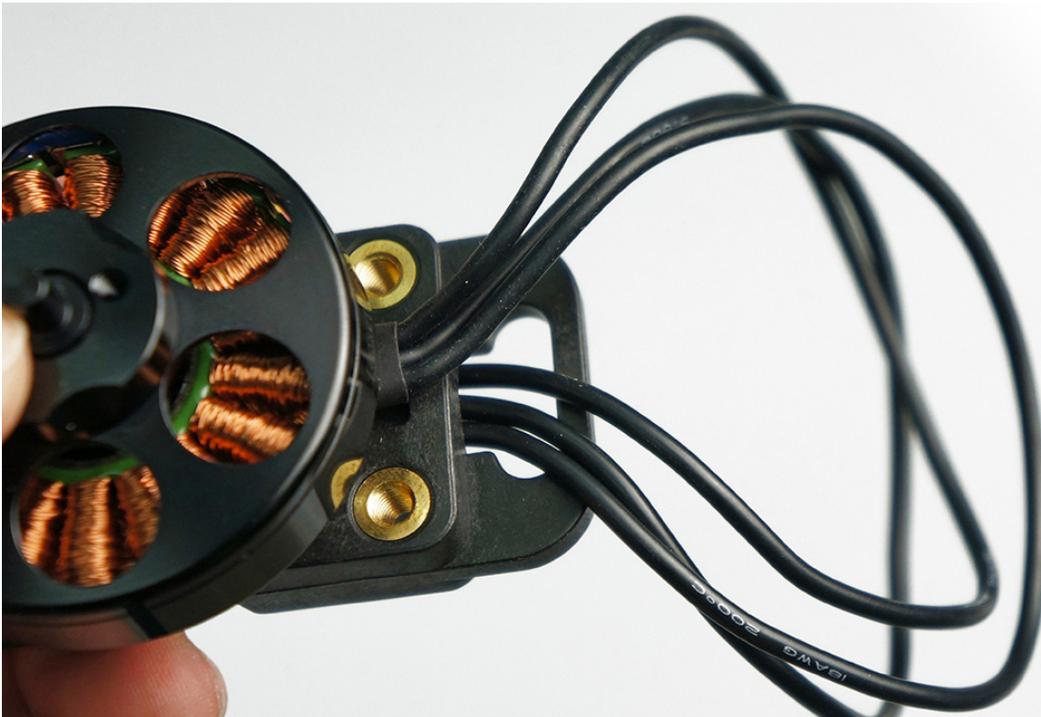


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Add small amount of thread-lock to the M3x8mm motor screws and fasten properly.



Thread the motor wires through the slot on the motor mount part and align the back of the motor with the mounting pattern on the motor mount part.



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The motor mount section of the assembly is now complete.



## Mount boom

Now, thread the motor wires through the carbon fiber tube and position the motor assembly on to the boom. Keep these screws fairly loose until the end of the install to allow you to vertically tweak the final alignment of the propeller and motor assembly to the frame.





## Mount boom support

Prepare the boom support parts; boom mount, boom brackets, landing gear and 4x M4x20mm screws.

You have three choices to support the motor mount to the boom, pick one:

- **Boom mount** - wide mount with notch which locks into the end of the carbon tube (original length)
- **Boom brackets** - small and light-weight, good for custom length tubes
- **Landing gear** - provides support for the arms and frame body

