Precision Aerobatics Thrust 50 Brushless motor with Rotorkool® technology

The development of our new PA Thrust® motors has followed our traditional design philosophy employed in our aircraft; which is doing things better. Thrust® motor is one of the coolest running high performance, high-torque and high efficiency brushless motor ever produced to date. The design incorporates our latest innovation, ***Rotorkool®*** which keeps the stator core material, the low resistance windings, highly permeable stator plates, high quality NMB Japan triple bearings and powerful neodymium magnets at optimum operating temperatures regardless of duration or the number of consecutive flights made*.

*provided sufficient airflow is permitted.

Motor specs

Outside Diameter	41.7mm/1.64"
Length	58.2mm/2.29"
Weight (gr/oz)	279gr / 9.84oz
Motor Shaft Dia.	5.0mm
Mounting Bolts Dia.	M3
Max efficiency Current A *	50A
Peak current A (45 sec)*	70A
Battery pack range **	4-6 LiPo / 12-18 NiCd
Poles	14
KV rpm/V	487kv
Recommended ESC	PA Quantum 65
Peak Watts	1500 watts

** Unrestricted airflow and air scoops are mandatory to ensure long service life and long term performance consistency. Extended Continuous Operation without the required cooling provisions may be detrimental to the coils and magnets and will void warranty.*

*** 2 x PA 3cells (11.1V) 2200mAh V2 packs are recommended (plugged in series). With 4 cells pack the chosen propeller must fit within the motor's limits (current drawn).*

The PA Thrust 50 is an excellent motor for .40-.60 size electric aircraft conversions.

Prop selection with 2xPA2200mah 20C-40C V2 Packs (6s)

VOX 14x7 - Good lower range overall propeller for sport/IMAC with decent freestyle and 3D performance. It allows good flight duration with fast throttle response and is best used on a calm weather. It allows slower harriers but with less stability and ailerons authority during hovering and high AOA maneuvers when compared to the VOX 15X7

APC 14x7E - provides nice speed and performance for IMAC with good tumbles but less stable high AOA flight with lesser ailerons authority than the VOX 14x7. However it draws similar current as the VOX 15x7 with lesser performance and prop wash therefore not a great option.

VOX T50-X - Excellent overall midrange propeller for 3D, freestyle and pattern. Optimum balance of thrust and speed. Provides good prop wash for slow speed high AOA maneuvers.

VOX 15X7 - **Perfect match to the Thrust 50!** Excellent higher range propeller for 3D, freestyle aerobatics and pattern flying. Great balance of thrust and speed that allows a wider performance envelope for aggressive flying. Double check the integrity of your plane's motor box to ensure it can withstand the increased loads. This is **THE** prop for the Extra MX especially for low and slow 3D. Even though it draws much lower amps than the APC 15x7E it produces a similar whopping **10.55lb** of thrust!! This clearly demonstrates the efficiency and advantage of the VOX over the APC! Adequate airflow to cool down the motor and ESC is mandatory, as well as **strict** throttle management (using full power **only** on vertical climbs due to its tremendous thrust).

A note about the Extra MX performance with this prop - Great speed, faster rolling rate, nasty tumbles and waterfalls with a very nice prop sound. It draws more amp than the VOX 14x7 but with the MX efficient design and lightweight it provides similar flight duration as less throttle is needed to fly the plane. Excellent ailerons authority allows more stable and controlled hovering, TR and harriers.

APC 15x7E - If you desire a little more speed than the VOX 15x7 then this prop might suit you better. Careful throttle management is **essential** when flying with the APC 15X7E. Not recommended for the Extra MX.

APC 15x8E - This is the highest range prop for the T50 and a good overall prop for 3D and freestyle for heavy models (6lb+ AUW). Much faster flight speed BUT lower efficiency and higher current drawn (= shorter flight duration) than the VOX 15x7 with less thrust and should only be used with a battery capacity of 3000mAH or above.
NOTE: Adequate airflow to cool down the motor and ESC is mandatory, as well as **strict** throttle management. Not recommended for the Extra MX.

We recommend getting a few different size propellers with your Thrust 50 motor. Swapping a propeller is an easy task so you may want to experiment and feel the difference to fit different style of flying. Also in a hot summer day you may want to use a smaller propeller while in a cooler day you can run the motor with a larger propeller.