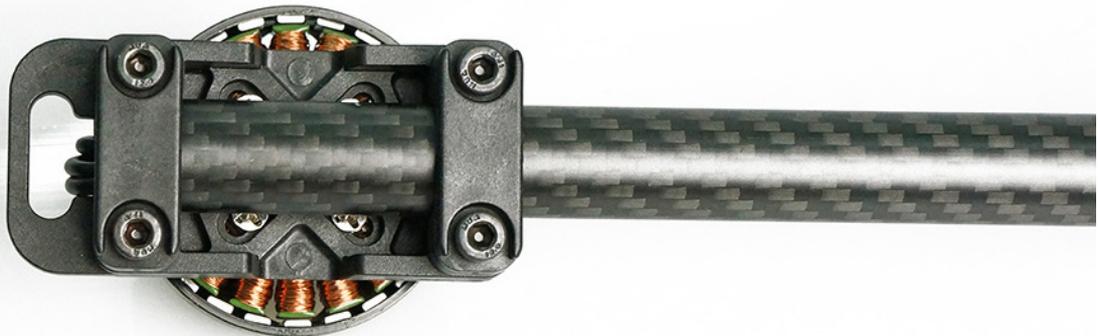


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Align the carbon fiber tube to the opposite side of the motor assembly, the notch in the mount should be arranged with the corresponding hole on the carbon fiber tube.

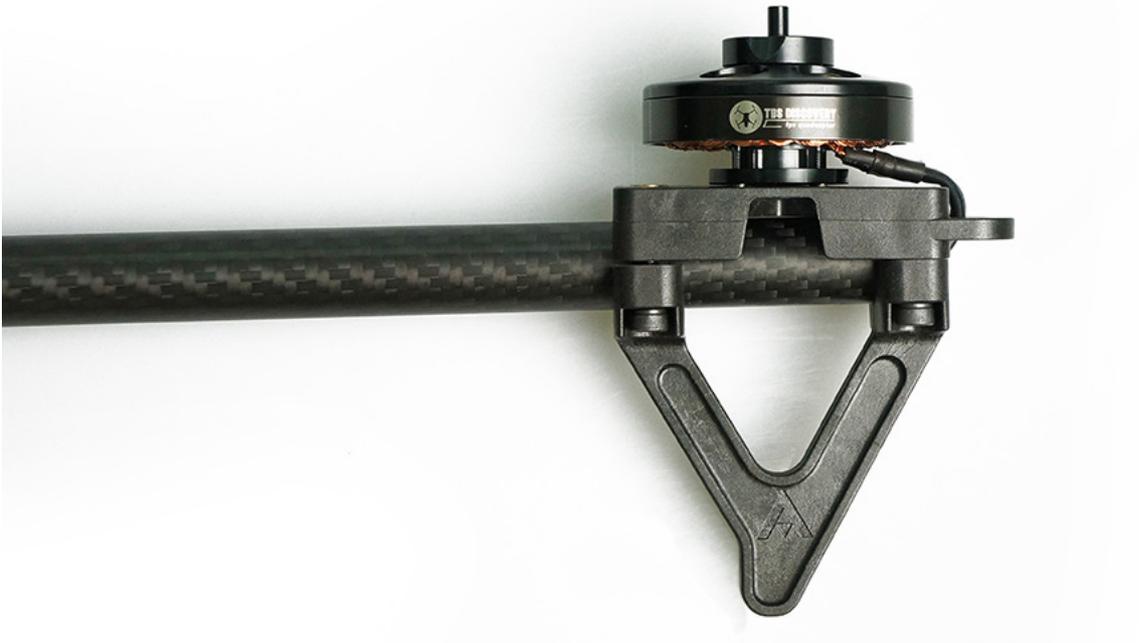


The **boom mount** and **boom brackets** provides a low profile and saves weight. It is recommended to use the **boom brackets** when using custom carbon tube length.

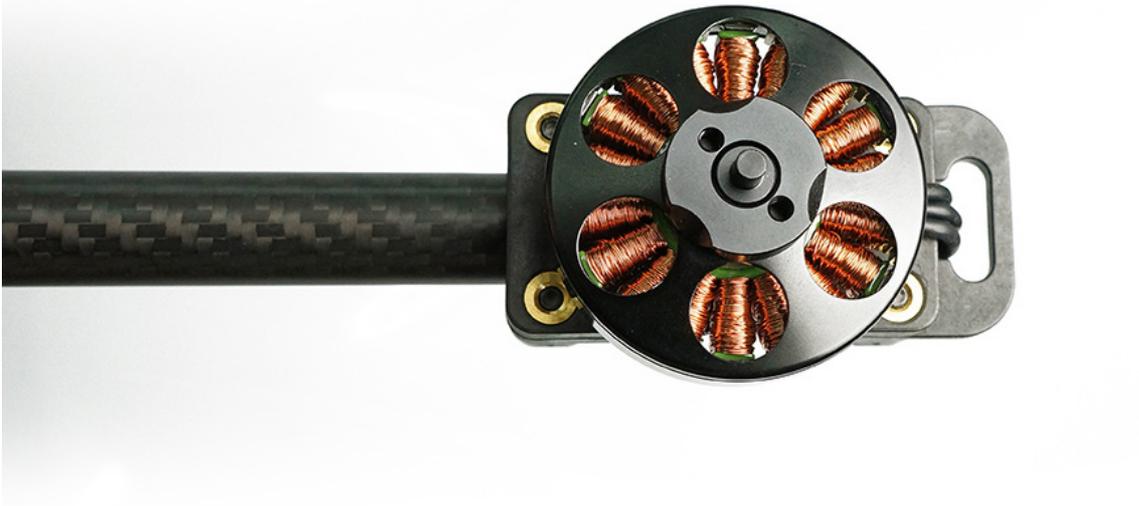


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Use four M4x20mm screws to secure the motor mount to the boom. Use a small drip of thread-lock to make sure vibrations from the motor will not weaken the boom grip.



The motor and boom support assembly is now complete.



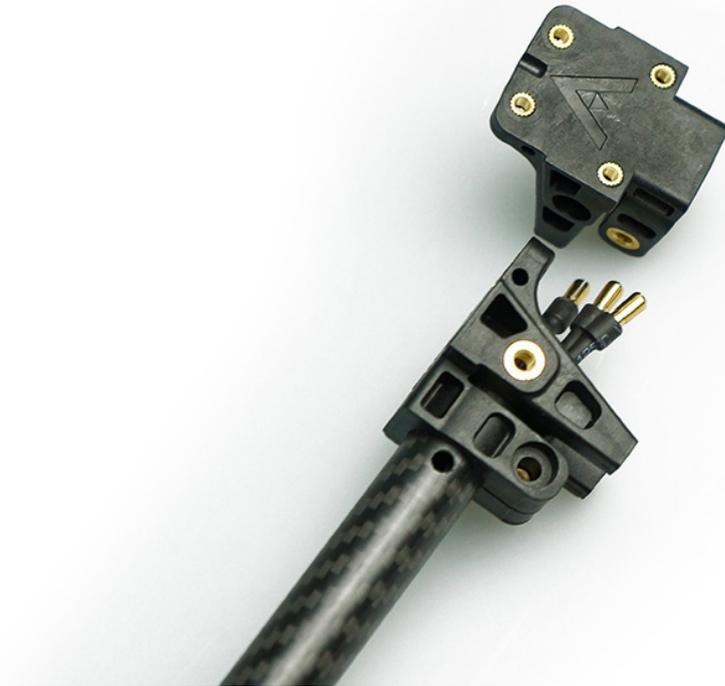
*Note:* On the v1.0 and v1.5 kits, there are two mounting holes from the top and two from the bottom, on the later versions the screws are all from the bottom to accommodate the use of “pancake” motors.



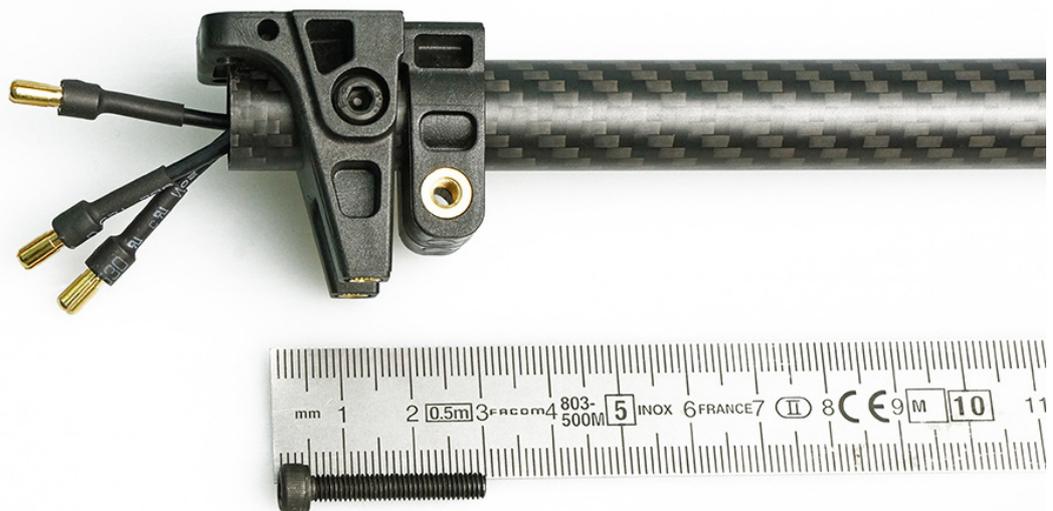
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## Mount frame clamp