Note :- Actual flight duration is dependent on the individual's flying style and the extent of throttle management used. To make initial flight duration estimates, refer to the dynamic flight testing graphs on the following pages to set the flight duration in accordance to the propeller used. This will be the conservative flight duration estimates whereby the actual flight duration specific to each individual can be then refined by taking note of the remaining battery capacities after the flight session to establish the consistent capacity draw. Due to the relatively flat nature of the discharge curve found on high grade, high performance batteries where it provides consistent performance throughout 90% of the pack's capacity, the drop in power at the last 10-20% of the pack's capacity sometimes goes unnoticed. As such it indirectly encourages the modeler to fly for an extended period and run the risk of encroaching into sudden ESC unexpected LVC (Low Voltage Cutoff). To avoid this, as a rule of thumb, set your flight timer to allow at least 15% spare capacity as a contingency measure to account for weather conditions, inconsistencies in routines and other eventualities you may have not anticipated.

A little background

For a number of years, modelers have accepted the notion that in order to attain top notch performance, one has to run outrunner motors to the extreme limit with the risk of overheating. In fact, heat has become inevitable part of contemporary high performance Brushless Motors and nothing much could be done about it.

However heat is one of the main contributors to premature magnet deterioration and bearing failures leading to permanent performance degradation over time or even dangerous and catastrophic destruction due to thrown magnets.

In order to avoid unwanted heat damaging the motor, some modelers have resorted to over sizing their motors. This in turn increases the all up weight and thereby affecting wing loading and flight performance. There seems to be a no win situation and the only way to enjoy this wonderful hobby is to accept the seemingly hopeless compromise.

Motor power has always been quoted in Watts, but heat is Watts too. So, the real question is *"Are all the quoted Watts being used to drive the motor, or is there a significant amount of Watts wasted in heat?* To answer that just touch your motor immediately after flight and if it is hot enough to burn your finger, THAT is where the Watts went as opposed to driving your airplane, therefore, quoted watts are essentially meaningless when evaluating a motor (because it does not indicate the efficiency). The propeller's RPM is the most important performance factor.

We at PA understood that without effectively eliminating heat, all the good motor attributes already available in our motors and as well as others, contributes very little to the motor's overall performance in service because heat building up under load means loss of efficiency and eventually leads to detrimental effects in the electro-magnetic properties of the motor. These effects cause significant deterioration of power, thrust and eventually flight times.

We set a target to make a high performance, extreme thrust motor, which is light, runs cool and efficient for maximum flight time, is made of highest grade materials and features precision engineering and machining.

This led to rethinking the design of current brushless outrunners, their strengths and limitations and thus led to the development of a completely new line of PA Thrust® motors.

About the design

Some of the common brushless outrunner manufacturers have gone as far as incorporating high temperature magnets and exotic adhesives to circumvent the effects of the heat problem. There are myriad of crude and inefficient cooling techniques ranging from a multitude of holes, to fins, to bolt-on fans and impellers.

Unlike those, the new PA Thrust® cooling design took a complete departure in the current thinking by engineering a High Velocity Force Cool Ventilation (HVFCV) into the rotor end bell **as well as** taking full advantage of thermodynamic properties of the stock material itself. HVFCV is achieved through a set of solid metal turbine impeller blades painstakingly **CNC milled** as an integral part of the rotor end bell assembly, which not only provides the positive force cool ventilation by drawing fresh cool air through the stator and magnets, but also doubles up as a heat pump to first draw excess heat from the rotor assembly itself and then act as a heat exchanger by expelling it through the air stream contacting the solid metal turbine blades as it spins at high velocity. Micro ridges, intentionally CNC cut into the rotor, further multiples the end bell's surface area and serve as radiators to further boost thermal dissipation achieving unparallel cooling and henceforth having the ability to swing larger propellers than other conventional outrunner motors of similar class while remaining considerably cooler and more efficient.

There is more to the "Cool" look of the CNC exterior casing than meets the eye, and looks can be deceiving. Under the hood, is where serious engineering comes into play. With only the highest quality materials and components used in the manufacture, the new PA Thrust® motors are manufactured with the tightest tolerance making it possible to maintain the smallest air gap between the stator and shaped neodymium magnets, significantly boosting torque and thrust. The relatively silent and vibration-free operation of the motor is a testament to the tight tolerance manufacturing regime we have adopted specifically to harness the maximum power produced by the motor (within the limits of today's technology) for the sole purpose of swinging the prop. This allows the motor to swing propellers of at least one size larger than any contemporary motors in its class while running cool with maximum efficiency.

The iPAs Drive Test Methodology:- An Engineered Approach to Testing

Through hundreds of hours of flight testing our airframe designs, we have established that there is a direct correlation between the airframe and drive system and one affects the other with consequences to the desired aerodynamic performance. We designed our power plants with the airframe that promotes efficient cooling. The idea behind the design was to allow the power plant and airframe to work in harmony in order to achieve optimum performance, that could never be easily achieved with a mix and match approach. Every step of the design from the airframe, motor, speed controller through to the matching power packs have been done in a very careful and measured fashion with the sole propose to achieve the maximum aerodynamic performance without compromising flight time. We call the result **iPAs**, PA **I**ntegrated **P**erformance **A**irframe-Drive **S**ystem, allowing any modeler to get it right the first time in the simplest and shortest way; the completely hassle free buy, fix, fly and forget method.