Feed the wires through the frame clamp part and slide the part onto the boom. Align the hole on the boom with the corresponding guide screw hole on the frame clamp.



Use the longest M4x25mm set screw in the kit, add thread-lock and insert it into the guide hole to lock the boom and frame clamp.



Next, use a M4x20mm screw and insert it into the second screw hole beneath the boom to ensure a good fit. Do not over tighten, the last screw is designed to keep the boom secured to the frame clamp.



If the boom clamp is a little loose, use a small strip (halfway around the tube) of electrical tape to close the gap between the tube and the clamp.



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## Mount propellers

Mount the propellers using our new innovative way to mount and dismount low level propellers on the new TBS 400kV "pancake" motor.

Prepare the motors and propellers, together with the supplied mounting accessories.



Make a note of the rotation of both the propeller and motor header. A anti-clockwise (counter-rotating) propeller should be matched with a motor marked by a white dot - indicating that anti-clockwise rotating will lock the propeller to the motor header when force is applied.



Arrange the disc with the largest center hole, below the propeller with the cut-out notches facing up. Align the



other disc with the counter-sunk screw holes, also facing up.



Add a small amount of thread-lock to the two screws and tighten properly.



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The complete propeller assembly should be absolutely flush. If there are any noticeable misalignment, remove the discs and sand the surface to remove any carbon fiber specs or foreign particles.