What iPAs means to you, the modeler? iPAs provides a pre-matched, optimum gear setup derived from hundreds of hours of flight testing that would make your PA model perform as advertised out of the box. This also means you will no longer need to try and figure out by experiments what gear best matches the airframe and the desired flight performance.

Below we will tell you a bit about the task of testing the gear to confirm the performance results.

While this may sound easy, it is actually a very complex test that should be done carefully. Any variations with the type of ESC set up, ESC brand, type of battery, charging of the battery pack (can even vary between same brand and type of pack), type of chargers, climate (environment temperature) and testing gear will derive different results. Even the duration of the bench run will change the reads due to the battery voltage drop caused by the internal resistance of the battery as well as the age of the battery. All those factors can create A LOT of read variations.

We conducted **multiple** tests (both static and dynamic tests) on each of our motors in different climates/temperature, using different testing equipment, changed ESC and batteries to determine the real performance of the motor. We also had the model flown by multiple test pilots to obtain different individual flying styles.

We believe that drive system testing should not be purely based on bench testing, because those are clinical test done in controlled environments that are completely different from actual flight conditions. Interactions of external environmental factors such as cooling, prop loading, G-Force etc. can not be accurately simulated on the bench. The real performance data comes from actual flights because this is where it counts the most. Therefore, we have taken the approach to conduct actual live (dynamic) test to acquire our data, i.e. flying the actual aircraft and performing actual 3D maneuvers, like any other experienced modeler would. We do not simply fly straight and level circuits and performing simple aerobatic maneuvers during our flight test but we actually fly our aircraft to the maximum limits of their aerodynamic performance envelope.

We strongly recommend going over the graphs below since they are the real dynamic test we've conducted with the motor.

iPAs Static Bench Testing Results
iPAs Gear: PA Thrust 50, Quantum 65, 2xPA2200mah 20-40C V2 (6 cells)

Prop Type	Battery Voltage (V)	Current (A)	RPM	Watts (W)	Static Thrust (oz)	Static Thrust (gr)	Static Thrust (lb)
VOX 13x6.5	22.42	31.6	9390	709	114.00	3,234	7.13
APC 13x6.5E	22.03	38.5	8955	850	109.90	3,116	6.87
VOX 14x7	22.63	37.1	9270	841	149.44	4,236	9.34
VOX 14x8	21.71	41.8	8685	909	131.20	3,720	8.20
APC 14x7E	21.97	43.2	8700	949	139.50	3,955	8.72
VOX T50-X	22.31	44.4	8835	990	164.96	4,676	10.31
VOX 15x7	21.83	44.5	8580	972	168.80	4,785	10.55
VOX 15x8	21.79	47.4	8475	1033	164.64	4,667	10.29
APC 15x7E	21.72	52.0	8235	1131	164.80	4,672	10.30
APC 15x8E	21.24	57.5	7920	1223	152.48	4,323	9.53

In 3D flights, thrust and power usually require the immediate power for few seconds to get out of a maneuver. We have based our static tests on this datum. We used 4 different brands of testing gear to verify the results and accuracy of reads. Test results may vary depend on your set up of your ESC, climate, altitude, duration of run etc.

Dynamic Flight Testing Results

The dynamic test is real time data acquisition by onboard data loggers installed on the actual aircraft which the gear is designed for. These airplanes are deliberately flown by advanced pilots executing actual advanced maneuvers to simulate the real world performance conditions where these airplanes are expected to be flown.

We have included several graphs to cover as many advanced freestyle and 3D routines as possible especially maneuvers that places the most demand on the drive system. The graphs also show the actual motor cooling performance as it goes through each different maneuver and air speeds.

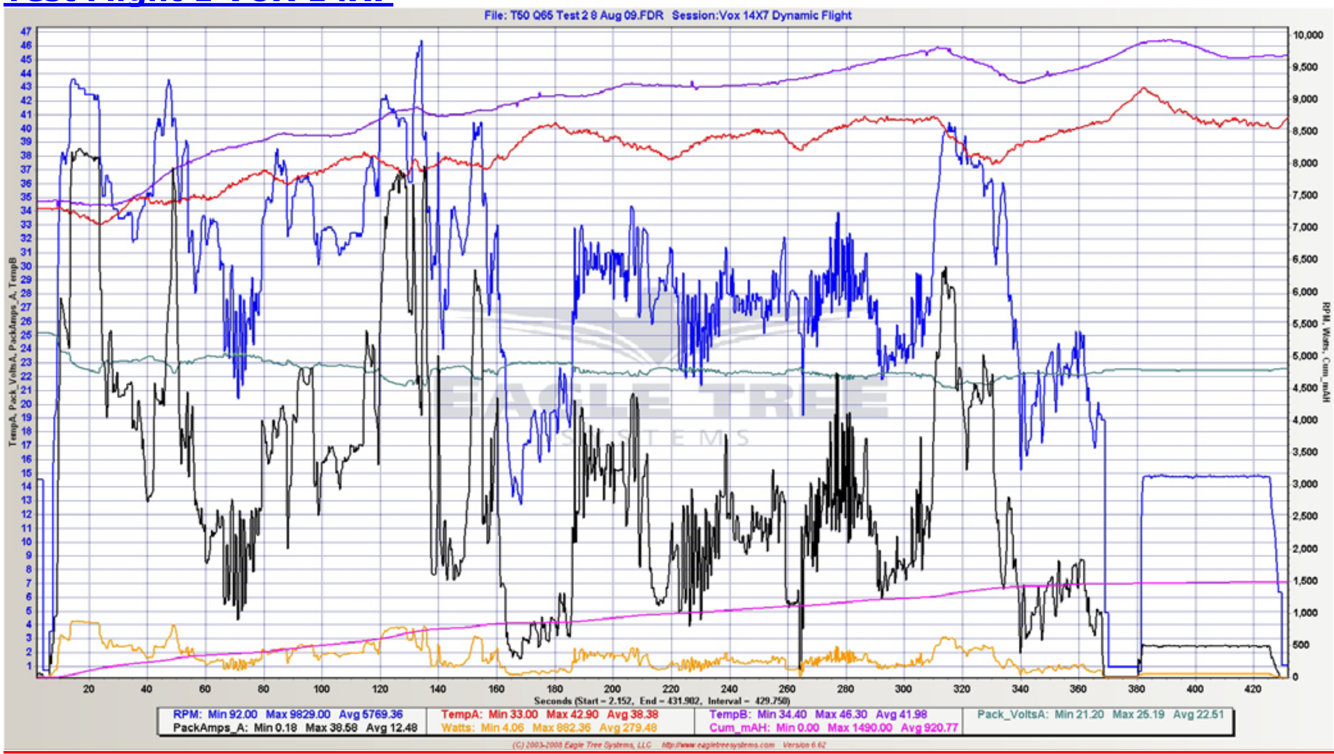
You may also want to look at all the temperature traces on the graph that indicates a fairly constant operating temperature throughout the flight in relation to the dynamic loads imposed by the propeller. This is where our exclusive Rotorkool® feature comes into action to keep motor core temperature considerably below the critical temperature limits of the neodymium magnets allowing our Thrust® motors to provide consistent performance far longer than any other motor.

iPAs Dynamic Flight Test Results

Gear used: PA Thrust 50, PA Quantum 65, PA 2200mah 20- 40C V2 (General Freestyle/Hardcore 3D Maneuvers)

Engineering Units
Current = Amps, Voltage = Volts, Power = Watts, Temperature = Deg C., RPM = RPM, Battery Capacity = mAH.

Test Flight 1 VOX 14X7



Graph interpretation & Flight Report:
Dynamic test was deliberately conducted in an extremely hot summer day with ambient Air temperature of 33 Deg C (91.4F). The intent to conduct this test during the hottest summer period as opposed to during the winter is deliberately aimed to induce the maximum thermal loads on the motor and in order to demonstrate the capabilities and effectiveness of the Rotorkool® design as well as the cooling efficiency of the Quantum 65 and the tested airframe.

The **red line (Temp A)** shows the fairly constant motor operating temperature band throughout the fight to be between 36–41 Deg C (96.8 -105.8F) rising and dropping within a narrow 5 Deg C (9.0F) range corresponding to the loads being imposed. The very narrow temperature range throughout the entire flight duration (in-spite executing demanding maneuvers) demonstrates the effectiveness of the Rotorkool® HVFCV feature and only rose after the motor came to a stop (after landing).