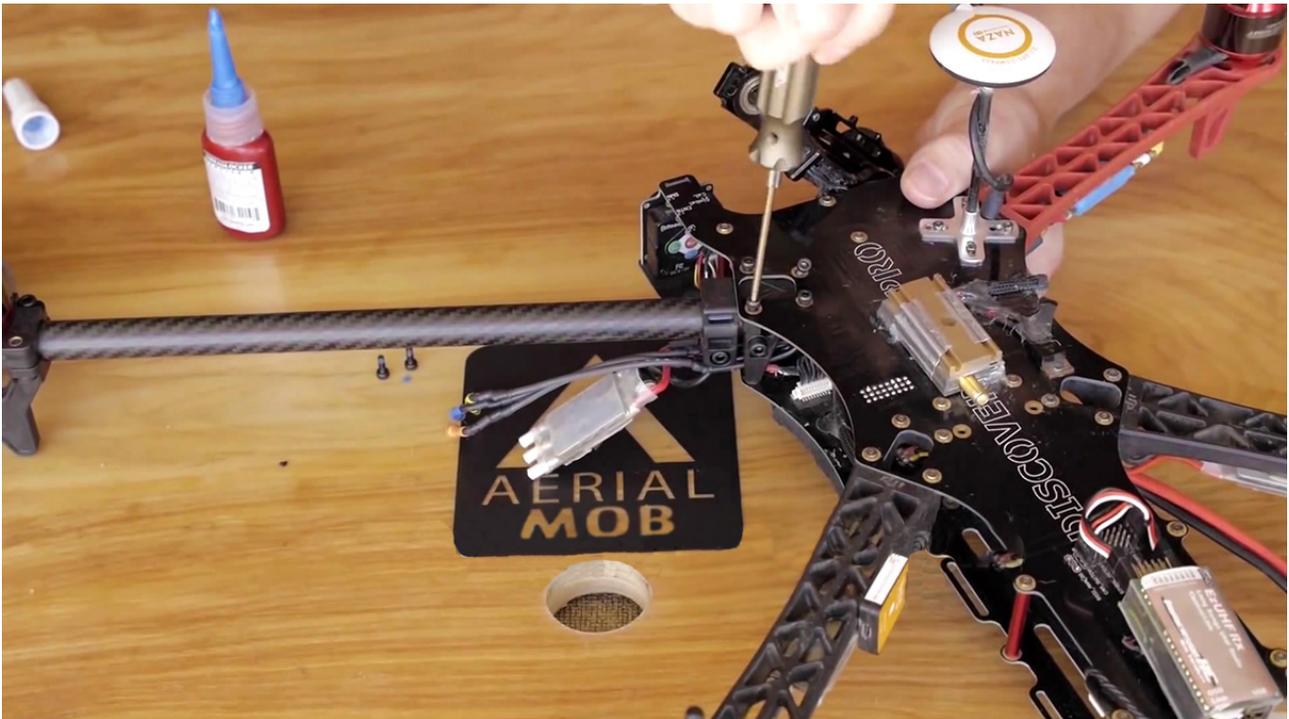


Mount the propeller assembly to the motors by spinning them a few turns while holding the motor bell. For quick swap, hold the motor bell and with a firm grasp at the core of the propeller, twist in the opposite direction of the propeller rotation to release the lock and unmount the propeller.



## Install arm

First put the motor and ESC wires through the bottom "U" of the frame clamp if you are going to install the ESCs on the boom, or leave the wires go through inside the frame.



Hold the bottom of the frame while positioning the arms over the mounting pattern. Use four screws on the top frame plate and two on the bottom to secure the arm to the frame.

## Install battery

A 6S 2500 to 4000mAh battery with an envelope smaller than W34 x H55 x L137mm will fit neatly in the TBS DISCOVERY and TBS DISCOVERY PRO battery bay. Longer batteries might make the platform tail heavy but the bigger power train can easily counter the imbalance.

For extended flight time, an additional battery can be strapped on the underside of the frame (around the CG spot). It should be connected in parallel to the other battery (via Y-adaptor cable). A mounting plate can be made to screw in place using the spare flight controller holes on the bottom plate. A large Velcro-strap is sufficient to keep the battery mounted.