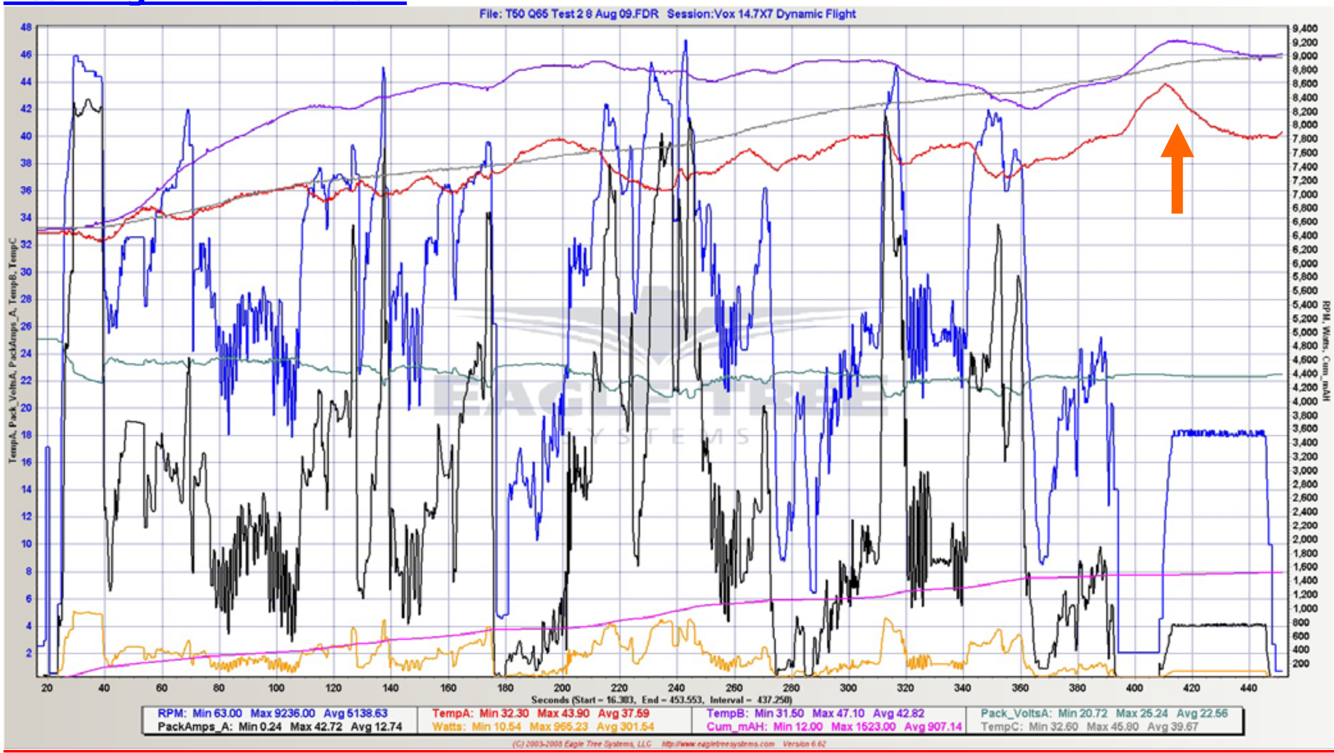
The cumulative battery capacity (**pink line**) after the 6.1 minute flight indicates that 1,490mAH was consumed.
This coupled with the high peaks of the RPM (**blue line**) clearly demonstrates that this flight was predominantly done performing lots of high energy maneuvers.
The **purple line (Temp B)** records the operating temperature of the Quantum 65 responding to the flight loads imposed by the Thrust 50 which in this flight shown at about 41-46 C (105.8-114.8F) throughout the entire flight and only rose after the motor stopped.

The battery voltage (**green line**) also shows a very constant high voltage throughout the flight and never fell below 21.2V providing very consistent performance throughout the entire session without the need to rearrange the flight maneuvers.

The peak watts (**orange line**) drawn in this test flight was **882.36W** with a maximum peak current of only **38.58A** (**black line**) confirming the cooling running of the battery packs. The low amp drawn combined with the high performance again clearly demonstrates the efficient **iPAs** setup.

No issues were noted on the Quantum 65 ESC and the throttle response was smooth and linear. The performance was very consistent with a very fast throttle response.

Test Flight 2 VOX T50-X



Graph interpretation & Flight Report:

Dynamic test was deliberately conducted in a very hot mid-summer day with ambient Air temperature of 32.3 Deg C (90.14F). The intent to conduct this test during the hottest summer period as opposed to during the winter is deliberately aimed to induce the maximum thermal loads on the motor and in order to demonstrate the capabilities and effectiveness of the Rotorkool® design as well as the efficiency of the **iPAs** gear and the cooling efficiency of the Quantum 65 and the tested airframe.

This graph can be useful when comparing it to the VOX 15x7 graph since the Vox T50-X is a mid range prop between the 14x7 and the 15x7.

The **red line (Temp A)** shows the motor operating temperature throughout the flight to be between 34.4-40Deg C (93.9-104F) and only rose after the motor has stopped after landing (at the 395 sec mark). Then the motor was restarted on idle for 30 sec (410-445 sec mark) and the motor's temperature dropped**.** That was done to demonstrate how well Rotorkool® HVFCV controls the temperature of the motor (refer to the orange arrow in the graph for the temp drop).

As demonstrated in the graph between 120-395 sec, the **redline** shows Rotorkool® was effectively managing the motor's temperature to remain within a narrow 5.6 Deg C (10.1F) band in spite of the larger VOX T50-X prop.

The **purple (Temp B)** records the operating temperature of the Quantum 65 responding to the flight loads imposed by the Thrust 50 and in this flight shows that it gradually increased and stabilized at about 45 Deg C (113F).

The **green line** shows the voltage performance of the PA2200mAH V2 (20C-40C) packs throughout the flight. Here you can see the battery packs' ability to hold fairly constant voltage which never fell below 20.72V throughout the entire flight session providing very consistent performance from end to end without the need to make any compromises on maneuvers sequence.

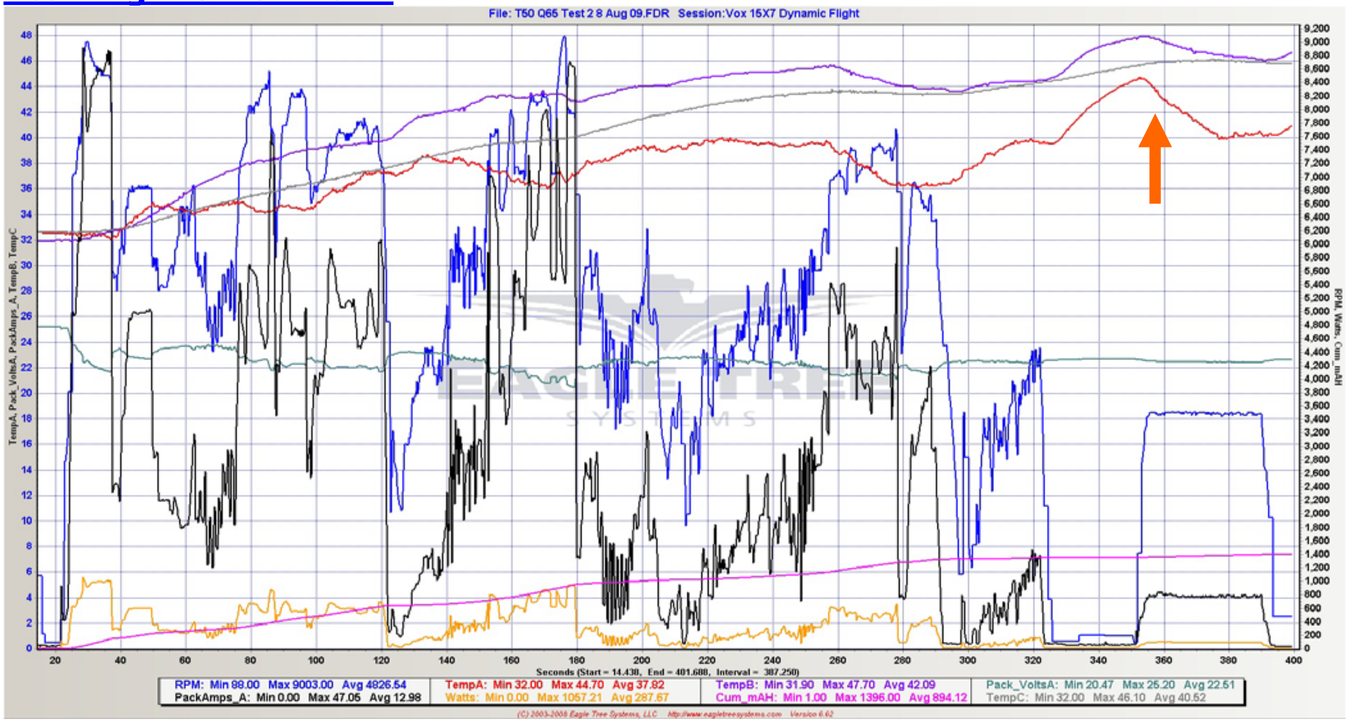
The **grey line (Temp C)** shows the battery temperature throughout the flight indicated that the batteries ran within safe operating temperature despite delivering **almost 1KW** during peaks.

The cumulative battery capacity (**pink line**) after the 6.6 minute flight drew only **1,490 mAH** (68% of the battery capacity) which demonstrates the efficiency of the iPAs setup.

The **orange line** (watts) shows the motor power output throughout the flight peaking to **965.23W** with a maximum peak current of only **42.72A** (**black line**).