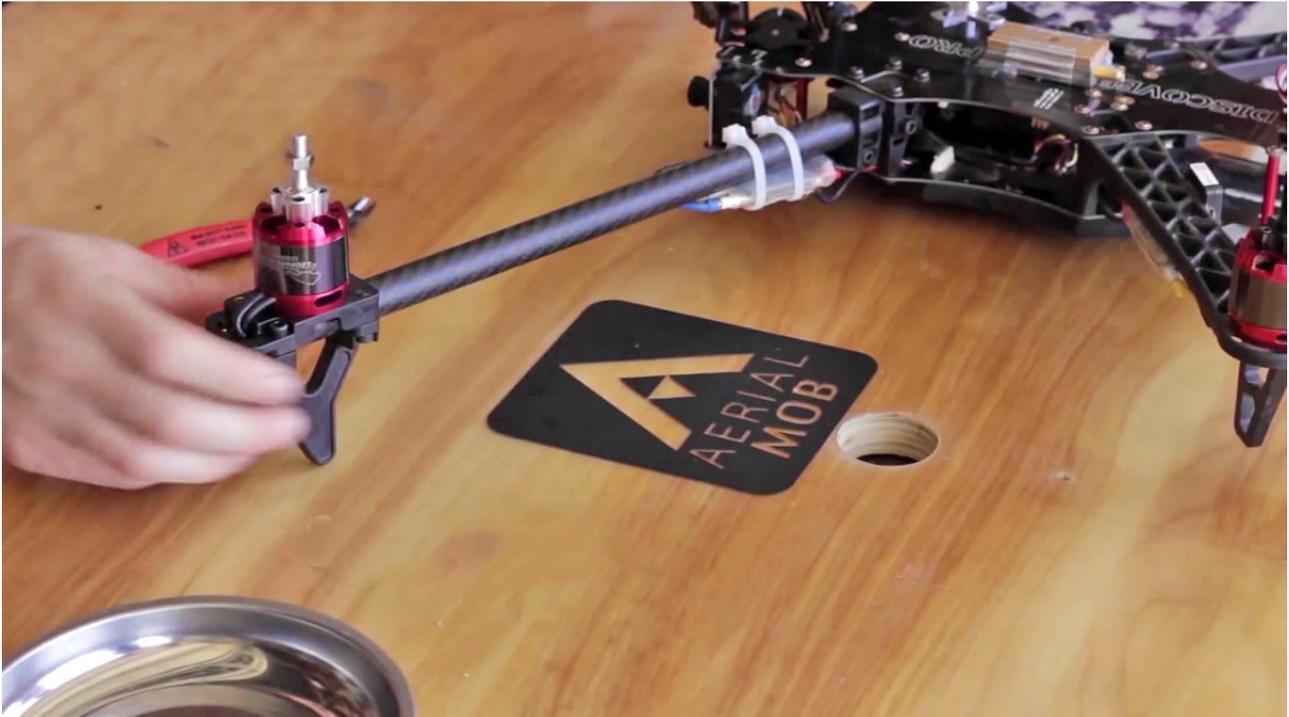


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## Speed controller mount

Cut the ESCs power leads to length and solder wires to the "+" and "-" pads on the bottom frame. Connect the motor wires to the ESCs.

Position the ESCs either on the booms using zip-ties to securing them, or staggered inside the frame for a cleaner look but at the expense of lower airflow for cooling.



If there is a lot of wire slack after the installation, consider re-doing the motor and/or ESC wires for a tidier install..

## Last tweaks

Now, complete the build by aligning the motor assembly perpendicular to the frame (90° angle). Look from behind the arm into the frame and use the propeller to position the motor assembly perfectly level to the top of the frame. Fasten the motor mount firmly to the boom by fastening the four screws.

Alternatively compare the distances from the tips of the propeller to a flat surface and align the motor until both tips have the same distance to the flat surface. The propeller should be perpendicular to the arm.

Getting this correct will make sure the entire power train runs at peak efficiency.



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## Flight controller configuration

If you use the DJI NAZA flight controller, update the PID settings to reflect the new power train and flight dynamics.

Setup	Gain	Pitch	Roll	Yaw	Vertical
TBS 400kV 15x5 6S4000mAh 30A	Basic/manual	145%	110%	120%	135%
NAZA-M V2	Attitude	150%	150%		



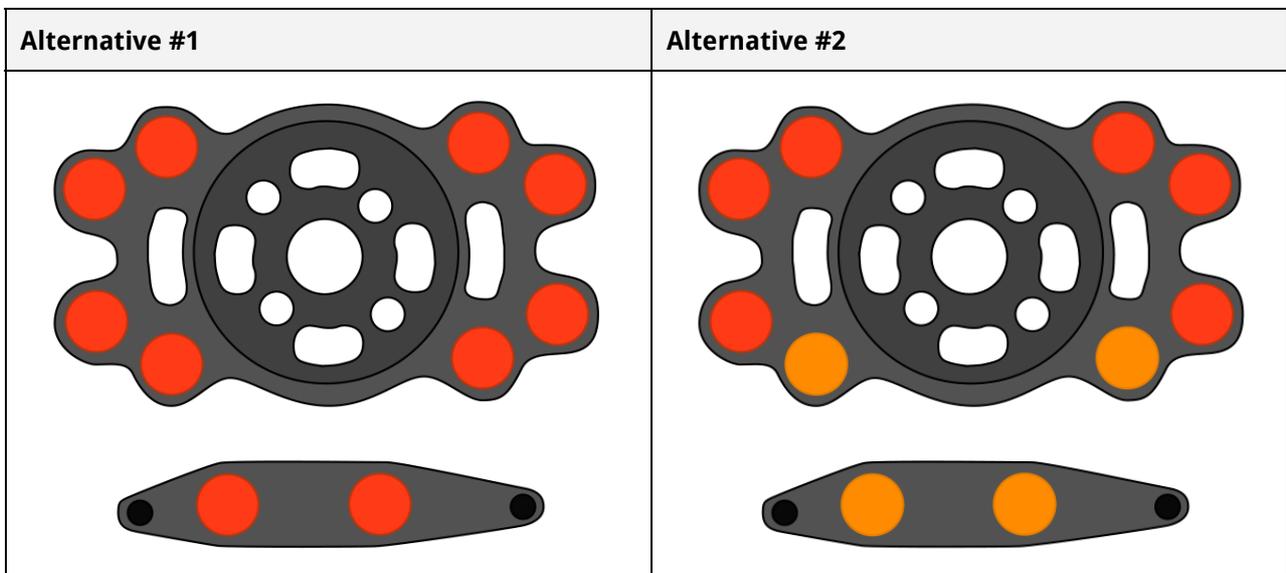
## Vibration damping system (TBS DISCOVERY PRO only)