The Quantum 65 ESC worked extremely well and the throttle response was smooth and linear. The performance was consistent with lots of energy.

Test Flight 3 VOX 15X7



Graph interpretation & Flight Report:

Dynamic test was deliberately conducted in a very hot mid-summer day with ambient Air temperature of 32 Deg C (89.6F). The intent to conduct this test during the hottest summer period as opposed to during the winter is deliberately aimed to induce the maximum thermal loads on the motor and in order to demonstrate the capabilities and effectiveness of the Rotorkool® design as well as the cooling efficiency of the Quantum 65 and the tested airframe.

This test flight is a consecutive flight which is evident by the higher starting motor and ESC temperatures of 33.0 Deg C (91.4F) which then dropped (after takeoff) to 32.0 Deg C (89.6F) and then raised to 36 Deg C (96.8F) once the motor was pushed to full throttle on the vertical climb at the beginning of the flight.

The **red line (Temp A)** shows the very constant motor operating temperature throughout the fight to be between 36–40 Deg C (96.8-104F), rising and dropping corresponding to the loads being imposed by the huge wooden VOX15X7 propeller. The very constant nature of the temperature trace on this flight shows how well RotorKool® controls the temperature maintaining it within a narrow band of only 6 Deg C (7.2F). A rise in temperature starting at 325 seconds mark was when the aircraft landed and the motor stopped and then restarted at idle (355-395sec) to cool down (Refer to the orange arrow in the graph for the motor temperature drop). That clearly demonstrates the self cooling capabilities and the high efficiency of the motor.

The **purple line (Temp B)** records the operating temperature of the Quantum 65 responding to the high flight loads imposed by the Thrust 50 rising and then stabilizing between 43.7-45.7 Deg C (110.6-114.2F).

The cumulative battery capacity (**pink line**) after the 5.4 minute flight drew only **1,396 mAH** (63% of the battery capacity) which demonstrates the efficiency of the iPAs setup.

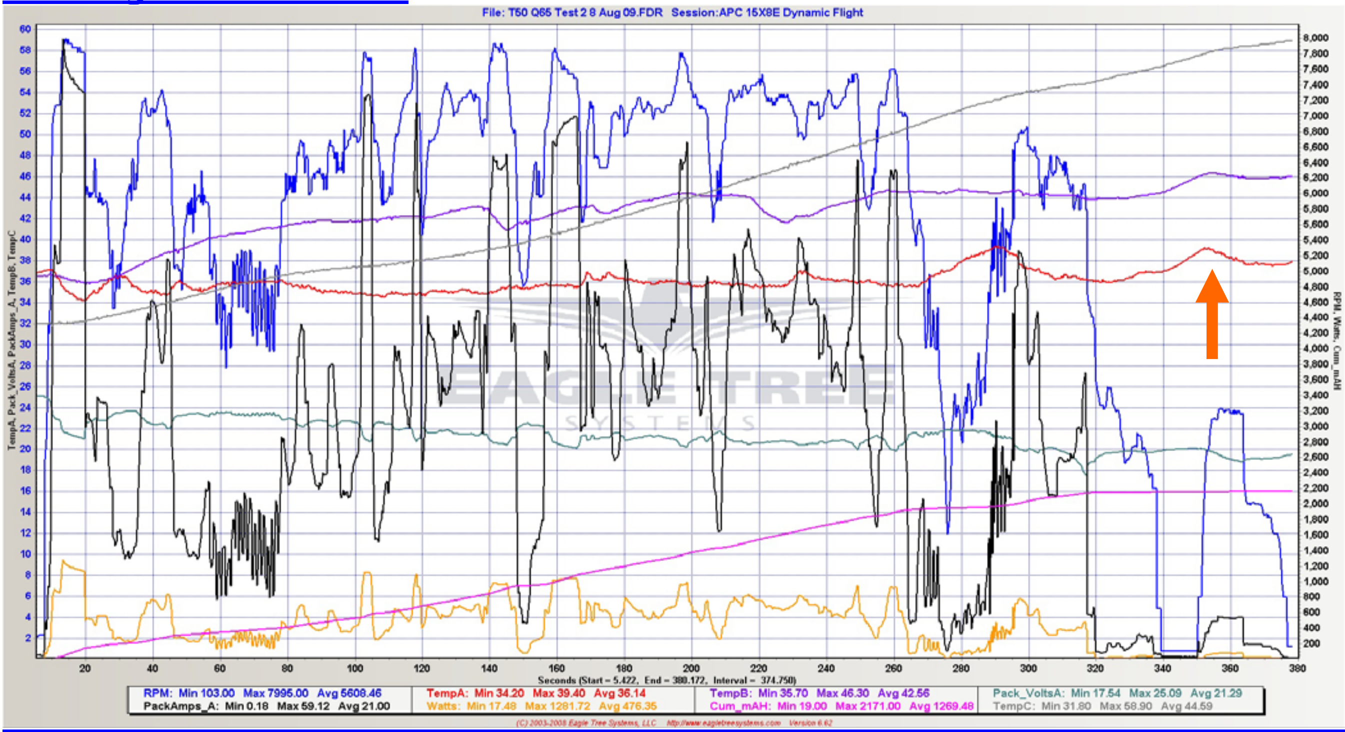
The **green line** (battery voltage) shows how well the battery is coping with the high loads imposed on the motor with this large prop. Throughout the entire flight the battery voltage never dropped below 20.47V providing very consistent performance throughout the entire session without the need to rearrange any flight maneuvers. Note that the pack was driven very hard **(1,057.21W)** yet the voltage remained within the safe range of the LVC.