With larger motors and propellers spinning at relatively low RPM, the platform will experience different harmonics and vibrations compared to a regular setup. These vibrations will normally be at lower frequencies and are harder to get rid off. It is therefore important that the entire system is well balanced, from battery CG, arms, motors and propellers (from least to most important).

Re-tuning the GoPro gimbal vibration damping system is necessary.

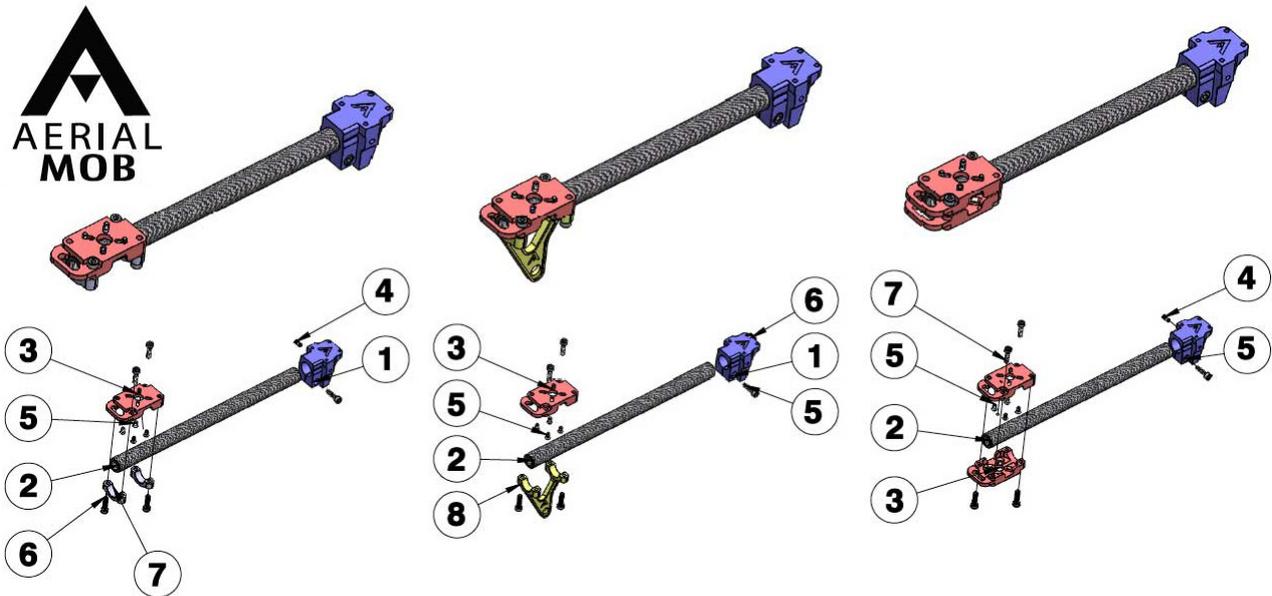
- The following list is a reminder of the different damping balls and elasticity available:
  - **Green** - soft silicone (5)
  - **Red** - medium silicone (10)
  - **Orange** - hard silicone (10)
  - **Yellow** - harder silicone (5)
  - **Black** - extra hard silicone (5)

The following is a recommended starting point when using propellers larger than 12-inch.