The **grey line (Temp C)** shows the battery temperature throughout the flight indicated that the batteries ran within normal safe operating temperature despite delivering **more than 1KW** during peaks.

The peak watts (**orange line**) drawn on this test flight drew a whopping **1,057.21W** with a maximum peak current of only **47.25A** (**black line**) clearly demonstrating the high efficiency of the **iPAs** setup with the VOX 15X7 prop.

No issues were noted on the Quantum 65 ESC and the throttle response was smooth and linear. The performance was consistent with lots of energy. There was absolutely no feel of any constraints in the maneuvers the test model is capable of performing.

[Test Flight 4 APC 15X8E]



Graph interpretation & Flight Report:

Dynamic test was deliberately conducted in a very hot summer day with ambient Air temperature of 32 Deg C (89.6F). The intent to conduct this test during the hottest summer period as opposed to during the winter is deliberately aimed to induce the maximum thermal loads on the motor and in order to demonstrate the capabilities and effectiveness of the Rotorkool® design as well as the cooling efficiency of the Quantum 65 and the tested airframe.

This test flight is a consecutive flight evident by the higher starting motor and ESC temperatures of 37 Deg C (98.6F) which then dropped to 34.2 Deg C (93.56F) once the motor was pushed to full throttle on the vertical climb takeoff at the beginning of the flight. This temperature drop demonstrate the effectiveness of the RotorKool® HVFCV feature even though the throttle was gunned to full power.

The **red line (Temp A)** shows the very constant motor operating temperature throughout the flight to be between 34.5–37.0 Deg C (94.1-98.6F) rising and dropping corresponding to the loads being imposed by the huge APC15X8E propeller. The very constant nature of the temperature trace on this flight shows how well RotorKool® controls the temperature maintaining it within a very narrow band of only 2.5 Deg C (4.5F). A rise in temperature starting at 335 seconds mark was when the aircraft landed and the motor stopped and then restarted at idle (350-375sec) to cool down (Refer to the orange arrow in the graph for the motor temperature drop). That clearly demonstrates the self cooling capabilities and the high efficiency of the motor.

The **purple line (Temp B)** records the operating temperature of the Quantum 65 responding to the flight loads imposed by the Thrust 50 rising and then stabilizing in a very narrow band of 41- 44.3 Deg C (105.8F- 111.7F) despite of the high loads imposed by the APC 15x8E.

The cumulative battery capacity (**pink line**) after the 5.6 minute flight drew **2,171 mAH** showing how hard the model was flown during this session. The battery voltage (**green line**) also shows a fairly constant voltage throughout 90% of the flight and never fell below 20V until the last 10% when LVC (Low Voltage Cutoff) occurred and the Quantum 65 automatically reduced power and allowed for a safe controlled landing. The consistent voltage throughout 90% of the session provided very consistent flight performance with absolutely no compromises having to be made on the maneuvers.

The **grey line (Temp C)** shows the battery temperature throughout the flight and indicates that the batteries were pushed hard to deliver **1.28KW (1.71HP)** during peaks. This graph also validates the need for battery packs of 3,000mah or above to run this APC 15x8E prop and demonstrates the performance potential of the Thrust 50 to run a more demanding prop if larger packs are used.

The peak watts (**orange line**) drawn on this test flight drew a whopping **1,281.72W** with a maximum peak current of only **59.12A** (**black line**) clearly demonstrating the high demands of the APC 15X8E prop.

The Quantum 65 ESC performed very well and the throttle response was smooth, direct with no hesitation in-spite of the abuse with this large prop. Throttle response was instantaneous with surplus reserves for punch-out during torque rolls and hover-recovery right up to the end of the flight.