## Diagrams

The diagrams below shows the exploded view of the AerialMob arm extensions to make it easy to see the different assemblies (brackets, landing gear, boom support).



Item	Part name	Description	Part Number
1	Boom/Frame Mounting Block	Clamp for boom to frame	MOB-ARM-640081
2	16mm Boom	CF Boom	MOB-ARM-640084
3	Motor Mount	Motor Mount	MOB-ARM-640088
4	m4 Set Screw	Set Screw	MOB-ARM-640021
5	m4 x 16mm hex bolt	Hex Bolt	MOB-ARM-640025
6	m3 x 8 hex bolt	Hex Bolt	MOB-ARM-640028
7	Simple Clamp	Alternate motor mount clamp	MOB-ARM-640093
8	Landing Gear	Landing Gear	MOB-ARM-640094
	Quad Arm Kit	Quad Arm Kit	MOB-ARM-640004



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## Good practices

We have compiled a list of all of the things that have been tried and tested in countless environments and situations by TBS crew and other experienced FPV pilots.

Follow these simple rules, even if rumors on the internet suggest otherwise, and you will have success in FPV.

- Start with the bare essentials and add equipment one step at a time, after each new equipment was added to proper range- and stress tests.
- Do not fly with a video system that is capable of outperforming your R/C system in terms of range.
- Do not fly with a R/C frequency higher than the video frequency (e.g. 2.4GHz R/C, 900MHz video).
- Monitor the vitals of your plane (R/C link and battery). Flying with a digital R/C link without RSSI is dangerous.
- Do not use 2.4GHz R/C unless you fly well within its range limits, in noise-free environments and always within LOS. Since this is most likely never the case, it is recommended to not use 2.4GHz R/C systems for longer range FPV.
- Do not fly at the limits of video, if you see noise in your picture, turn around and buy a higher-gain receiver antenna before going out further.
- Shielded wires or twisted cables only, anything else picks up RF noise and can cause problems.
- When using powerful R/C transmitters, make sure your ground station equipment is properly shielded.
- Adding Return-To-Home (RTH) to an unreliable system does not increase the chances of getting your plane back. Work on making your system reliable without RTH first, then add RTH as an additional safety measure if you must.
- Avoid powering the VTx directly from battery, step-up or step-down the voltage and provide a constant level of power to your VTx. Make sure your VTx runs until your battery dies.
- Do not power your camera directly unless it works along the complete voltage range of your battery. Step-up or step-down the voltage and provide a constant level of power to your camera. Make sure your camera runs until your battery dies.
- A single battery system is safer than using two dedicated batteries for R/C and FPV. Two batteries in parallel even further mitigate sources of failure.
- For maximum video range and "law compatibility", use 2.4GHz video with high-gain antennas.
- When flying with R/C buddies that fly on 2.4GHz, or when flying in cities, it is perfectly possible to use 2.4GHz video provided you stick to the channels that do not lie in their band (CH5 to CH8 for Lawmate systems, available from TBS).
- Do not use diversity video receivers as a replacement for pointing your antennas, diversity should be used to mitigate polarization issues.
- Improving the antenna gain on the receiver end is better than increasing the output power (except in RF-noisy areas). More tx power causes more issues with RF on your plane. 500mW is plenty of power!



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- Try to achieve as much separation of the VTx and R/C receiver as possible to lower the RF noise floor and EMI interference.
  - Do not buy the cheapest equipment unless it is proven to work reliably (e.g. parts falling off, multitudes of bug fix firmware updates, community hacks and mods are a good indicator of poor quality and something you do NOT want to buy for a safe system). Do due diligence and some research before sending your aircraft skyward.



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# Appendix

*Manual written and designed by ivc.no in cooperation with TBS.*

